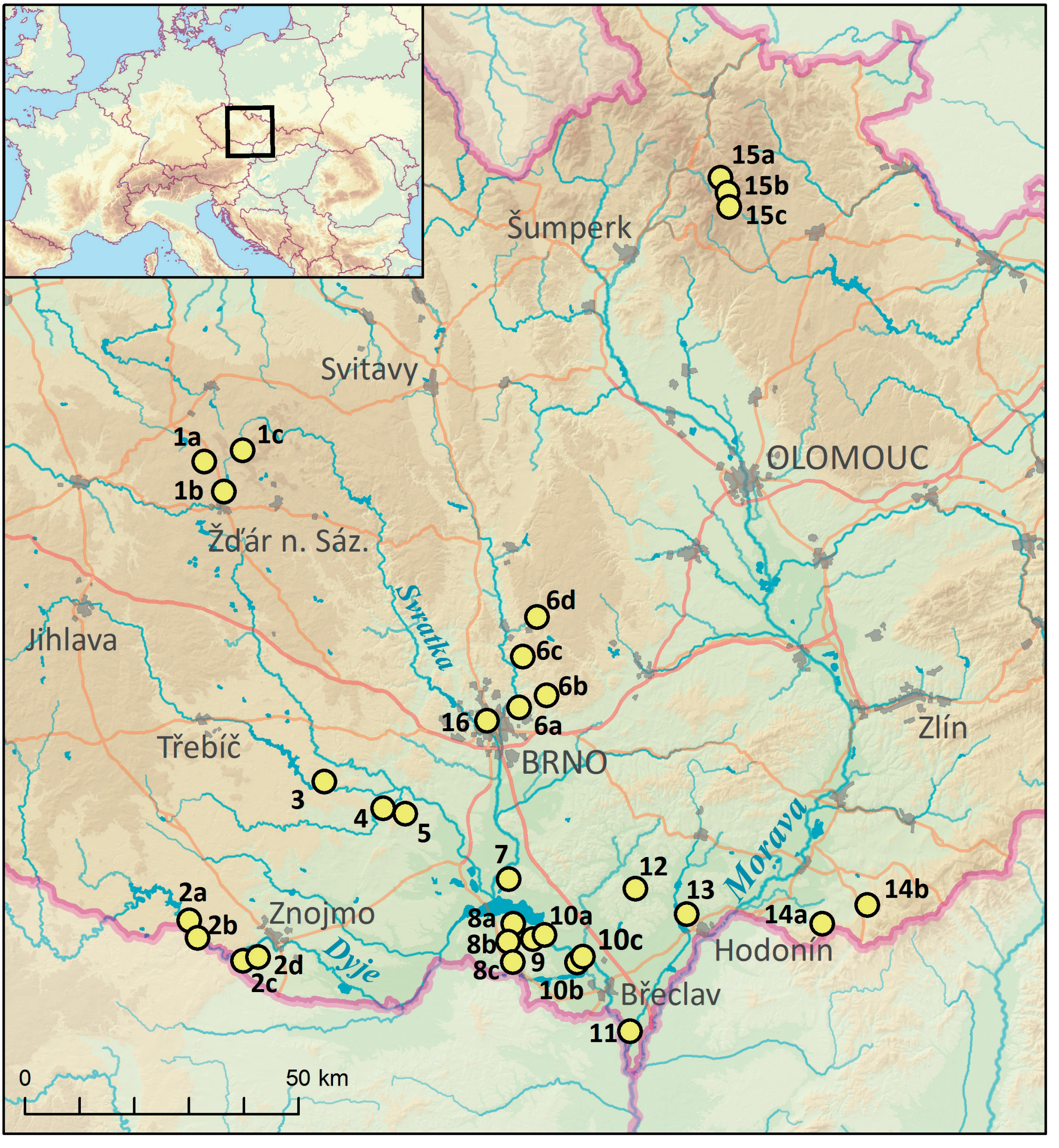
Botanical Excursions in Moravia

Field Guide for the 58th IAVS Symposium

Edited by Milan Chytrý, Jiří Danihelka & Dana Michalcová



1 Žďár Hills: **1a** *Dářko* National Nature Reserve, **1b** *Louky u Černého lesa* Nature Monument, **1c** *Žákova hora* National Nature Reserve

2 Podyjí National Park: **2a** *Ledové sluje* ridge, **2b** Dyje valley near Hardegg, **2c** Šobes meander, **2d** Havraníky-Znojmo heathlands

3 Mohelno Serpentinite Steppe

4 Krumlov-Rokytná Conglomerates

5 Krumlov Wood

6 Moravian Karst: **6a** Hády Hill, **6b** Říčka valley, **6c** Josefov valley, **6d** Macocha abyss and the karst valleys nearby

7 Pouzdřany Steppe and Kolby Wood

8 Pavlov Hills: **8a** Děvín Hill, **8b** *Tabulová* National Nature Reserve, **8c** *Svatý kopeček* Nature Reserve

9 *Milovická stráň* Nature Reserve

10 Dyje floodplain near Lednice (Lednice-Valtice Cultural Landscape): **10a** *Křivé jezero* National Nature Reserve, **10b** Lednice Chateau Park, **10c** Pavelka Meadow

11 Dyje-Morava floodplain near Lanžhot

12 *Špidláky* Nature Reserve

13 Hodonínská Dúbrava Wood

14 White Carpathian Mountains: **14a** Čertoryje meadows, **14b** Zahrady pod Hájem meadows

15 Hrubý Jeseník Mountains: **15a** Ovčárna chalet and Sedlové peatbog, **15b** Mount Petrovy kameny, **15c** Velká kotlina cirque

16 Botanical Garden of the Faculty of Science, Masaryk University, Brno

Botanical Excursions in Moravia

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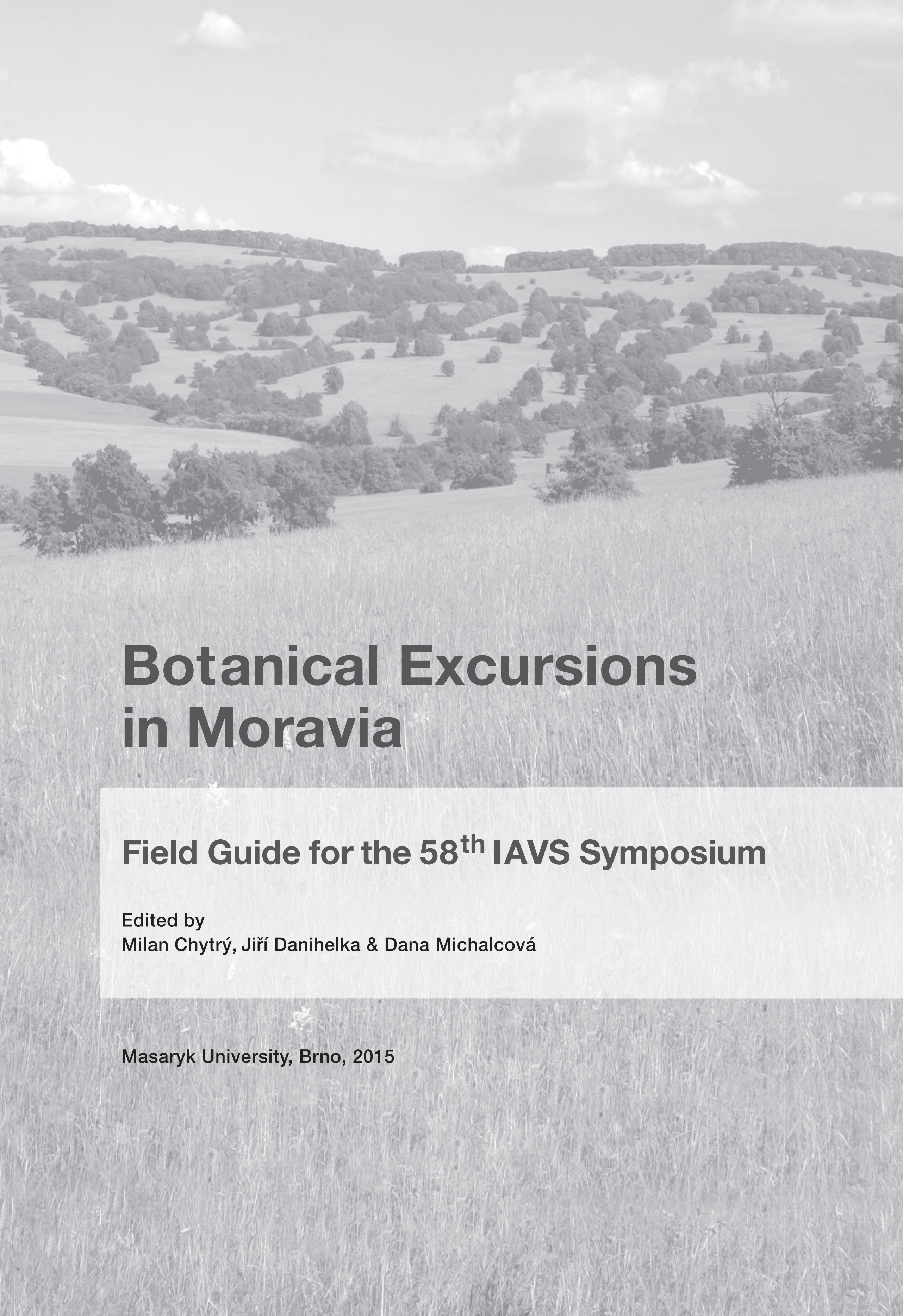

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Edited by
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Masaryk University, Brno, 2015

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Introduction

Milan Chytrý

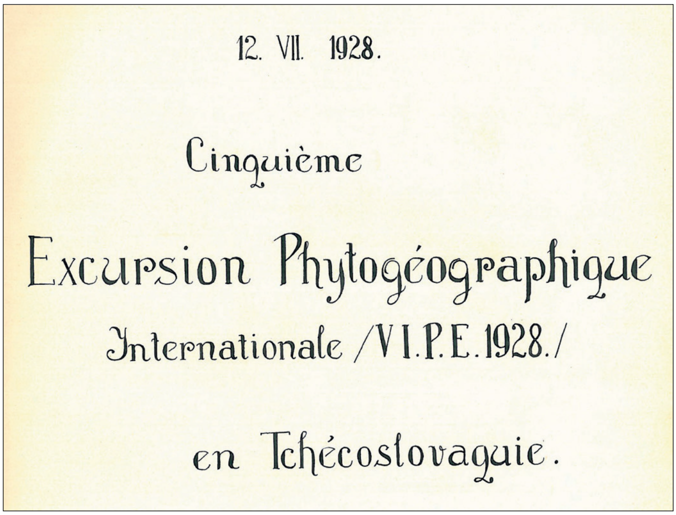
The 58th Annual Symposium of the International Association for Vegetation Science (IAVS), held in Brno in the Czech Republic on 19–24 July 2015, is an excellent opportunity for vegetation ecologists from all continents to meet, present the best of their research results and discuss current and future projects. IAVS symposia have also traditionally been associated with field excursions giving the global community of vegetation ecologists the chance of learning about the vegetation, flora and environment of the host country. The Brno Symposium is to be no exception to this.

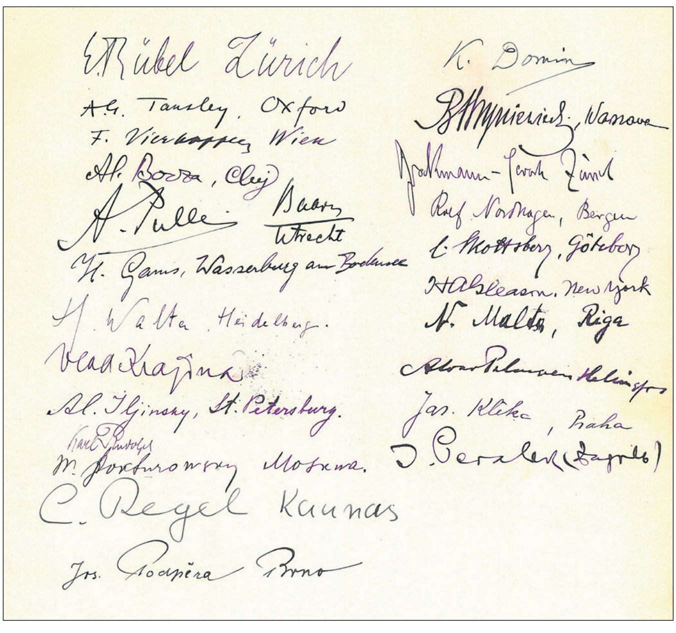
The Local Organizing Committee of the 58th IAVS Symposium has prepared a series of field excursions in Moravia, the eastern part of the Czech Republic, featuring sites that can easily be reached on one-day trips from the symposium venue in Brno. There will be a four-day excursion on 16–19 July 2015 and several one-day excursions on 18, 19 and 22 July 2015, mostly in the southern part of Moravia. The excursion sites are described in this volume. The post-symposium excursion on 25–30 July 2015 will visit the Western Carpathians in Slovakia; localities to be visited on this excursion are described in another volume (Janišová & Šibík 2015).

International excursions of vegetation ecologists are not new to Brno. The Fifth International Phytogeographical Excursion (IPE) to Czechoslovakia and Poland was hosted by Professor Josef Podpěra at Masaryk University in July 1928. En excursion group of nineteen leading European and North American phytogeographers and vegetation ecologists, accompanied by nine Czech botanists, visited some of the sites in southern Moravia that are also to be visited during the 58th IAVS Symposium: the Moravian Karst, the Mohelno Serpentinite Steppe, the Pavlov Hills, the White Carpathian Mountains, the Masaryk University's Botanical Garden and Mendel's Memorial in Brno city centre (Rübel 1930). Thirty years later, Czechoslovakia was again host to the 12th International Phytogeographical Excursion (1 July to 5 August 1958) attended by 58 foreign and 60 Czechoslovak botanists. Brno and sites of botanical interest in southern Moravia were again visited at that time. History repeats itself, though the people are different and the vegetation in 2015 is somewhat different from the vegetation our predecessors saw at the same sites in 1928 and 1958.

This volume is the result of an extensive update and the addition of new excursion sites to the texts prepared for previous conference excursions organized by botanists from Masaryk University: *The Austrian-Czech Botanical Field Seminar in Moravia* in Brno (June 1996; Danihelka et al. 1996), *the 3rd Planta Europa Conference* in Průhonice (June 2001) and *the 17th International Workshop European Vegetation Survey* in Brno (May 2008; Chytrý 2008). It contains basic information and lists of selected plant species that can be seen at individual sites. The taxonomy and nomenclature of vascular plant species follow the *Checklist of vascular plants of the Czech Republic* (Danihelka et al. 2012), while that of bryophytes and lichens follows Kučera et al. (2012) and Liška et al. (2008), respectively. Information on alien species (neophytes) is in accordance with Pyšek et al. (2012). The concept and nomenclature of vegetation types follows the four-volume monograph *Vegetation of the Czech Republic* (Chytrý 2007–2013). More condensed information on the country's vegetation types is contained in the *Habitat Catalogue of the Czech Republic* (Chytrý et al. 2010). General information in English on the vegetation and flora of the Czech Republic can be found in reviews by Chytrý (2012) and Kaplan (2012), respectively. Detailed information on the country's flora in Czech is contained in eight volumes of the *Flora of the Czech Republic* published in 1988–2011 (Hejný et al. 1988 et seq.) and in the *Key to the flora of the Czech Republic* (Kubát et al. 2002). Information on endangered flora is provided in the national Red Data Book (Čeřovský et al. 1999) and Red List (Grulich 2012). The classification of the country into 91 biogeographical regions along with the description of these regions has been provided by Culek et al. (2013). Detailed descriptions of nature reserves and other protected areas are found in the fourteen-volume encyclopedic series *Protected Areas of the Czech Republic* (Mackovčin & Sedláček 1999–2009). Basic information about 75 Important Plant Areas of the Czech Republic, several of them to be visited during the 58th IAVS Symposium, has been summarized by Čeřovský et al. (2007). Potential natural vegetation has been mapped by Neuhäuslová et al. (1997) and maps summarizing the environment and biogeography of the Czech Republic are available in the *Landscape Atlas of the Czech Republic* (Hrnčiarová et al. 2009). Spatial distribution of various climatic features based on the measurements from the period 1961–2000 is provided in the *Climate Atlas of Czechia* (Tolasz et al. 2007), which is also used as a reference for climate data throughout this volume unless indicated otherwise. An excellent set of maps of the Czech Republic including hiking maps, historical maps and aerial photographs is available on the server Mapy.cz; the maps of localities in this volume are taken from this source.

As the guides of the 58th IAVS Symposium excursions and the authors of this volume, we hope that you enjoy the field trips in our country.





Record in the Memorial Book of the Institute of General and Systematic Botany of Masaryk University with signatures of the participants of the Fifth International Phytogeographical Excursion:

E. Rübel, A. Tansley, F. Vierhapper, A. Borza, A. Pulle, H. Gams, H. Walter, V. Krajina, A. Iljinsky, K. Rudolph, W. Dokturowsky, C. Regel, J. Podpěra, K. Domin, B. Hryniewiecki, H. Brockmann-Jerosch, R. Nordhagen, C. Skottsberg, H. Gleason, N. Malta, A. Palmgren, J. Klika and I. Pevalek.

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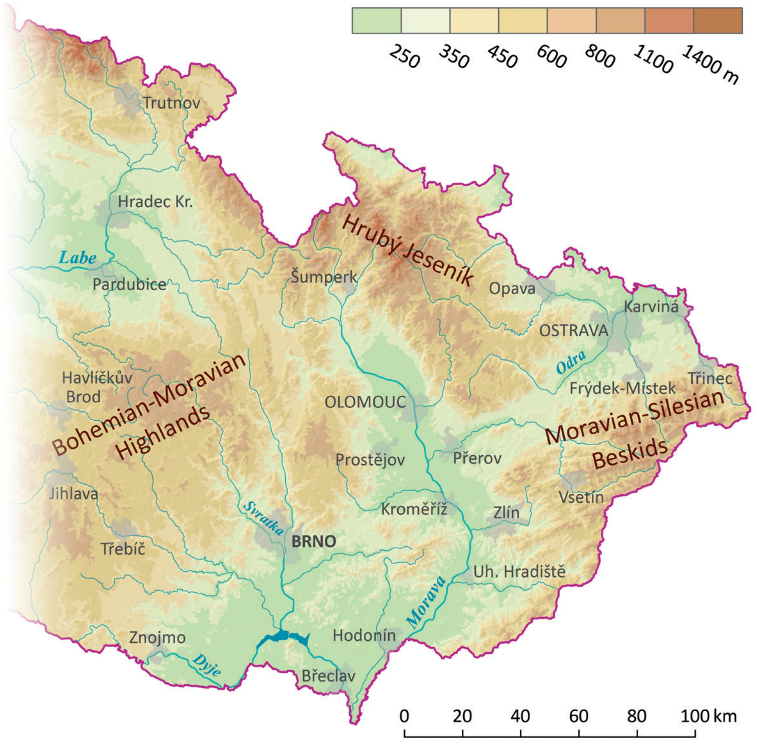
Geography and biogeography of Moravia

Milan Chytrý

Introduction

Moravia (*Morava* in Czech) is a historical land encompassing the eastern part of the Czech Republic, with the cities of Brno and Olomouc being its historical capitals. It is one of the three historical Czech Lands, the others being Bohemia (*Čechy*, the western part of the Czech Republic) and the Czech part of Silesia (*Slezsko*, occupying a small area in the north-eastern part of the Czech Republic). Since 1949, Moravia has no longer been an administrative unit, although its name is preserved in the official names of some of the current administrative regions established on the territory of this historical land (e.g. the South Moravian Region).

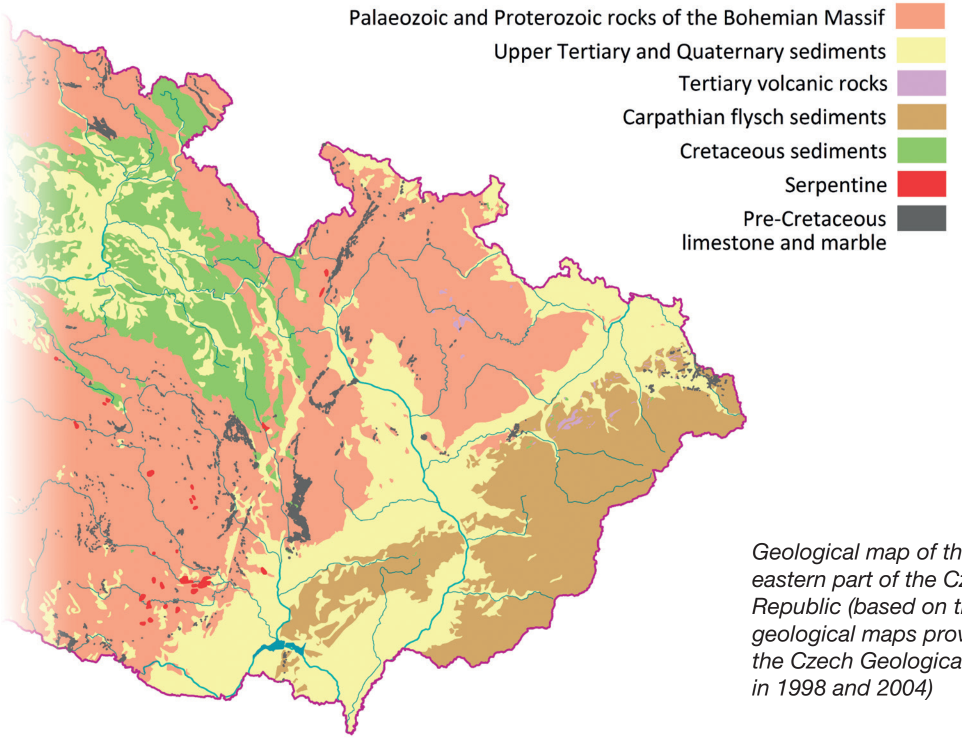


The eastern part of the Czech Republic (all maps in this chapter and the map on the inside cover were prepared by O. Hájek)

Geology, geomorphology and soils

Moravia is situated on the transition zone between two of Central Europe's major mountain systems: the Bohemian Massif (*Český masiv*) in the north-west and the Western Carpathians (*Západní Karpaty*) in the south-east (Chlupáč et al. 2011). The Bohemian Massif is an old mountain system consisting of Proterozoic and Palaeozoic crystalline rocks (mainly gneiss and granite) which was formed during the Variscan (= Hercynian) Orogeny in the upper Palaeozoic. The core of the Bohemian Massif is in Bohemia, though two major ranges extend into Moravia. The first is the Bohemian-Moravian Highlands (*Českomoravská vrchovina*) in western Moravia, characterized by a gently undulating landscape reaching greatest altitudes of 837 m in the Jihlava Hills (*Jihlavské vrchy*) and 836 m in the Žďár Hills (*Žďárské vrchy*). The second is the Sudetes (*Sudety*) running along the Czech-Polish border, with a greatest altitude of 1492 m in the Hrubý Jeseník Mountains. The summit areas of the Hrubý Jeseník Mountains lie above the timberline. The prevailing crystalline rocks of the Bohemian Massif give rise to poor acidic soils, particularly cambisol and, in the higher mountains, also podzol. Base-rich rocks occur mainly in the Moravian Karst near Brno (Devonian sedimentary limestone deposited over the crystallinic fundament) and in north-western Moravia where the Bohemian-Moravian Highlands border on the Bohemian Cretaceous Basin which is filled with Upper Cretaceous mudstones, marls and sandstones. Small patches of metamorphosed limestone (marble, crystalline limestone) and serpentinite are found in the Bohemian-Moravian Highlands and other parts of the Bohemian Massif, usually exerting a remarkable influence on the vegetation cover.

The Carpathian Mountains were formed during the Alpine Orogeny in the Mesozoic and Tertiary (Chlupáč et al. 2011). As they are younger than the Bohemian Massif, they are generally more rugged and also contain many limestone areas in addition to crystallinic rocks. The north-western part of the Carpathians, located in Slovakia and adjacent areas, is called the Western Carpathians. In Moravia, the Western Carpathians are represented only by the Flysch Belt, an outer part of the Carpathian range which extends from Moravia along the Polish-Slovak borderland to western Ukraine. Flysch is a sedimentary series of the Palaeogene age consisting of alternating layers of shale (mudstone) and sandstone, which was deposited in the foreland basin of the Western Carpathians during the Alpine Orogeny. The Flysch Belt is formed of several nappes, large sheets of flysch sediments that have been moved over the Western Carpathian foreland. In some areas, particularly in southern Moravia, the flysch sediments tend to be calcareous, while in other areas (north-eastern Moravia in particular) they are mostly acidic. The flysch sediments are generally soft, resulting in a gently undulating landscape. Alternation of water-holding shales with permeable sandstones results in small-scale landslides, which often open up springs on flysch slopes. As in the Bohemian Massif, the predominant soil type in the Carpathian part of Moravia is cambisol and, at higher altitudes, also podzol, but the Carpathian flysch-derived soils are generally deeper and less stony or gravelly than the soils in the Bohemian Massif. The highest altitude of 1323 m in the Carpathian part of Moravia is reached in the Moravian-Silesian Beskids (*Moravskoslezské Beskydy*) in north-eastern Moravia.

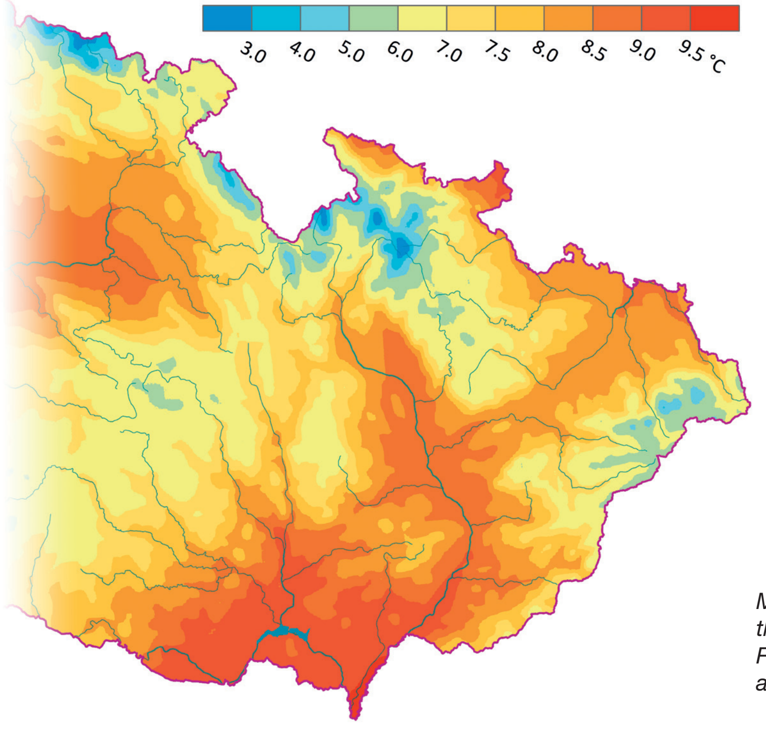


Geological map of the eastern part of the Czech Republic (based on the digital geological maps provided by the Czech Geological Survey in 1998 and 2004)

The lowland area between the Bohemian Massif and the Western Carpathians at altitudes between 150 and 300 m is formed of Neogene and Quaternary sediments. In places there are remarkable accumulations of loess, an eolian sediment deposited in cold and dry phases of the Pleistocene, some of which contain a valuable fossil record of the Palaeolithic human cultures and their environment. The chernozems and related soils in this area are the most fertile in Moravia, for which reason most of the land has been converted to arable fields.

Climate

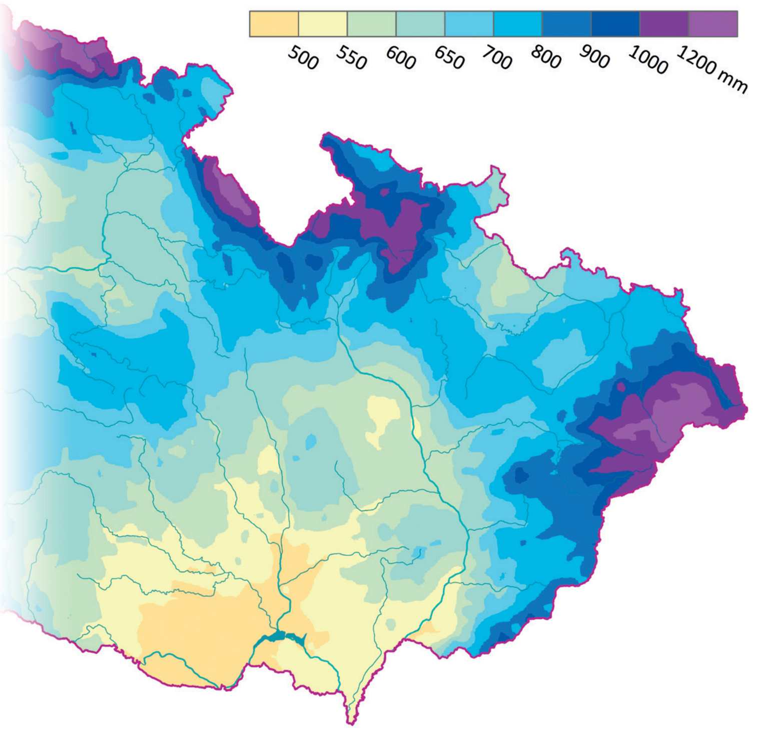
The climate of Moravia is temperate subcontinental, generally supporting broad-leaved deciduous forest, but in the south it is transitional to a drier forest-steppe climate and on the summits of the Hrubý Jeseník Mountains it supports coniferous forests and even small areas of alpine tundra (Chytrý 2012). The warmest and driest part of Moravia are the lowlands south of Brno with mean annual temperatures of 9–10 °C and an annual precipitation sum of 450–550 mm (Tolasz et al. 2007). The low precipitation is due to the position of southern Moravia in the lee of the Bohemian-Moravian Highlands which capture a considerable proportion of the precipitation coming to Central Europe predominantly with the north-western winds from the Atlantic Ocean. The lowlands in north-eastern Moravia, such as those around the city of Ostrava, are also relatively warm (mean annual temperatures of 8–9 °C), though the precipitation is about 700–800 mm in this region which directly borders the Polish lowland and lacks orographic rain-shading. The lowest mean annual temperatures (1–2 °C) are on the summits of the Hrubý Jeseník Mountains in northern Moravia, and the highest precipitation (more than 1200 mm) on the summits of the Moravian-Silesian Beskids in north-eastern Moravia (Tolasz et al. 2007). The coldest month in Moravia is January with a mean temperature of about –1.5 °C in the lowlands and about –6 °C on the highest mountain summits. The warmest month is July with a mean temperature of about 19 °C in the lowlands and about 11 °C in the highest mountains. Precipitation is characterized by a distinct summer peak, with 150–500 mm falling within the three summer months and 50–300 mm within the three winter months, depending on the altitude (Tolasz et al. 2007).



Mean annual temperatures of the eastern part of the Czech Republic (data from Tolasz et al. 2007)

Landscape and vegetation history

In the cold phases of the Pleistocene Moravia was located in a non-glaciated corridor between the continental ice sheet spreading over the Polish lowlands in the north and the extensive mountain glacier of the Alps in the south. During the Saale Glaciation (corresponding to the Riss Glaciation of the Alps) the continental ice sheet reached the lowlands along the Odra River in north-eastern Moravia, though the front of the continental ice sheet stopped about 250 km north of Moravia in central Poland during the last glaciation (Vistulian, Würm). Moravia was, therefore, an important biogeographical boundary between cold-suboceanic western Europe and continental eastern Europe.



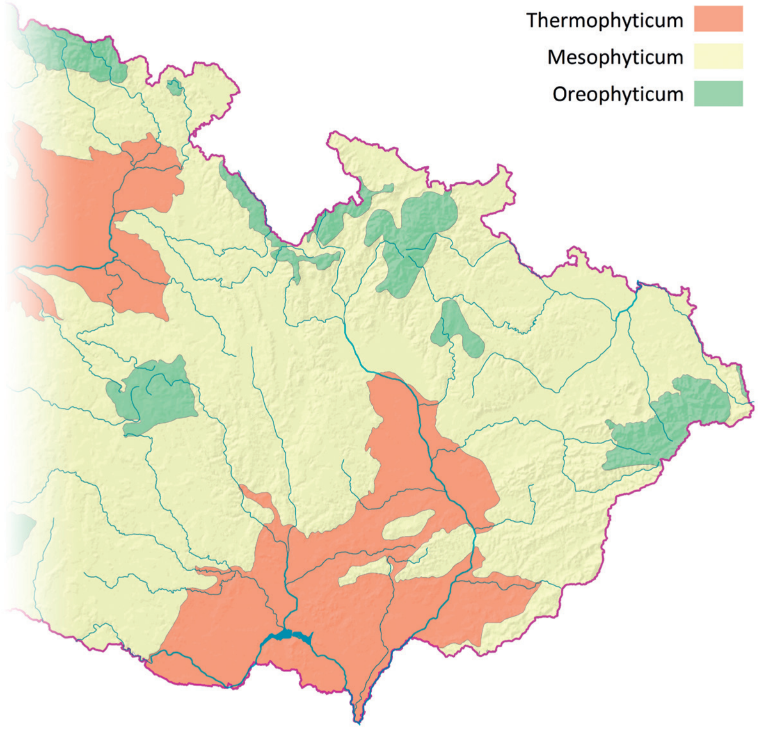
Mean annual precipitation sum of the eastern part of the Czech Republic (data from Tolasz et al. 2007)

Records of fossil molluscs and pollen indicate that the full-glacial landscape of the Moravian lowlands was probably covered by continental steppe-tundra and forest-steppe (Ložek 2001; Rybníčková & Rybníček 2014). It was an important migration corridor for large herbivores, and the camps of Palaeolithic hunter-gatherers were found in southern and central Moravia (Musil 2014). However, large areas in the Carpathian mountain valleys of north-eastern Moravia were probably covered by boreal coniferous forest with *Picea*, *Larix*, *Pinus cembra*, *P. sylvestris* and *Betula* (Jankovská & Pokorný 2008; Kuneš et al. 2008).

Open landscape was gradually forested with the early Holocene climatic amelioration, starting ca. 11.6 cal. ka BP (calendar thousand years before present), first with open forests of *Pinus sylvestris* and *Betula pendula* and later on with closed forests of more demanding broad-leaved trees such as *Acer*, *Fraxinus*, *Quercus*, *Tilia* and *Ulmus*, which created a mid-Holocene landscape mosaic referred to as 'mixed oak forest' (*Quercetum mixtum*) in the palynological literature. *Picea abies* spread at middle and higher altitudes. Although forest became dominant in the landscape, both the mollusc and pollen fossil records indicate that the Moravian lowlands never became completely forested even in the warm and precipitation-rich Holocene climatic optimum (Atlantic, ca. 8–4.5 cal. ka BP; Kuneš et al. 2015). In addition to large herbivores, the open landscape was probably maintained by the Mesolithic people and, since ca. 7.5 cal. ka BP, by Neolithic farmers. The continuity of open landscape supported the survival of many light-demanding species of the Late-glacial steppe and open pine-birch forests. The Moravian lowlands have been continuously settled and used for agriculture since the Neolithic, although the human population density varied, being particularly high in the Bronze Age and Iron Age (ca. 4–2 cal. ka BP) and low in the Roman Period and Migration Period (1st millennium AD). *Carpinus betulus* was the latest tree species, not spreading over the lowlands until the early Subatlantic (ca. 2.5–2 cal. ka BP), probably supported by forest disturbance by humans (Pokorný 2002). Its spread gave rise to the currently widespread oak-hornbeam forests in the Moravian lowlands and upland fringes.

In contrast to the agricultural lowlands, higher altitudes above approximately 450 m in the Bohemian-Moravian Highlands, the Sudetes and the Carpathians had very sparse or no settlements and were covered by submontane and montane forests during most of the Holocene. *Fagus sylvatica* and *Abies alba* expanded in these forests in the Subboreal (ca 4.5–2.5 cal. ka BP), forming mixed spruce-fir-beech forests. These areas were not deforested until the High Medieval colonization which took place mainly in the 13th–14th centuries. Beech wood was extensively used for charcoal production, for which reason the proportion of *Fagus sylvatica* in submontane and montane forests decreased while that of the conifers *Picea abies* and *Abies alba* increased (Nožička 1957). Since the early 19th century, plantations of *Picea abies* and *Pinus sylvestris* have been established throughout Moravia, now being the dominant type of forest, especially in the Bohemian-Moravian Highlands (ÚHÚL 2007).

Alongside forests and arable land, grasslands are another important component of the current landscape in Moravia, in particular dry grasslands at low altitudes in southern Moravia, mesic grasslands at mid-altitudes and in the lowlands of northern Moravia, and wet grasslands at higher altitudes and in the floodplains (Chytrý 2007). Some of the dry grasslands may be of primary origin, being a direct continuation of the Pleistocene steppe, although used by humans for millennia (Kuneš et al. 2015). However, most of the grasslands are secondary, developed at the sites of potential forest from the native pools of light-demanding species and used by humans for livestock grazing or hay making (Hejcman et al. 2013). Some are extremely rich in species, including the meadows in the White Carpathian (*Bílé Karpaty*) Mountains with world-record counts of vascular plant species in a small area (Merunková et al. 2012; Wilson et al. 2012). Unfortunately, following the socio-economic changes after WWII, many of these grasslands were either abandoned or subjected to intensive management, both processes leading to a decline in biodiversity. Most valuable grasslands are currently mown or grazed as part of subsidized nature conservation management.

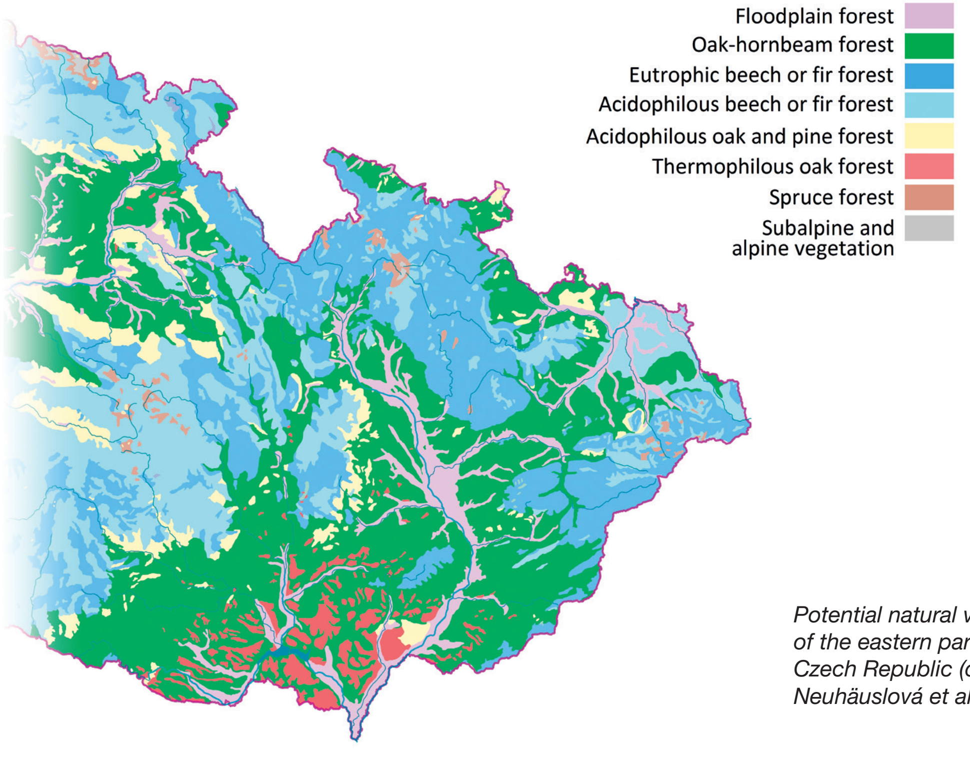


Phytogeographical division of the eastern part of the Czech Republic (based on Skalický 1988)

The main biogeographical patterns in Moravia

The main biogeographical gradient in Moravia is that between the warm and dry lowlands of southern Moravia and the mountain areas in the north-west, north and north-east. This gradient is reflected in the phytogeographical division of the Czech Republic (Skalický 1988; see also Kaplan 2012), which distinguishes the region of thermophilous flora (Thermophyticum) in the lowlands of southern and central Moravia, the region of mesophilous flora (Mesophyticum) in most other parts of Moravia, and the region of mountain flora (Oreophyticum) in the highest mountain areas. The Moravian Thermophyticum is a north-western promontory of the Pannonian Province (a part of the Pontic-South Siberian Region in the phytogeographical division of Meusel et al. 1965) which encompasses the forest-steppe region of Hungary and the adjacent parts of the Pannonian (= Carpathian) Basin. It is characterized by the occurrence of many species of eastern and southern distribution. The boundary of the Pannonian Province with the Bohemian Massif (often referred to as the Hercynian region in biogeography) and the Carpathians is the most important biogeographical boundary in Central Europe, as these mountain areas belong to the Middle European Region (Meusel et al. 1965). Within the Mesophyticum and Oreophyticum, there is a clear biogeographical distinction between the Bohemian Massif and the Western Carpathians, reflecting the different migration histories of these regions. Roughly the same regional patterns as in the phytogeographical division are reflected in the zoogeographical division (Mařan 1958).

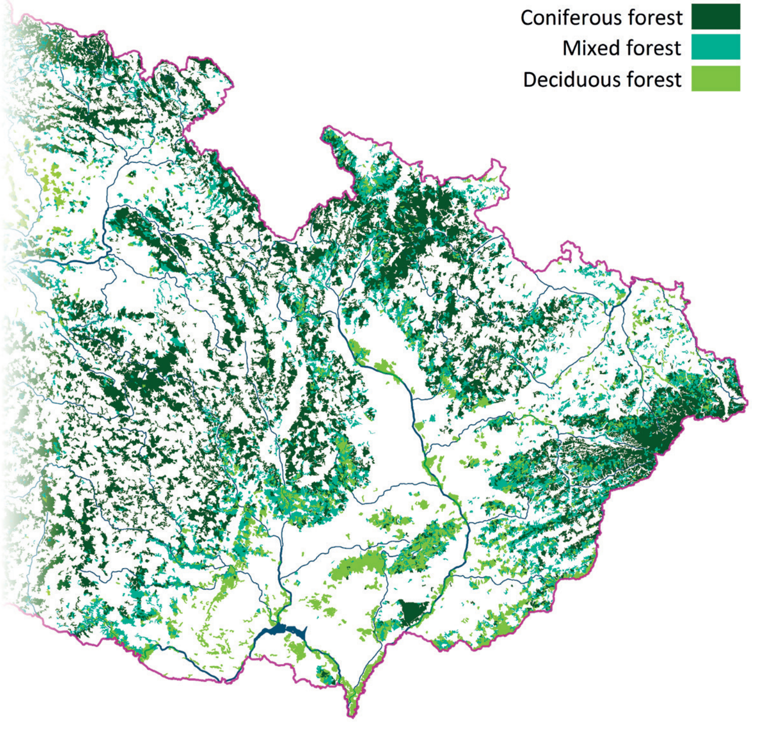
The altitudinal zonation of Moravian vegetation can be described using the vegetation belts proposed by Skalický (1988): (1) The lowland belt at altitudes up to about 220 m is characterized by floodplain forests and meadows, wetlands, sand grasslands and, in fragmenary remnants in southern Moravia, by saline vegetation. (2) The colline belt in dry areas at altitudes up to about 500 m contains thermophilous oak forests, oak-hornbeam forests and steppe grasslands. (3) The supracolline belt occurs at the same altitudes as the colline belt though in areas with a wetter and cooler climate that supports oak-hornbeam, acidophilous oak, fir and beech forests, and mesic, semi-dry and wet grasslands. (4) The submontane belt reaches approximately 800 m a.s.l. and is dominated by fir-beech forests, mesic and wet meadows and pastures. (5) The montane belt at altitudes up to 1100 m is characterized by beech, fir and spruce forests, mesic and wet grasslands, and mires. (6) The supramontane belt is dominated by natural spruce forests which reach approximately 1300 m a.s.l. in the Hrubý Jeseník Mountains, with a maximum at 1405 m. (7) The subalpine belt includes the grassland and heathland areas above the timberline in the Hrubý Jeseník Mountains (1492 m) and on Mount Králický Sněžník (1424 m). Patches of alpine vegetation types occur locally in the Hrubý Jeseník Mountains, though the alpine vegetation is discontinuous here. The distribution of the hypothesized potential natural vegetation within the altitudinal belts is outlined in the map by Neuhäuslová et al. (1997).



Potential natural vegetation of the eastern part of the Czech Republic (data from Neuhäuslová et al. 1997)

Nature conservation

There is one National Park (Podyjí National Park) and eight Protected Landscape Areas (PLA) in Moravia (Mackovčin & Sedláček 1999–2009), the latter being large areas with a less strict conservation regime than that of the National Parks (IUCN category V). Each PLA has its own administration and management office. The following PLAs are described in this volume: *Žďárské vrchy*, *Moravský kras*, *Pálava*, *Bílé Karpaty* and *Jeseníky*. The other three PLAs are *Litovelské Pomoraví*, *Poodří* and *Beskydy* in central and north-eastern Moravia, the first two protecting alluvial ecosystems along the Morava and Odra Rivers, respectively, the last protecting mountain ecosystems of the Moravian-Silesian Beskids. In additon to the National Parks and PLAs, the Czech legislation also recognizes the categories National Nature Reserve, Nature Reserve, National Nature Monument and Nature Monument. The legislative protection of valuable natural areas has a long tradition in this country and many of these territories have been protected for several decades. Many have recently been declared Sites of Community Importance within the European Union Natura 2000 network. There are two UNESCO Biosphere Reserves in Moravia: *Bílé Karpaty* (White Carpathians), overlapping with the PLA of the same name, and *Lower Morava*, including the PLA *Pálava* (with the Pavlov Hills) and adjacent areas, although the protection of a large part of the latter Biosphere Reserve has no legal support in the national legislation.



Forest cover of the eastern part of the Czech Republic (based on the CORINE Land Cover 2000 data set; Bossard et al. 2000)

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1 Žďár Hills

Tomáš Peterka

Introduction

The Žďár Hills (Žďárské vrchy) are located on the border between Bohemia and Moravia in the north-eastern part of the Bohemian-Moravian Highlands between the towns of Hlinsko, Nové Město na Moravě, Polička, Žďár nad Sázavou and Ždírec nad Doubravou, about 50–80 km NW of Brno. The region is characterized by a picturesque cultural landscape with a mosaic of woods, meadows, pastures, small fields, ponds and scattered settlements.

Fen meadows with Dactylorhiza majalis and Eriophorum angustifolium are a valuable habitat in the Žďár Hills. Photo T. Peterka.

Geology, soils, climate and hydrology

The bedrock of the Žďár Hills consists mostly of crystalline rocks of the Proterozoic and Palaeozoic age, i.e. various kinds of gneiss, migmatite, granite, granodiorite and phyllite with small bodies of amphibolite, marble, serpentinite and erlan (Čech et al. 2002). Calcium-rich Cretaceous sandstones and claystones occur locally in a narrow depression in the *Dlouhé meze* area that represents a spur of the geological unit of the Bohemian Cretaceous Basin. The region is characterized by broad and shallow valleys separated by flat crests with gentle slopes. Scattered rock formations and boulder fields occur on the crests, e.g. *Čtyři palice*, *Devět skal*, *Dráteničky*, *Milovské perničky*, *Štarkov* and *Zkamenělý zámek.* The altitude ranges from approximately 500 m to 836 m at the top of Mount *Devět skal*.

The prevailing soil type in the Žďár Hills is cambisol, mostly acidic, with podzol occurring in the highest and precipitation-richest parts of the region. Calcium-rich Cretaceous sediments and marble and serpentinite outcrops are covered by shallow leptosols. Gleysols and histosols develop in places well-saturated with groundwater, with stagnosols (pseudogleys) at intermittently wet sites.

The mean annual temperature is 5 –7 °C and the annual precipitation sum is 650–800 mm over a large part of the area, though it can reach as much as 1100 mm at altitudes above 800 m. The European Continental Divide crosses the region. While the north-western part of the area is drained by the Chrudimka, Doubrava and Sázava Rivers to the Labe (Elbe) River and onwards to the North Sea, the south-eastern part is drained by the Oslava and the Svratka to the Danube and the Black Sea. The gently undulating landscape has proved suitable for fishpond construction. Today, the region has almost two hundred fishponds, of which *Velké Dářko* (205 ha) is the largest.

Landscape history and nature conservation

The site name *Žďár* and its adjective *Žďárské* are derived from the word *žďáření* which means *slash-and-burn*. Arable fields were established in places of cleared forest during the High Medieval colonization of the area in the 13th century. Until then, the region had been covered by primeval forests in the borderland between the Kingdom of Bohemia and the Margraviate of Moravia. In the 15th and 16th centuries large farms, ponds, glassworks and iron works were established here. The higher altitudes were not colonized until the 18th century. By the beginning of the 19th century, the region was one of the most important iron-producing areas in Central Europe and the glass products made in the villages of Herálec and Milovy were known throughout Europe. Since that time most of the remaining natural forests have been clearcut and replaced with plantations of Norway spruce (*Picea abies*). The negative impact of human activity on nature and biodiversity strengthened in the second half of the 20th century when the ‘traditional’ extensive management of the landscape intensified, including systematic draining of wet meadows and excessive use of heavy machinery, fertilizers and other chemicals. In spite of this, the region still harbours many endangered and rare plant species and sites with (semi-)natural habitats, for which reason it was declared a Protected Landscape Area in 1970. There are currently a total of fifty sites (mostly mires, wet meadows, rock formations and remnants of natural forests) protected as National Nature Reserves, Nature Reserves and Nature Monuments.

Vegetation

The Žďár Hills are situated in the submontane and montane vegetation belts. Until its colonization in the 13th century almost the entire area was covered with primeval beech forest of *Fagus sylvatica* with *Abies alba* and *Picea abies* (Rybníčková & Rybníček 1988). Although these forests were largely replaced by spruce plantations in the 19th century, natural forests still occur in the region and their best-preserved stands are protected in reserves. At higher altitudes, the predominant natural vegetation type are montane acidophilous beech forests of the association *Calamagrostio villosae-Fagetum sylvaticae* (alliance *Luzulo-Fagion sylvaticae*), while at lower altitudes, this type of forest is replaced by submontane acidophilous beech forest of the association *Luzulo luzuloidis-Fagetum sylvaticae* (*Luzulo-Fagion sylvaticae*) and herb-rich beech and fir forests (associations *Galio odorati-Fagetum sylvaticae*, *Mercuriali perennis-Fagetum sylvaticae* and *Galio rotundifolii-Abietetum albae*, alliance *Fagion sylvaticae*). Although spruce forests are largely represented by plantations, some spruce stands with a natural canopy structure and species composition are still preserved on wet sites, e.g. the bottoms of broad stream valleys and mire margins, and can be classified as the associations *Calamagrostio villosae-Piceetum abietis*, *Equiseto sylvatici-Piceetum abietis* and *Soldanello montanae-Piceetum abietis* (alliance *Piceion abietis*). Their moss layer is well developed, containing mainly *Sphagnum* and *Polytrichum* species. The ravine forests (associations *Mercuriali perennis-Fraxinetum excelsioris* and *Arunco dioici-Aceretum pseudoplatani*, alliance *Tilio platyphylli-Acerion*), dominated principally by *Acer pseudoplatanus*, *Fraxinus excelsior* and *Ulmus glabra*, develop in places on the steep slopes. Riparian forests with *Alnus glutinosa* (alliance *Alnion incanae*) occur along slow-flowing streams and around forested springs. While the association *Piceo abietis-Alnetum glutinosae* is usually found in the montane belt at altitudes above 700 m, the association *Carici remotae-Fraxinetum excelsioris* is rather typical of the submontane vegetation belt. In the latter community, *Alnus glutinosa* often grows together with *Fraxinus excelsior.* A few outcrops of serpentinite or gneiss are covered by acidophilous forests of *Pinus sylvestris* (association *Vaccinio myrtilli-Pinetum sylvestris*, alliance *Dicrano-Pinion sylvestris*). Mire woodlands of the alliance *Vaccinio uliginosi-Pinion sylvestris*, dominated by *Betula pubescens*, *Pinus sylvestris* and rarely also by the Central European endemic bog pine *Pinus uncinata* subsp. *uliginosa*, have developed locally on peat accumulations.

Minerotrophic mires and mire meadows are one of the most remarkable habitats of the Žďár Hills, represented mainly by moderately rich fens (alliance *Caricion canescenti-nigrae*) and poor fens (alliance *Sphagno-Caricion canescentis*), and in places also by rich fens (alliance *Sphagno warnstorfii-Tomentypnion nitentis*). Communities of extremely rich fens (alliance *Caricion davallianae*) are restricted to the calcium-rich bedrocks of the *Dlouhé meze* area. Although mires were destroyed in many places in the second half of the 20th century, there are still several well-preserved examples of this habitat that harbour endangered species of vascular plants (e.g. *Carex dioica*, *Eleocharis quinqueflora*, *Pedicularis palustris*, *Polygala amarella* and *Trichophorum alpinum*) and bryophytes (e.g. *Hamatocaulis vernicosus* and *Paludella squarrosa*). The bog vegetation of the *Sphagnion magellanici* alliance covers only small patches within fen complexes with the exception of the *Dářko* site. Mires are usually accompanied by willow carrs dominated by *Salix aurita* and occasionally *S. cinerea* (association *Salicetum auritae*, alliance *Salicion cinereae*).

Meadows and pastures are the most common type of secondary treeless vegetation in the Žďár Hills (Balátová-Tuláčková 1980). Wet meadows of the alliance *Calthion palustris* occur most frequently, while mesic meadows of the alliance *Arrhenatherion elatioris* and non-fertilized meadows of the alliance *Molinion caeruleae*, which are wet in spring but dry in summer, are less frequent. The oligotrophic grasslands dominated by *Nardus stricta*, *Festuca filiformis* and *F. rubra* occur on nutrient-poor, acidic, moderately dry and wet soils (associations *Festuco capillatae-Nardetum strictae* and *Campanulo rotundifoliae-Dianthetum deltoidis*, alliance *Violion caninae*). Semi-dry grasslands of the alliance *Bromion erecti* are present only on sunny slopes on the calcareous bedrock of *Dlouhé meze*. Rock outcrops are occupied by heathlands with *Vaccinium myrtillus* and *V. vitis-idaea* (association *Calamagrostio arundinaceae-Vaccinietum myrtilli*, alliance *Genisto pilosae-Vaccinion*).

The structure and functioning of semi-natural submontane grasslands in the Žďár Hills were studied within the Kameničky project, part of the UNESCO Man and Biosphere Programme, by the team of plant ecologists from the Institute of Botany of the then Czechoslovak Academy of Sciences in Brno, led by Professor Milena Rychnovská, in 1975–1985. During this interdisciplinary research, the grassland ecosystems were explored with respect to edaphic factors, soil fertility, water budget, the nitrogen and carbon cycle, productivity, the population structure of stands and the interactions of plants with other organisms (Rychnovská et al. 1993). Experimental plots were situated near the field station in the village of Kameničky in the north-central part of the Žďár Hills.

Littoral zones of ponds and other water bodies are covered by communities of tall sedges or large perennial grasses such as *Carex rostrata* and *Calamagrostis canescens* (alliance *Magno-Caricion elatae*) in oligotrophic to mesotrophic water bodies, whereas *Carex acuta* or *Phalaris arundinacea* (alliance *Magno-Caricion gracilis*) and *Equisetum fluviatile*, *Phragmites australis* or *Typha latifolia* (alliance *Phragmition australis*) prevail in mesotrophic to eutrophic habitats. The aquatic vegetation of the fishponds is mostly composed of *Lemna minor*, *Persicaria amphibia* and *Utricularia australis*. Some endangered or vulnerable aquatic plants (e.g. *Callitriche hermaphroditica*, *Potamogeton alpinus*, *Sparganium natans* and *Utricularia minor*) were also recorded within the region. Vegetation of low-growing annual to perennial graminoids and dicots can occur on exposed pond bottoms. The typical species of this habitat include *Carex bohemica*, *Coleanthus subtilis*, *Elatine hydropiper*, *Eleocharis acicularis*, *E. ovata*, *Juncus bulbosus*, *Limosella aquatica*, *Rumex maritimus* and (rarely) *Elatine triandra*, *Spergularia echinosperma* and *Tillaea aquatica*.

Flora

The first floristic records from the Žďár Hills were published in monographic flora works by the Czech botanist Ladislav Čelakovský in the 1860s–1880s. Knowledge of local flora was further improved by the regional botanists Filip Kovář, Petr Havelka and Miroslav Servít at the turn of the 20th century (Smejkal 1958). Later, prominent Czech botanists Josef Podpěra, Karel Domin, Jan Šmarda and Emil Hadač visited the area and published their records of vascular plants and bryophytes. In the second half of the 20th century, the flora of the Žďár Hills was investigated principally by Miroslav Smejkal, Ivan Růžička, Vladimír Zabloudil and Petr Bureš.

The flora of the Žďár Hills comprises approximately a thousand species of vascular plants (Bureš & Smejkal 1990). The occurrence of montane element is in marked contrast to adjacent areas, with species such as *Blechnum spicant*, *Cicerbita alpina*, *Diphasiastrum tristachyum*, *Epilobium nutans* (now probably extinct), *Huperzia selago*, *Salix silesiaca*, *Streptopus amplexifolius* and *Thelypteris limbosperma* (Bureš 1990). Another species group includes montane plants that occur frequently in the

Žďár Hills and that are also found in adjacent areas (e.g. *Circaea alpina*, *Cirsium heterophyllum*, *Dryopteris dilatata*, *Lycopodium annotinum*, *Petasites albus*, *Polygonatum verticillatum*, *Rosa pendulina*, *Scorzonera humilis* and *Thalictrum aquilegiifolium*). Taxa with a sub-Atlantic distribution range are represented by *Hypericum humifusum*, *Juncus bulbosus*, *J. squarrosus*, *Lotus pedunculatus*, *Montia fontana* agg., *Pedicularis sylvatica* and *Taraxacum nordstedtii*. Several species are on the eastern limit of their distribution range in the region, such as *Carex pulicaris*, *Chrysosplenium oppositifolium* and *Lathyrus linifolius* (Bureš & Ženíšková 1996; Bureš & Řepka 1991). *Cardamine trifolia*, *Soldanella montana* and *Willemetia stipitata* are examples of the Alpic element.

An important group in the flora of the Žďár Hills is made up of plants that are widespread in the boreal zone of Europe and scattered in Central Europe. These species were much more frequent in Central Europe during the Late Glacial and early Holocene and are considered relicts from these periods. Most of them are confined to mires or coniferous forests, e.g. *Andromeda polifolia*, *Carex chordorrhiza*, *C. dioica*, *C. lasiocarpa*, *C. pauciflora* (now missing), *Dryopteris cristata*, *Eriophorum gracile*, *E. vaginatum*, *Stellaria longifolia*, *Trichophorum alpinum*, *Trientalis europaea*, *Vaccinium oxycoccos* and *V. uliginosum*. The mosses *Calliergon giganteum*, *Meesia triquetra*, *Paludella squarrosa* and *Scorpidium scorpioides*, specialists of mineral-rich fens, also belong to this group (Rybníček 1966).

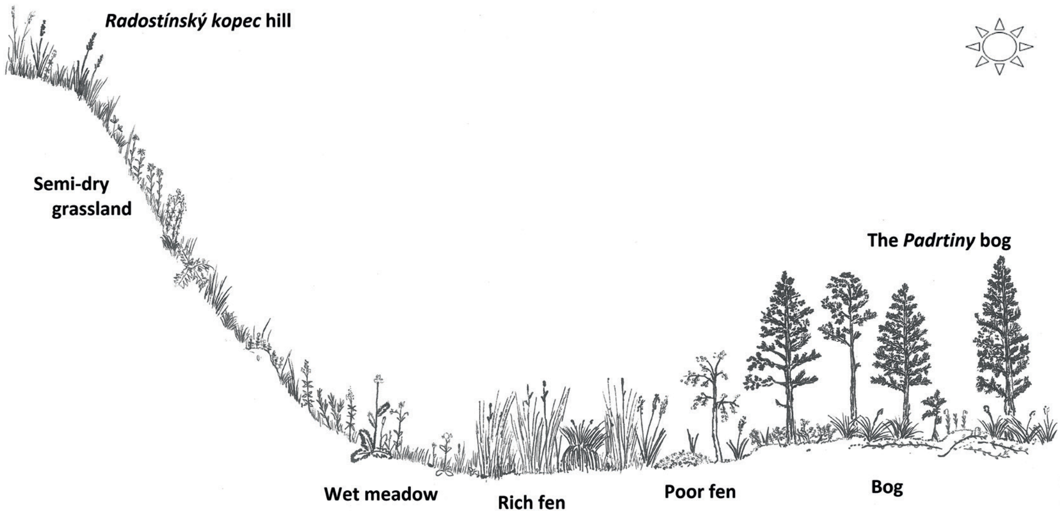
The flora of the region also contains several taxa endemic to Central Europe and subendemic to the Czech Republic, namely *Gentianella praecox* subsp. *bohemica*, *Knautia arvensis* subsp. *serpentinicola* and *Pinus uncinata* subsp. *uliginosa* (Růžička 1999).

The Žďár Hills with excursion sites and the boundary of the Žďárské vrchy *Protected Landscape Area (green dashed line). All the maps used in the descriptions of excursion sites are taken from the server Mapy.cz.*

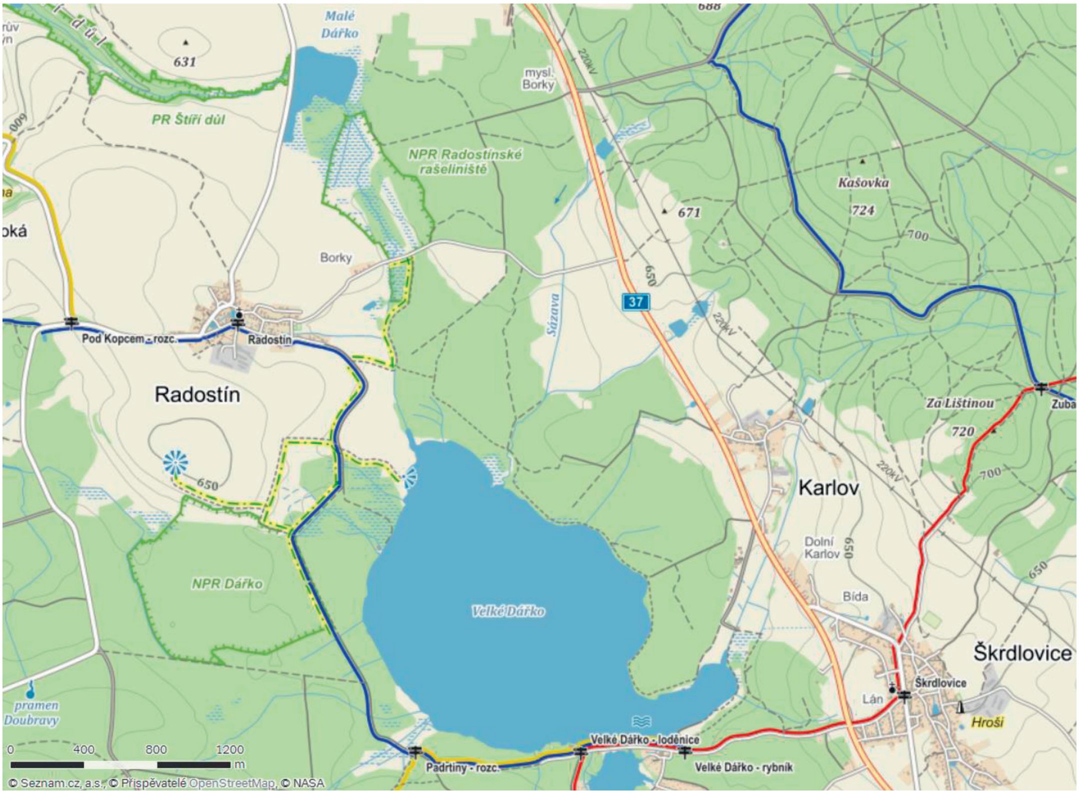
(1a) *Dářko* National Nature Reserve

This site, situated 1–1.8 km south of the village of Radostín and 0.5–1 km west of the Velké Dářko fishpond at altitudes of 620–653 m, features contrasting natural phenomena that have been protected in a nature reserve since 1933. The bedrock is composed of Cretaceous calcareous sandstones and claystones which form the hill *Radostínský kopec* (653 m), a dominant feature of the local landscape.

A large fen complex was formed in the flat terrain below the hill by the terrestrialization of a shallow lake in the early Holocene (Čech et al. 2002). The older sediments of minerotrophic (ground-water fed) fen were gradually covered by bog peat of a depth of up to 8–9 m during the wet Atlantic period (Břízová 2009). The bog, known as *Padrtiny*, is the largest mire complex in the Bohemian-Moravian Highlands, covering an area of about 150 ha.



The schematic vegetation transect of the northern part of the Dářko site. Orig. T. Peterka.



Dářko National Nature Reserve west of the Velké Dářko fishpond.

The *Padrtiny* site is covered by pine bog woodlands (association *Ledo palustris-Pinetum uncinatae*, alliance *Sphagnion magellanici*). A sparse tree layer is composed mainly of *Pinus uncinata* subsp. *uliginosa* (syn. *P. rotundata*), *P. sylvestris* and their hybrid *P.* ×*rhaetica* nothosubsp. *digenea. P. uncinata* subsp. *uliginosa* is an endemic taxon of Central Europe, distributed mainly in the mountain areas of the Czech Republic (Krušné Mountains, Smrčiny, Český les, Slavkovský les, Šumava, Ždár Hills and Hrubý Jeseník Mountains) and the Třeboň Basin of South Bohemia, and extending slightly beyond the borders of the country (by less than 25–30 km) into Germany (Saxony and Bavaria), northern Austria and south-western Poland (Businský 2009). Only about thirty populations of *P. uncinata* subsp. *uliginosa* are known within the whole distribution range. The species-poor herb layer of the wooded bog is formed of tussocks of *Eriophorum vaginatum* and dwarf shrubs (*Andromeda polifolia*, *Vaccinium myrtillus*, *V. oxycoccos* and *V. uliginosum*). The moss layer contains predominantly *Sphagnum* species including *S. angustifolium*, *S. fallax*, *S. magellanicum*, *S. rubellum* and *S. russowii*, accompanied by *Aulacomnium palustre*, *Polytrichum commune*, *P. strictum* and *Straminergon stramineum*. Treeless patches are covered by stands of *Eriophorum vaginatum* and *Sphagnum fallax* (association *Eriophoro vaginati-Sphagnetum recurvi*, alliance *Sphagnion magellanici*). Towards the bog margins, the wooded bog vegetation of *Sphagnion magellanici* is replaced by peatland forest vegetation with a higher representation of *Calluna vulgaris*, *Vaccinium vitis-idaea* and *Pleurozium schreberi* and a lower cover of Sphagna (associations *Vaccinio uliginosi-Pinetum sylvestris* and *Vaccinio-Pinetum montanae* of the alliance *Vaccinio uliginosi-Pinion sylvestris*). The dominant tree species are *Pinus sylvestris* and *P. uncinata* subsp. *uliginosa*, accompanied by birches (*Betula pendula* and *B. pubescens*) and spruce (*Picea abies*). Pure birch forests are found on wetter sites in the lagg zone (association *Vaccinio uliginosi-Betuletum pubescentis*, alliance *Vaccinio uliginosi-Pinion sylvestris*).

Forested peat bog at the Padrtiny site in the Dářko National Nature Reserve. Pinus sylvestris with reddish bark on the left and the Central European endemic Pinus uncinata subsp. uliginosa with dark bark and conic crown on the right. Photo J. Juřička.

Fen vegetation occurs in a narrow belt on the northern margin of *Padrtiny* directly below the hill *Radostínský kopec*. Rich fens are represented by the association *Menyantho trifoliatae-Sphagnetum teretis* (alliance *Sphagno warnstorfii-Tomentypnion nitentis*), dominated here by the tall sedge *Carex lasiocarpa*. Like other rich-fen communities, this vegetation type contains calcium-tolerant *Sphagnum* species (*S. contortum*, *S. teres* and *S. warnstorfii*) and 'brown mosses', i.e. non-sphagnaceous weft-forming bryophytes such as *Campylium stellatum* and *Tomentypnum nitens*. This association is further characterized by species of boreal distribution, including *Carex chordorrhiza*, a critically endangered plant species growing here on one of about ten current localities in the Czech Republic. Poor acidic fens (associations *Sphagno recurvi-Caricetum rostratae* and *Polytricho communis-Molinietum caeruleae*, alliance *Sphagno-Caricion canescentis*) also occur here, dominated by *Polytrichum commune* or *Sphagnum fallax* and lacking species that require higher concentrations of minerals (e.g. *Parnassia palustris* and *Valeriana dioica*) as well as species of ombrotrophic mires (e.g. *Andromeda polifolia* and *Eriophorum vaginatum*).

The south-facing slopes of *Radostínský kopec* are covered by semi-dry grasslands (association *Carlino acaulis-Brometum erecti*, alliance *Bromion erecti*) and mesic grasslands (association *Ranunculo bulbosi-Arrhenatheretum elatioris*, alliance *Arrhenatherion elatioris*), including *Arrhenatherum elatius*, *Bromus erectus*, *Carex flacca*, *Carlina acaulis*, *Centaurea scabiosa*, *Cirsium acaulon* (now probably replaced by the hybrid *C. acaulon* × *C. oleraceum*; Bureš et al. 2000), *Galium album*, *Inula salicina*, *Knautia arvensis* agg., *Pimpinella saxifraga*, *Trifolium montanum* and *Trisetum flavescens*. Such contact between a base-rich semi-dry grassland with a bog is extremely unusual in Central Europe. A fine-scale mosaic of wet and intermittently wet meadows (alliances *Calthion palustris* and *Molinion caeruleae*) has developed on the boundary between the hillside grasslands and the mires at the foothill. The species-rich herb layer contains a number of herbs (e.g. *Cardamine pratensis*, *Cirsium rivulare*, *Galium boreale*, *G. uliginosum*, *Lychnis flos-cuculi*, *Ranunculus acris*, *R. auricomus* agg., *Succisa pratensis* and *Valeriana dioica*) and graminoids (e.g. *Anthoxanthum odoratum*, *Avenula pubescens*, *Briza media*, *Carex nigra*, *C. pallescens*, *C. panicea*, *Deschampsia cespitosa*, *Festuca rubra* and *Molinia caerulea* agg.).

The grasslands and fens were formerly regularly mown for hay, but some competitively strong grasses (*Calamagrostis epigejos* and *Molinia caerulea* agg.) have expanded in some places following abandonment in the 20th century. Today, the most valuable communities are mown once a year.

The mires of *Padrtiny* and its surroundings were investigated by Jaromír Klika and Jan Šmarda (Klika & Šmarda 1944) in the 1940s and thereafter by Kamil Rybníček (Rybníček 1964). In the 1970s, Robert Neuhäusl conducted a detailed study of the vegetation-environment relationships at this site, including extensive measurements of evapotranspiration, soil temperature and moisture, soil and groundwater chemistry and other variables (Neuhäusl 1975).

Appendix 1a Selected species of vascular plants and bryophytes in the *Dářko* National Nature Reserve. In all Appendices alien species (neophytes) are indicated by '(neo)'.

Vascular plants in the Padrtiny pine bog
Alnus glutinosa
Alnus incana
Andromeda polifolia
Athyrium filix-femina
Avenella flexuosa
Betula pendula
Betula pubescens
Calamagrostis villosa
Calluna vulgaris
Carex canescens
Carex nigra
Carex pauciflora (probably extinct)
Carex pilulifera
Carex rostrata
Deschampsia cespitosa
Drosera rotundifolia
Dryopteris carthusiana
Dryopteris dilatata
Dryopteris filix-mas
Equisetum sylvaticum
Eriophorum angustifolium
Eriophorum vaginatum
Frangula alnus
Maianthemum bifolium
Melampyrum pratense
Molinia caerulea agg.
Picea abies
Pinus ×*rhaetica* nothosubsp. *digenea* (*P. sylvestris* × *P. uncinata* subsp. *uliginosa*)
Pinus sylvestris
Pinus uncinata subsp. *uliginosa* (= *P. rotundata*)
Salix aurita
Senecio nemorensis agg.
Sorbus aucuparia
Stellaria longifolia
Trientalis europaea
Vaccinium myrtillus
Vaccinium oxycoccos
Vaccinium uliginosum
Vaccinium vitis-idaea
Viola palustris

Bryophytes in the Padrtiny pine bog
Atrichum undulatum
Aulacomnium palustre
Bazzania trilobata
Calypogeia azurea
Calypogeia integristipula
Calypogeia neesiana
Cephalozia bicuspidata
Cephalozia catenulata
Cephalozia connivens
Cephaloziella elachista
Chiloscyphus cuspidatus
Chiloscyphus profundus
Dicranella heteromalla
Dicranodontium denudatum
Dicranum montanum
Dicranum polysetum
Dicranum scoparium
Herzogiella seligeri
Hylocomium splendens
Hypnum cupressiforme
Lepidozia reptans
Leucobryum glaucum
Mylia anomala
Odontoschisma denudatum
Orthodontium lineare
Plagiothecium curvifolium

Plagiothecium denticulatum
Pleurozium schreberi
Pohlia nutans
Polytrichum commune
Polytrichum formosum
Polytrichum strictum
Ptilidium ciliare
Sanionia uncinata
Sciuro-hypnum curtum
Sphagnum angustifolium
Sphagnum capillifolium
Sphagnum fallax
Sphagnum fimbriatum
Sphagnum flexuosum
Sphagnum girgensohnii
Sphagnum magellanicum
Sphagnum palustre
Sphagnum papillosum
Sphagnum rubellum
Sphagnum russowii
Straminergon stramineum
Tetraphis pellucida
Warnstorfia fluitans

Vascular plants of mires and grasslands between the *Padrtiny* bog and the hill *Radostínský kopec*

Achillea millefolium
Agrostis canina
Agrostis capillaris
Alchemilla spp.
Alopecurus pratensis
Anthoxanthum odoratum
Arrhenatherum elatius
Avenula pubescens
Betula pendula
Betula pubescens
Bistorta officinalis
Briza media
Bromus erectus
Calamagrostis epigejos
Campanula patula
Campanula rapunculoides
Campanula rotundifolia
Cardamine pratensis agg.
Carex ×alsatica (*C. demissa × C. flava*)
Carex appropinquata
Carex canescens
Carex cespitosa
Carex chordorrhiza
Carex demissa
Carex dioica
Carex echinata
Carex flacca
Carex flava
Carex hartmanii
Carex lasiocarpa
Carex nigra
Carex pallescens
Carex panicea
Carex pilulifera
Carex rostrata
Carlina acaulis
Carum carvi
Centaurea jacea
Centaurea scabiosa
Cerastium holosteoides
Cirsium acaulon (probably extinct)
Cirsium palustre
Cirsium rivulare
Comarum palustre
Crataegus sp.
Cynosurus cristatus
Dactylis glomerata
Dactylorhiza majalis
Deschampsia cespitosa
Dianthus deltoides
Epilobium angustifolium
Epilobium palustre
Equisetum fluviatile
Equisetum palustre
Equisetum sylvaticum
Eriophorum angustifolium
Eriophorum vaginatum
Festuca ovina
Festuca rubra
Frangula alnus
Galium album
Galium boreale
Galium palustre agg.
Galium pumilum
Galium uliginosum
Galium verum
Gentianella praecox subsp. *bohemica*
Geum rivale
Gymnadenia conopsea
Hypericum maculatum
Inula salicina
Juncus alpinoarticulatus
Juncus articulatus
Juncus bulbosus
Juncus conglomeratus
Juncus effusus
Juncus filiformis
Knautia arvensis agg.
Lathyrus pratensis
Leontodon hispidus
Leucanthemum vulgare agg.
Linum catharticum
Lotus corniculatus
Luzula campestris
Luzula multiflora
Lychnis flos-cuculi
Lysimachia vulgaris
Mentha arvensis
Molinia caerulea agg.
Myosotis nemorosa
Nardus stricta
Orchis purpurea (extinct)
Orchis ustulata (extinct)
Parnassia palustris
Pedicularis palustris (probably extinct)
Pedicularis sylvatica
Peucedanum palustre
Phleum pratense
Picea abies
Pilosella lactucella
Pilosella officinarum
Pimpinella major
Pimpinella saxifraga
Plantago lanceolata
Plantago major
Plantago media
Poa humilis
Poa pratensis
Poa trivialis
Polygala vulgaris
Potentilla erecta
Primula elatior
Ranunculus acris
Ranunculus auricomus agg.
Ranunculus bulbosus
Ranunculus flammula
Ranunculus repens
Rhinanthus minor
Rosa canina agg.
Rumex acetosa
Salix aurita
Salix caprea
Salix pentandra
Salix rosmarinifolia
Salvia verticillata
Sanguisorba minor
Scorzonera humilis
Scorzoneroides autumnalis
Succisa pratensis
Taraxacum sect. *Palustria*
Taraxacum sect. *Taraxacum*
Tephroseris crispa
Thymus pulegioides
Trichophorum alpinum (probably extinct)
Trifolium dubium
Trifolium montanum
Trifolium pratense
Trifolium repens
Trisetum flavescens
Urtica dioica
Utricularia minor (probably extinct)
Vaccinium myrtillus
Vaccinium oxycoccos
Vaccinium uliginosum
Vaccinium vitis-idaea
Valeriana dioica
Veronica chamaedrys

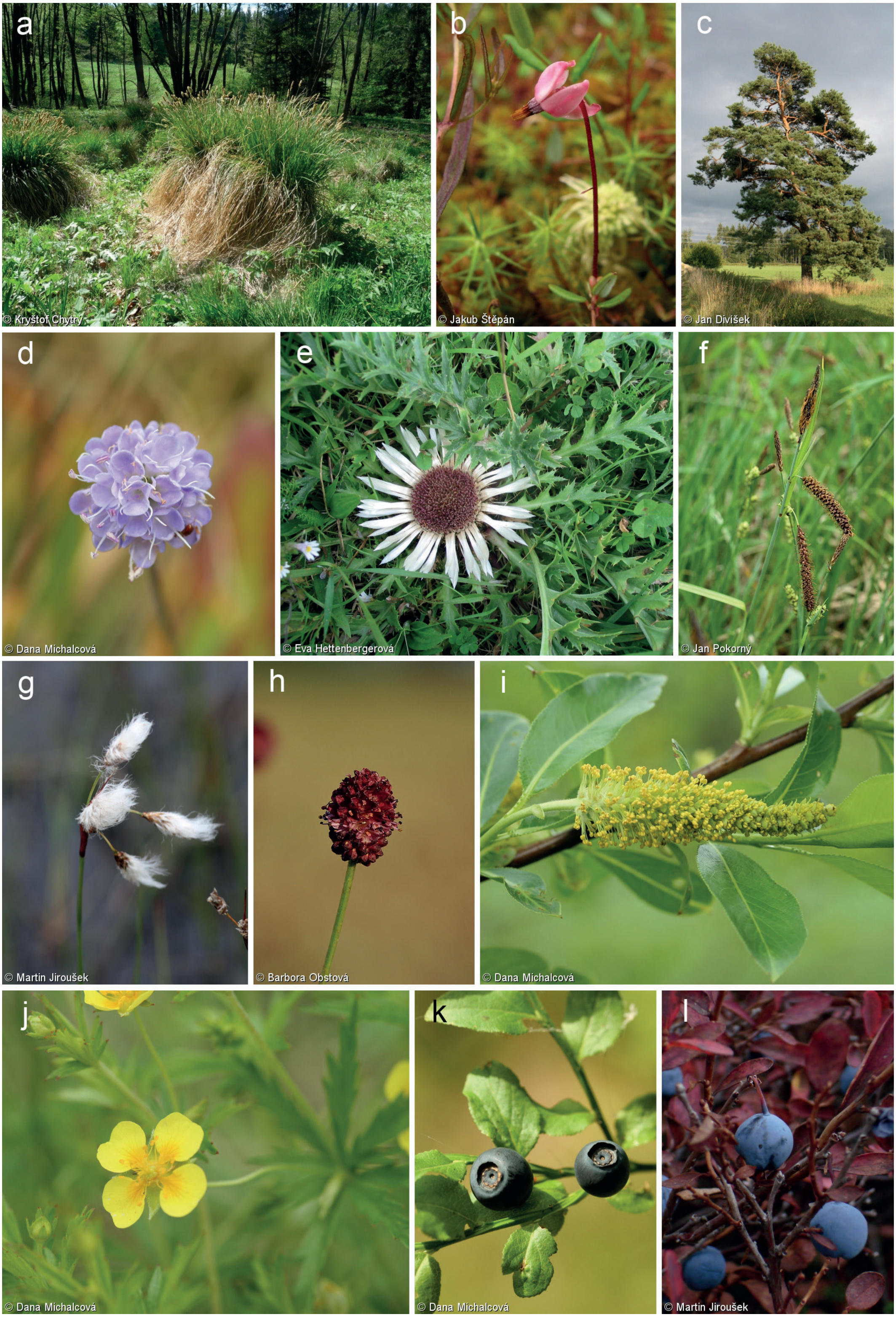


Plate 1a Plants of the *Dářko* National Nature Reserve in the Žďár Hills: (a) *Carex appropinquata*, (b) *Vaccinium oxycoccos*, (c) *Pinus sylvestris*, (d) *Succisa pratensis*, (e) *Carlina acaulis*, (f) *Carex flacca*, (g) *Eriophorum angustifolium*, (h) *Sanguisorba officinalis*, (i) *Salix pentandra*, (j) *Potentilla erecta*, (k) *Vaccinium myrtillus*, (l) *Vaccinium uliginosum*.

Veronica scutellata
Vicia cracca
Viola canina
Viola palustris

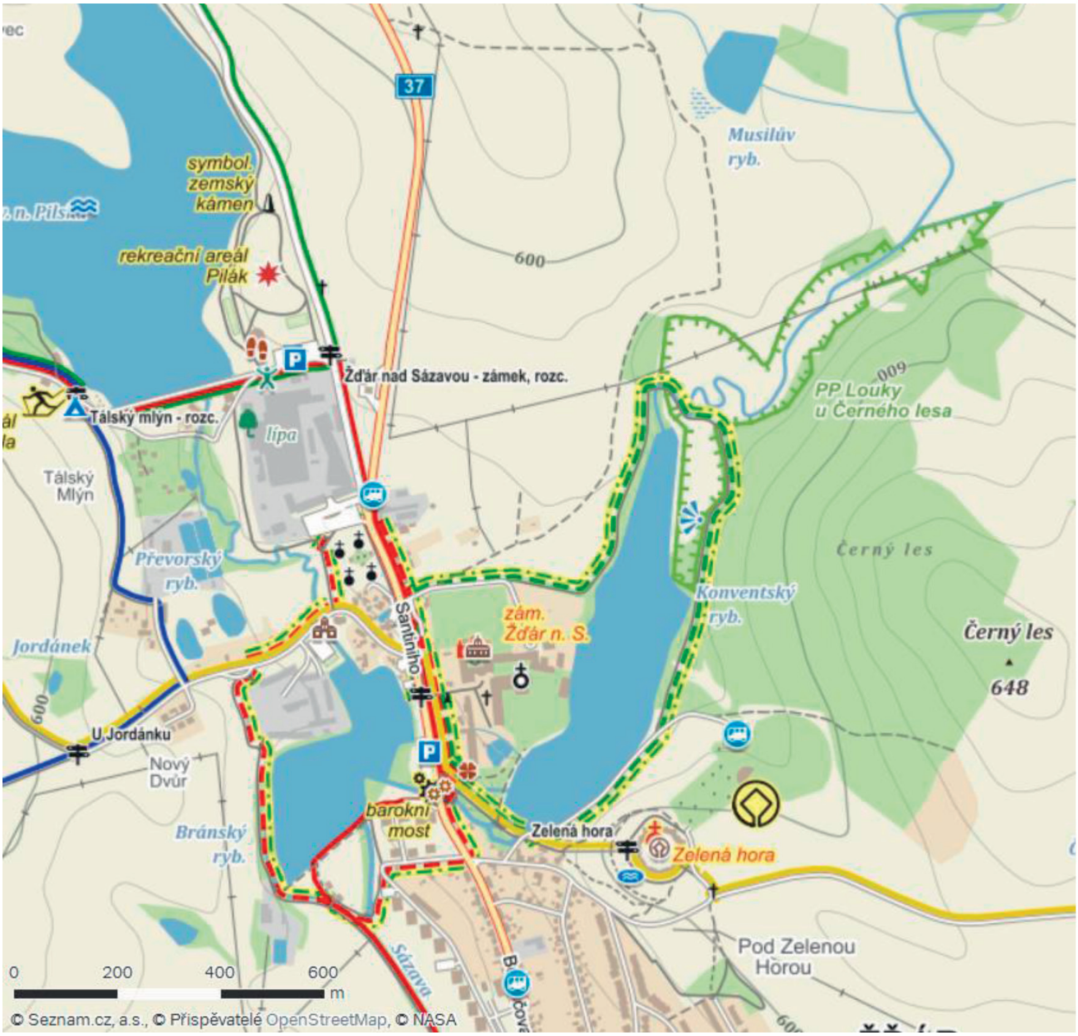
Bryophytes of mires and grasslands between the *Padrtiny* bog and the hill *Radostínský kopec*
Aneura pinguis
Atrichum undulatum
Aulacomnium palustre
Breidleria pratensis
Bryum pseudotriquetrum
Calliergon cordifolium
Calliergonella cuspidata
Campylium stellatum
Climacium dendroides
Dicranum bonjeanii
Fissidens adianthoides
Plagiomnium elatum
Plagiothecium denticulatum
Pleurozium schreberi
Pohlia nutans
Polytrichum commune
Pseudocampylium radicale
Rhytidiadelphus squarrosus
Rhytidiadelphus triquetrus
Sarmentypnum exannulatum
Scorpidium cossonii
Scorpidium scorpioides (extinct)
Sphagnum contortum
Sphagnum fallax
Sphagnum flexuosum
Sphagnum palustre
Sphagnum papillosum
Sphagnum teres
Sphagnum warnstorfii
Straminergon stramineum
Thuidium assimile
Thuidium recognitum
Tomentypnum nitens

(1b) *Louky u Černého lesa* Nature Monument

The locality is situated at the fishpond *Konventský rybník* north of the town of Žďár nad Sázavou in the valley of the stream *Stržský potok*. The Nature Monument was established in 1988 on an area of 10.6 ha at altitudes of 570–580 m. The locality is also listed as a Site of Community Importance within the Natura 2000 network due to the occurrence of the moss *Hamatocaulis vernicosus*. The bedrock is composed of gneiss with intercalated amphibolites (Čech et al. 2002).

Fen meadows in the Louky u Černého lesa Nature Monument. Photo T. Peterka.

The locality is a good example of the minerotrophic mire and mire meadow of the Žďár Hills. The mire vegetation here includes mainly rich fens (association *Menyantho trifoliatae-Sphagnetum teretis*, alliance *Sphagno warnstorfii-Tomentypnion nitentis*) dominated by the tall sedge *Carex lasiocarpa* with an admixture of *C. rostrata* and less frequently *C. diandra*. The lower herb layer is composed of *Eriophorum angustifolium*, short sedges (*Carex dioica*, *C. nigra* and *C. panicea*) and hygrophilous dicot herbs (*Menyanthes trifoliata*, *Valeriana dioica* and *Viola palustris*). The species-rich moss layer contains calcium-tolerant peat mosses (e.g. yellow-brown *Sphagnum contortum*, brown-green *S. teres* and red *S. warnstorfii*) and pleurocarpous mosses of the *Amblystegiaceae* family (*Breidleria pratensis*, *Campylium stellatum*, *Scorpidium cossonii*, *Tomentypnum nitens* and occasionally *Hamatocaulis vernicosus*). Small populations of the rare relict mosses *Meesia triquetra* and *Paludella squarrosa*



Louky u Černého lesa Nature Monument and the Pilgrimage Church of St. John of Nepomuk on the hill Zelená hora (UNESCO World Heritage Site) on the northern edge of the town of Žďár nad Sázavou.

(with a total of 4 and 14 extant occurrences, respectively, in the Czech Republic) are present at this site (Novotný & Kubešová 2003). These circumpolar boreo-arctic species, confined to well-preserved rich fens, are endangered and declining in Central Europe.

Rich fens are locally replaced by moderately rich fens (alliance *Caricion canescenti-nigrae*), poor fens (alliance *Sphagno-Caricion canescentis*) and wet meadows (alliance *Calthion palustris*). The latter contain more nutrient-demanding dicot herbs or graminoids, such as *Bistorta officinalis*, *Caltha palustris*, *Cardamine pratensis* agg., *Cirsium oleraceum*, *Filipendula ulmaria*, *Holcus lanatus*, *Lychnis flos-cuculi*, *Mentha arvensis*, *Ranunculus acris*, *R. auricomus* agg. and *Scirpus sylvaticus*. The permanently waterlogged depressions are covered by *Carex rostrata* without Sphagna (association *Equiseto fluviatilis-Caricetum rostratae*, alliance *Magno-Caricion elatae*). Mires and wet meadows are surrounded by scattered willow carrs of *Salix aurita* and *S. cinerea* (association *Salicetum auritae*, alliance *Salicion cinereae*). The reserve also comprises low scrub of *Salix rosmarinifolia.* The meandering stream is fringed by galleries of *Alnus glutinosa* (alliance *Alnion incanae*) and *Salix euxina* (association *Salicetum fragilis*, alliance *Salicion albae*). The pond bank is covered by monodominant stands of *Phalaris arundinacea* (association *Phalaridetum arundinaceae*, alliance *Magno-Caricion gracilis*) and, locally, also *Calamagrostis canescens* (association *Carici elatae-Calamagrostietum canescentis*, alliance *Magno-Caricion elatae*). Monodominant stands of *Phragmites australis* (association *Phragmitetum australis*, alliance *Phragmition australis*) are found along the stream.

The mire meadow has been mown by nature conservationists once a year to prevent successional changes such as the expansion of trees, shrubs and tall graminoids or dicots, e.g. *Filipendula ulmaria*, *Phalaris arundinacea* and *Phragmites australis*.

The Pilgrimage Church of St. John of Nepomuk (UNESCO World Heritage Site) is situated on the hill *Zelená hora* close to the site. The monks of the Cistercian order in Žďár nad Sázavou dedicated this church to the Czech martyr John of Nepomuk and began the project before his beatification (Kotrba 1976). The church, built in 1719–1722, is a masterpiece by Jan Blažej Santini Aichl, a Czech architect of Italian descent. It combines elements of Baroque and Gothic architecture which was typical of the period of Re-Catholicization in the Czech Lands. The church is built on a ground plan of a five-pointed star and is surrounded by a cloister in the form of a ten-pointed star.

Appendix 1b Selected species of vascular plants and bryophytes in the *Louky u Černého lesa* Nature Monument.

Vascular plants
Abies alba
Acer platanoides
Acer pseudoplatanus
Aconitum lycoctonum
Aegopodium podagraria
Agrostis canina
Alnus glutinosa
Alopecurus pratensis
Anemone nemorosa
Angelica sylvestris
Anthoxanthum odoratum
Athyrium filix-femina
Avenella flexuosa
Betula pendula
Bistorta officinalis
Briza media
Calamagrostis canescens
Calamagrostis epigejos
Calla palustris
Caltha palustris
Calystegia sepium
Cardamine amara
Cardamine pratensis agg.
Carex canescens
Carex diandra
Carex dioica
Carex echinata
Carex elongata
Carex lasiocarpa
Carex nigra
Carex panicea
Carex rostrata
Carex vesicaria
Cirsium oleraceum
Cirsium palustre
Comarum palustre
Crepis paludosa
Dactylorhiza majalis
Deschampsia cespitosa
Dryopteris carthusiana
Epilobium palustre
Equisetum arvense
Equisetum fluviatile
Equisetum sylvaticum
Eriophorum angustifolium
Festuca rubra
Ficaria verna subsp. *verna*
Filipendula ulmaria
Frangula alnus
Galium palustre agg.
Galium uliginosum
Geum rivale
Glyceria fluitans
Holcus lanatus
Holcus mollis
Hypericum maculatum
Impatiens noli-tangere
Juncus articulatus
Juncus conglomeratus
Juncus effusus
Juncus filiformis
Lathyrus pratensis
Lemna minor
Lonicera nigra
Lotus corniculatus
Lotus pedunculatus
Luzula multiflora
Luzula sudetica
Lychnis flos-cuculi
Lycopus europaeus
Lysimachia nummularia
Lysimachia thyrsiflora
Lysimachia vulgaris
Lythrum salicaria
Maianthemum bifolium
Mentha aquatica
Mentha arvensis
Menyanthes trifoliata
Myosotis nemorosa
Myosoton aquaticum
Parnassia palustris
Pedicularis sylvatica
Persicaria maculosa
Peucedanum palustre
Phalaris arundinacea
Phragmites australis
Picea abies
Poa annua
Populus tremula
Potentilla erecta
Primula elatior
Prunella vulgaris
Prunus avium
Prunus padus
Quercus robur
Ranunculus acris
Ranunculus auricomus agg.
Ranunculus flammula
Ranunculus repens
Rubus idaeus
Rubus ser. *Glandulosi*
Rumex acetosa
Rumex aquaticus
Rumex obtusifolius
Salix aurita
Salix cinerea
Salix euxina (= *S. fragilis*)
Salix pentandra
Salix rosmarinifolia
Salix triandra
Sanguisorba officinalis
Scirpus sylvaticus
Scutellaria galericulata
Sorbus aucuparia
Stachys sylvatica
Stellaria graminea
Succisa pratensis
Typha latifolia
Urtica dioica
Utricularia australis
Vaccinium myrtillus
Vaccinium vitis-idaea
Valeriana dioica
Veronica scutellata
Viola palustris

Bryophytes
Aulacomnium palustre
Brachythecium mildeanum
Brachythecium rivulare
Breidleria pratensis
Bryum pseudotriquetrum
Calliergon cordifolium
Calliergon giganteum
Calliergonella cuspidata
Campylium stellatum
Cirriphyllum piliferum
Climacium dendroides

Plate 1b Plants of the *Louky u Černého lesa* Nature Monument in the Žďár Hills: (a) *Lysimachia vulgaris*, (b) *Carex rostrata*, (c) *Cirsium palustre*, (d) *Salix cinerea*, (e) *Menyanthes trifoliata*, (f) *Filipendula ulmaria*, (g) *Viola palustris*, (h) *Alnus glutinosa*, (i) *Comarum palustre*, (j) *Lychnis flos-cuculi*, (k) *Cirsium oleraceum*, (l) *Juncus effusus*.

Drepanocladus polygamus
Hamatocaulis vernicosus
Hypnum cupressiforme
Marchantia polymorpha
Meesia triquetra
Paludella squarrosa
Philonotis caespitosa
Plagiomnium elatum
Plagiomnium undulatum
Polytrichum commune
Polytrichum formosum
Pseudobryum cinclidioides
Pseudocampylium radicale
Rhytidiadelphus squarrosus
Riccardia multifida
Scorpidium cossonii
Sphagnum auriculatum
Sphagnum contortum
Sphagnum fallax
Sphagnum flexuosum
Sphagnum teres
Sphagnum warnstorfii
Straminergon stramineum
Tomentypnum nitens

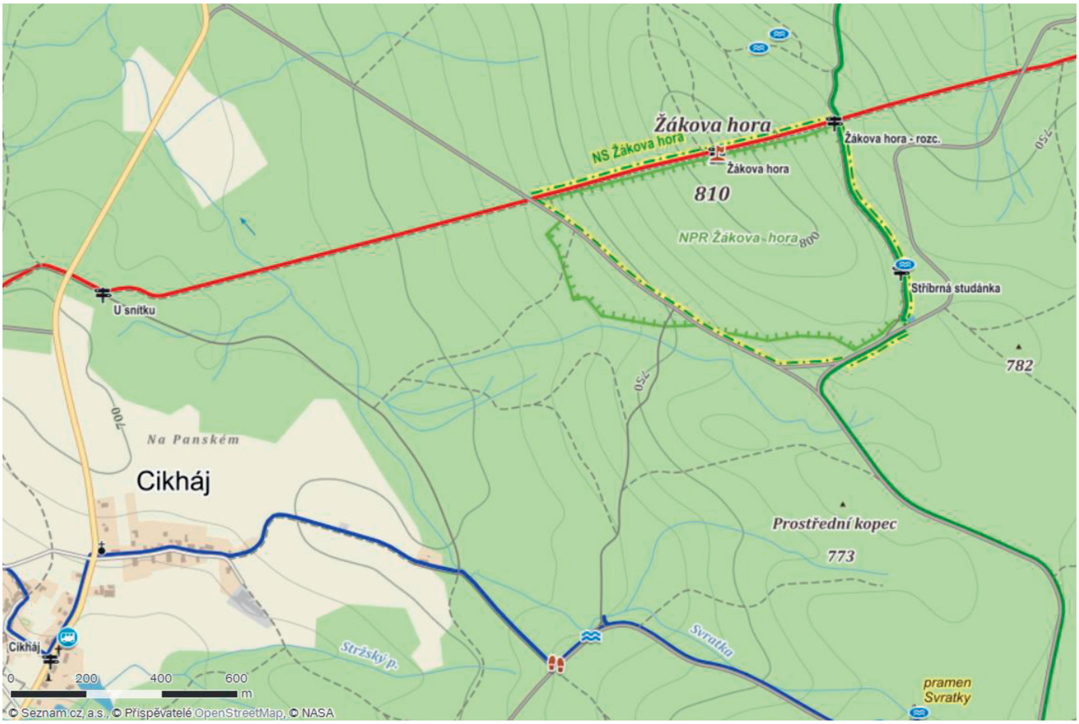
(1c) *Žákova hora* National Natural Reserve

Žákova hora protects a remnant of natural beech forest situated about 2–2.5 km NE of the village of Cikháj at altitudes of 726–810 m. It is quite unique as most of the natural forests of the Bohemian-Moravian Highlands have been converted into arable land, grasslands or coniferous forestry plantations.

The reserve comprises forests on south-west-facing slopes and the flat summit of the hill *Žákova hora*. The bedrock consists of migmatites and gneiss with bodies of amphibolite (Čech et al. 2002). The prevailing soil type in the area is cambisol with transitions to cambic podzols. Gleysols and stagnosols are found around springs.

Old-growth beech forest (Fagus sylvatica) in the Žákova hora National Nature Reserve. Photo T. Peterka.

The forest remained untouched for a long time thanks to its location far from human settlements, but the growing need for charcoal led to selective felling in the 19th century. Later on, a natural uneven-aged forest structure regenerated spontaneously. The site has been protected since 1933 (Vrška et al. 2002). Mesotrophic beech forests (associations *Galio odorati-Fagetum sylvaticae* and *Mercuriali perennis-Fagetum sylvaticae*, alliance *Fagion sylvaticae*) predominate in the reserve. The tree layer consists of *Fagus sylvatica* with an admixture of *Acer platanoides*, *A. pseudoplatanus*, *Picea abies* and (rarely) *Alnus glutinosa*, *Fraxinus excelsior* and *Ulmus glabra.* Silver fir (*Abies alba*), one of the main woody plants of old-growth forests, now occurs sporadically. The main reasons for its decline may be selective felling in the past and browsing by deer which became abundant following the extermination of large predators (bear, lynx, wolf) in the 18th–19th centuries. The herb layer includes elements of mesophilous broad-leaved forests such as *Athyrium filix-femina*, *Calamagrostis arundinacea*, *Corydalis cava*, *Daphne mezereum*, *Dentaria bulbifera*, *D. enneaphyllos*, *Dryopteris carthusiana*, *D. filix-mas*, *Festuca altissima*, *Galium odoratum* and *Prenanthes purpurea.* The association *Mercuriali perennis-Fagetum sylvaticae* is further characterized by a stronger representation of nutrient-demanding species such as *Actaea spicata*, *Galeobdolon luteum* agg., *Geranium robertianum*, *Mercurialis perennis*, *Stachys sylvatica* and *Urtica dioica*.



Žákova hora National Nature Reserve near the village of Cikháj.

Mesotrophic beech forests are replaced by acidophilous beech forests on nutrient-poor soils (association *Calamagrostio villosae-Fagetum sylvaticae*, alliance *Luzulo-Fagion sylvaticae*). The herb layer contains acidotolerant species such as *Avenella flexuosa*, *Calamagrostis villosa*, *Hieracium murorum*, *Maianthemum bifolium*, *Oxalis acetosella* and *Vaccinium myrtillus*.

Small stands of herbaceous spring vegetation of the alliance *Caricion remotae* (associations *Caricetum remotae* and *Cardamino-Chrysosplenietum alternifolii*) with *Cardamine amara*, *Carex sylvatica*, *Chaerophyllum hirsutum*, *Circaea alpina*, *Petasites albus* and *Veronica montana* are found in areas surrounding springs and on other wet sites.

In contrast to the reserve, the neighbouring forests are mostly even-aged plantations of the native conifer *Picea abies* with herb and moss layers almost absent. Nevertheless, several stands on wetter sites (e.g. stream valleys) are very similar to the natural spruce forest of the associations *Soldanello montanae-Piceetum abietis* and *Calamagrostio villosae-Piceetum abietis* (alliance *Piceion abietis*). Their herb layer contains *Calamagrostis villosa* and typical species of boreo-continental coniferous forests, such as *Avenella flexuosa*, *Dryopteris carthusiana*, *Maianthemum bifolium*, *Trientalis europaea* and *Vaccinium myrtillus*. The moss layer is well developed with the prevailing species being *Dicranum scoparium*, *Polytrichum formosum* and *Sphagnum girgensohnii*.

The bark of old broad-leaved trees is a substrate for numerous epiphytic bryophytes, e.g. *Amblystegium serpens*, *Hypnum cupressiforme* s.l., *Isothecium alopecuroides* and the rare moss *Dicranum viride* (Kučera et al. 2013). Rotting wood is a suitable habitat for wood-decay fungi and xylophagous beetles.

The historical core of the reserve is unmanaged to enable natural forest development. The natural composition of the tree layer in the marginal part of the reserve (protected since 1990) is restored by the underplanting of beech and fir in spruce-dominated forests.

Appendix 1c Selected species of vascular plants and bryophytes in the *Žákova hora* National Nature Reserve.

Vascular plants
Abies alba
Acer platanoides
Acer pseudoplatanus
Actaea spicata
Aegopodium podagraria
Agrostis stolonifera
Ajuga reptans
Alnus glutinosa
Anemone nemorosa
Asarum europaeum
Athyrium filix-femina
Avenella flexuosa
Calamagrostis arundinacea
Calamagrostis epigejos
Calamagrostis villosa
Cardamine amara
Cardamine flexuosa
Carex pilulifera
Carex remota
Carex sylvatica
Chaerophyllum hirsutum
Circaea alpina
Circaea ×intermedia (*C. alpina* × *C. lutetiana*)
Circaea lutetiana
Corydalis cava
Daphne mezereum
Dentaria bulbifera
Dentaria enneaphyllos
Deschampsia cespitosa
Dryopteris carthusiana
Dryopteris dilatata
Dryopteris filix-mas
Epilobium angustifolium
Epilobium montanum
Equisetum sylvaticum
Fagus sylvatica
Festuca altissima
Festuca gigantea
Fragaria vesca
Fraxinus excelsior
Galeobdolon luteum agg.
Galeopsis pubescens
Galeopsis tetrahit
Galium odoratum
Geranium robertianum
Gymnocarpium dryopteris
Hieracium murorum
Hordelymus europaeus
Impatiens noli-tangere
Lathraea squamaria
Leucojum vernum
Luzula pilosa
Lysimachia nemorum
Lysimachia nummularia
Maianthemum bifolium
Mercurialis perennis
Milium effusum
Moehringia trinervia
Mycelis muralis
Neottia nidus-avis
Oxalis acetosella
Paris quadrifolia
Petasites albus
Picea abies
Poa nemoralis
Polygonatum verticillatum
Prenanthes purpurea
Ranunculus repens
Rubus idaeus
Rubus ser. *Glandulosi*
Rumex acetosella
Sambucus nigra
Sambucus racemosa
Sanicula europaea
Scrophularia nodosa
Senecio nemorensis agg.
Sorbus aucuparia
Stachys sylvatica
Stellaria alsine
Stellaria nemorum
Thelypteris limbosperma
Trientalis europaea
Ulmus glabra
Urtica dioica
Vaccinium myrtillus
Veronica chamaedrys
Veronica montana
Veronica officinalis
Viola reichenbachiana
Viola riviniana

Bryophytes
Amblystegium serpens
Atrichum undulatum
Brachytheciastrum velutinum
Brachythecium rutabulum
Brachythecium salebrosum
Bryum moravicum
Calypogeia azurea
Campylidium sommerfeltii
Cephalozia bicuspidata
Cephalozia catenulata
Chiloscyphus coadunatus
Chiloscyphus profundus
Dicranella heteromalla
Dicranum montanum
Dicranum scoparium
Dicranum viride
Herzogiella seligeri
Hypnum cupressiforme s.l.
Hypnum pallescens
Isothecium alopecuroides
Lepidozia reptans
Metzgeria furcata
Paraleucobryum longifolium
Plagiothecium curvifolium
Plagiothecium laetum
Plagiothecium nemorale/succulentum
Pleurozium schreberi
Pogonatum aloides
Pohlia nutans
Polytrichum formosum
Pterigynandrum filiforme
Ptilidium pulcherrimum
Rhizomnium punctatum
Sanionia uncinata
Scapania umbrosa
Sciuro-hypnum curtum
Sciuro-hypnum populeum
Sciuro-hypnum reflexum
Solenostoma gracillimum
Sphagnum girgensohnii
Tetraphis pellucida

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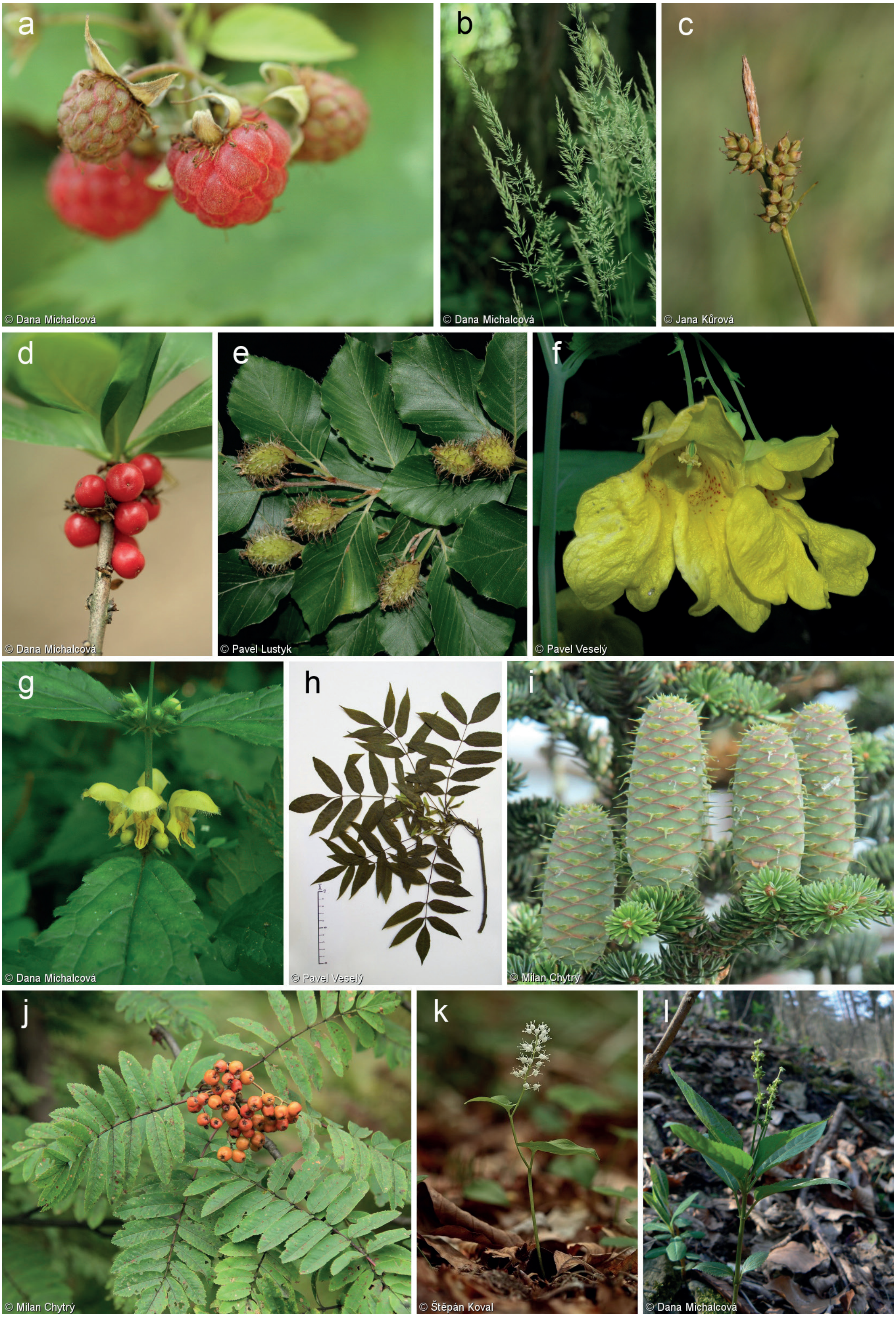

Plate 1c Plants of the *Žákova hora* National Nature Reserve in the Žďár Hills: (a) *Rubus idaeus*, (b) *Calamagrostis arundinacea*, (c) *Carex pilulifera*, (d) *Daphne mezereum*, (e) *Fagus sylvatica*, (f) *Impatiens noli-tangere*, (g) *Galeobdolon montanum*, (h) *Fraxinus excelsior*, (i) *Abies alba*, (j) *Sorbus aucuparia*, (k) *Maianthemum bifolium*, (l) *Mercurialis perennis*.

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2 Podyjí National Park

Milan Chytrý & Vít Grulich

Introduction

Podyjí National Park is situated in south-western Moravia between the towns of Znojmo and Vranov nad Dyjí along the Czech-Austrian border. The Austrian Thayatal National Park is adjacent on the other side of the national border.

The National Park is located on the south-eastern edge of the Bohemian-Moravian Highlands (*Českomoravská vrchovina*). The most remarkable feature of the park's landscape is the 60–230 m deep, V-shaped valley of the Dyje River (*Thaya* in German). The slopes of the valley are steep, with abundant rock outcrops, and dissected by numerous ravines. The valley is surrounded by a gently undulating landscape that is typical of the Bohemian-Moravian Highlands. The highest point of the National Park is the hill *Býčí hora* (536 m) in its western part; the lowest point (208 m) is the level of the Dyje River on the eastern edge of the National Park.

The forested valley of the Dyje River with deeply incised meanders is the core area of the Podyjí National Park. Photo Z. Lososová.

Geology, geomorphology and soils

The area is built of the Proterozoic crystalline rocks of the Bohemian Massif. Granitoids (granite and granodiorite) predominate in the eastern part of the National Park south-west of the town of Znojmo where they are locally overlaid by soft Miocene deposits. Gneiss is the main bedrock type in the western part of the National Park, between the towns of Vranov nad Dyjí and Hardegg. Acidic mica schist is the most common bedrock in the central part, though outcrops of more base-rich bedrock (amphibolite, marble) are also encountered in this area. Quaternary eolian deposits (loess) are found mainly in the eastern part of the area (Batík 1992).

The Dyje River Valley is characterized by numerous meanders deeply incised in the ancient crystallinic bedrock. These meanders are of Tertiary origin, when they initially developed in a flat landscape. Vertical erosion intensified and the meanders became deeply incised due to the upward movement of the Bohemian Massif during the Alpine Orogeny (Ivan & Kirchner 1994).

The predominant soil type is cambisol. Luvisols are found on crystalline plateaus and gentle slopes with a thick layer of weathering products of ancient rocks or young deposits. Leptosols occur around outcrops of crystalline siliceous bedrock (ranker) or crystalline limestone (rendzina). Gleysols are found in shallow wet depressions on the plateaus, and loamy-sandy fluvisols on the alluvial terraces of the valley bottom. Chernozems are developed on fine-grained Tertiary and Quaternary deposits in the eastern part of the area.

Climate

The climate in the eastern part of the National Park is dry and warm, typical of the southern Moravian lowlands. The mean annual temperature in Znojmo is about 9 °C and the annual precipitation sum is lower than 500 mm. Moving to the north-west, the climate becomes increasingly cooler and wetter, with mean annual temperature about 8 °C and annual precipitation of 500–550 mm. The complex topography of the river valley generates remarkable mesoclimatic patterns. Whereas the gently undulating landscape above the valley, at least in the central and north-western part of the area, has some oceanic climatic features with smaller differences between minimum and maximum temperatures, the climate of the river valley is more continental. The upper parts of the south-facing slopes may warm up considerably during the daytime, though they cool to temperatures lower than elsewhere in the valley on clear nights (Tichý 1998, 1999b). There are two types of temperature inversion in the valley. Inversion due to topographical shading mainly affects the lower parts and foots of north-facing slopes. It is most intense during the daytime and limits temperature maxima. This type of inversion supports the occurrence of montane plants. The second type of inversion is caused by the cold-air drainage that occurs from time to time on clear and calm nights and creates a temperature difference of up to 3 °C between the warmer upper slopes and the cooler valley bottom. This inversion may cause frost injury to sensitive plants, particularly in spring. It is possible that some species of oceanic distribution and even *Fagus sylvatica* may be outcompeted from the valley due to frost injury (Chytrý & Tichý 1998).

Landscape history and nature conservation

The Podyjí National Park area was already settled by humans in the Neolithic. The main settlements have always been in the eastern part of the area, with Hradiště near Znojmo being the most important centre with extensive fortification (Podborský & Vildomec 1972). In contrast, fossil snail records suggest that the central and western part of the National Park was predominantly forested in the Holocene climatic optimum, corresponding to the Neolithic (Ložek & Vašátko 1997). In the period of consolidation of the Czech state in the 10th–14th centuries, the area was on its southern edge and a chain of castles, some of which were in the Dyje Valley, was built here to guard the state border. Most of the villages currently existing in the wider area were mentioned in written sources as early as the 12th or 13th century. Watermills were built in the deep river valley and some forests on river terraces were converted into hay meadows. Some south-facing slopes in the valley were used to plant vineyards. The right side of the Dyje Valley in the eastern part of the National Park was deforested, though forest cover was preserved in more western parts of the valley (Vrška 1998; Táborská 1999). Two artificial lakes were built on the Dyje River: the Vranov reservoir (1934) just above the present National Park and the Znojmo reservoir (1967) in the eastern part of the park, causing the disappearance of valuable valley sections. The expulsion of the German-speaking people after WWII led to the complete depopulation of most of the villages in this area. In 1951, the Dyje Valley became part of the Iron Curtain, a prohibited zone established by the Czechoslovak Communist regime to control the state border with democratic Western Europe. Watermills and other buildings in this area were demolished during this period. The closure of the area for four decades (until the political changes of 1989) led to the restoration of natural succession processes over a large area. Forest returned to many of the formerly deforested valley slopes and terraces, although in many places this regrowth was dominated by the introduced North American tree *Robinia pseudoacacia*.

This specific historical development has meant that the Dyje Valley has remained unspoilt by the construction of roads, railways, weekend cottages, forest logging and plantation forestry between the towns of Vranov nad Dyjí and Znojmo, in contrast to other deep river valleys of the Bohemian

Massif. For this reason the Podyjí Protected Landscape Area (PLA) was established in this area in 1978. Although conservation and research activities were restricted in the 1980s due to the large overlap of the PLA with the Iron Curtain zone, some research results obtained in the 1980s could be used as arguments for transforming the PLA into a National Park. This happened in 1991 when the Podyjí National Park was established on an area of 63 km^2 including the Dyje Valley and the adjacent landscape. A buffer zone is formed of an additional 29 km^2. This is the smallest of the four Czech Republic's National Parks. The National Park became bilateral on 1 January 2000 with the establishment of the Thayatal National Park (13 km^2) in the adjacent area in Austria.

History of botanical research

The flora of the area was studied in detail by Adolf Oborny, a secondary school teacher from Znojmo, in 1870–1920. Since then, hardly any species new to the region have been found except for a few species in taxonomically intricate groups. The comprehensive and critical *Flora des Znaimer Kreises* (*Flora of the Znojmo Province*; Oborny 1879) enables a comparison with the current situation. Another local flora, also of high quality, was published by Himmelbaur & Stumme (1923). It refers to the state of the flora during WWI, when the Viennese botanist Wolfgang Himmelbaur performed military service in Znojmo. Several reports on the flora of this area were published by Anton Fröhlich, Jindřich Suza, Jan Šmarda and other botanists in the 1920s–1930s.

In 1951 the territory was closed to the public as a state border area. In the early 1950s, primary-school teacher and amateur botanist Vratislav Drlík prepared a manuscript of the flora of the Znojmo district which was not published during his lifetime and remained unknown to botanists for several decades. After the discovery of the manuscript in the family archive half a century later, it was published as an important source of historical information on the flora of the area before the landscape changes of the second half of the 20th century (Drlík et al. 2005). No systematic botanical research was performed in this area from that time until the fall of the Iron Curtain in 1989.

Masaryk University conducted a comprehensive botanical survey on both the Czech and Austrian sides of the national border in the early 1990s in association with the establishment of the National Park in 1991. This project, led by Professor Jiří Vicherek, resulted in an inventory of plant communities and a vegetation map (Chytrý & Vicherek 1995, 2003; Tichý 1999a), a floristic survey (Grulich & Chytrý 1993; Grulich 1996) culminating in the publication of a local distribution atlas of vascular flora (Grulich 1997), surveys of macromycetes, lichens and bryophytes (Antonín et al. 2000), and a series of journal articles. Other studies were devoted to vegetation of wet grasslands (Balátová-Tuláčková 1993) and aquatic vegetation (Rydlo 1995). Research into the local flora continues following the major survey from the 1990s (Bravencová et al. 2007).

Vegetation

The Podyjí National Park is situated in the transitional area between the Pannonian and Hercynian (Central European) phytogeographical provinces. The *Pannonicum* corresponds to the continental forest-steppe biome, and the *Hercynicum* to the broad-leaved deciduous forest biome. The boundary between these regions generally follows the geological dividing line between the Bohemian Massif (the north-western and central part of the National Park, with higher altitudes, lower temperatures, higher precipitation, ancient siliceous bedrock and a landscape mosaic of forest tracts and treeless areas) and the outer depressions of the Western Carpathians and the Eastern Alps (the south-eastern part of the National Park, with lower altitudes, a warmer and drier climate, Tertiary and Quaternary deposits, and a landscape largely deforested since prehistoric times; Chytrý et al. 1999).

The predominant vegetation type of the National Park is broad-leaved deciduous forest. Submontane beech forests (associations *Galio odorati-Fagetum sylvaticae* and *Mercuriali perennis-Fagetum sylvaticae*, alliance *Fagion sylvaticae*) are the main types of potential natural vegetation in the western (Hercynian) part, near the towns of Vranov nad Dyjí and Hardegg. They are found in the gently undulating landscape outside the river valley at altitudes above 450 m. Hercynian oak-hornbeam forests (association *Galio sylvatici-Carpinetum betuli*, alliance *Carpinion betuli*) are predominant in the central part of the National Park and in the river valleys. Moving to the east towards the Pannonian Province, oak-hornbeam forests are replaced by acidophilous oak forests (associations *Luzulo luzuloidis-Quercetum petraeae* and *Viscario vulgaris-Quercetum petraeae*, alliance *Quercion roboris*) and, on the south-eastern slope of the Bohemian Massif, by thermophilous oak forests (association *Sorbo* *torminalis-Quercetum*, alliance *Quercion petraeae*). A mosaic of thermophilous oak forests (association *Quercetum pubescenti-roboris*, alliance *Aceri tatarici-Quercion*) and Pannonian oak-hornbeam forests (association *Primulo veris-Carpinetum betuli*, alliance *Carpinion betuli*) is assumed to be the potential natural vegetation in the outer depressions of the Western Carpathians, which are adjacent to the Bohemian Massif in the east; however, this area has been largely deforested since the Neolithic.

The distribution of natural vegetation types is clearly related to landforms in the deep valley of the Dyje River (Chytrý & Vicherek 1995; Tichý 1999a; Zelený & Chytrý 2007). The narrow discontinuous floodplain is covered by riverine alder forests (association *Stellario nemorum-Alnetum glutinosae*, alliance *Alnion incanae*). Steep lower slopes support ravine forests (association *Aceri-Tilietum*, alliance *Tilio platyphylli-Acerion*), while more gentle lower and middle slopes are covered by oak-hornbeam forests (association *Galio sylvatici-Carpinetum betuli*, alliance *Carpinion betuli*). South-facing upper slopes are covered by thermophilous oak forests (the associations *Sorbo torminalis-Quercetum* and *Genisto pilosae-Quercetum petraeae*, both of the alliance *Quercion petraeae*), whereas the north-facing slopes support acidophilous oak forests (the associations *Luzulo luzuloidis-Quercetum petraeae*, *Viscario vulgaris-Quercetum petraeae* and *Vaccinio vitis-idaeae-Quercetum roboris*, all of the alliance *Quercion roboris*). Small patches of *Pinus sylvestris* forests (association *Hieracio pallidi-Pinetum sylvestris*, alliance *Dicrano-Pinion sylvestris*) are found on larger rock outcrops and cliffs tops.

The river valley includes patches of primary treeless habitats on cliffs, rock faces and talus slopes. These are covered by scrub (alliances *Prunion fruticosae* and *Berberidion vulgaris*) or dry grasslands (alliances *Festucion valesiacae* and *Alysso-Festucion pallentis*) on south-facing slopes. North-facing treeless patches are dominated by rocky grasslands of *Calamagrostis arundinacea* on siliceous bedrock and, in a few places also by *Sesleria caerulea* grassland (alliance *Diantho lumnitzeri-Seslerion*) on marble outcrops (Chytrý & Vicherek 2003). Talus slopes are covered with cryptogamic vegetation and, near the forest edges, with species-poor communities of mosses and ferns. There are rich bryophyte communities, particularly on open north-facing talus slopes where several species of boreal distribution are found (Kubešová 2003a; Kubešová & Chytrý 2005).

Secondary treeless vegetation is found mainly in the border area of the National Park and in the adjacent landscape (Chytrý & Vicherek 2003). Meadows of the alliances *Arrhenatherion elatioris* and *Calthion palustris* are the predominant types of secondary grasslands in the western and central part. *Arrhenatherion* meadows (associations *Pastinaco sativae-Arrhenatheretum elatioris* and *Ranunculo bulbosi-Arrhenatheretum elatioris*) are also found on the deforested terraces of the Dyje River and in its floodplain. The river is fringed by riverine reeds with *Phalaris arundinacea* and *Carex buekii* (associations *Rorippo-Phalaridetum arundinaceae* and *Caricetum buekii*, alliance *Phalaridion arundinaceae*). The largely deforested south-eastern slope of the Bohemian Massif in the eastern part of the National Park is well known for its extensive dry heathland with thermophilous and continental species (association *Euphorbio cyparissiae-Callunetum vulgaris*, alliance *Euphorbio cyparissiae-Callunion vulgaris*) and acidophilous dry grasslands (association *Potentillo heptaphyllae-Festucetum rupicolae*, alliance *Koelerio-Phleion phleoidis*). The area of the outer depression of the Western Carpathians is mainly dominated by arable land and vineyards, and the most remarkable type of semi-natural vegetation there is the *Convolvulo arvensis-Elytrigion repentis* ruderal grassland on road verges on loess.

Flora

During the survey of the flora of the Czech-Austrian bilateral Podyjí/Thayatal National Park and adjacent areas in the 1990s, 1290 species of vascular plants were recorded, including 9% neophytes, in an area of approximately 127 km^2 (Grulich 1997).

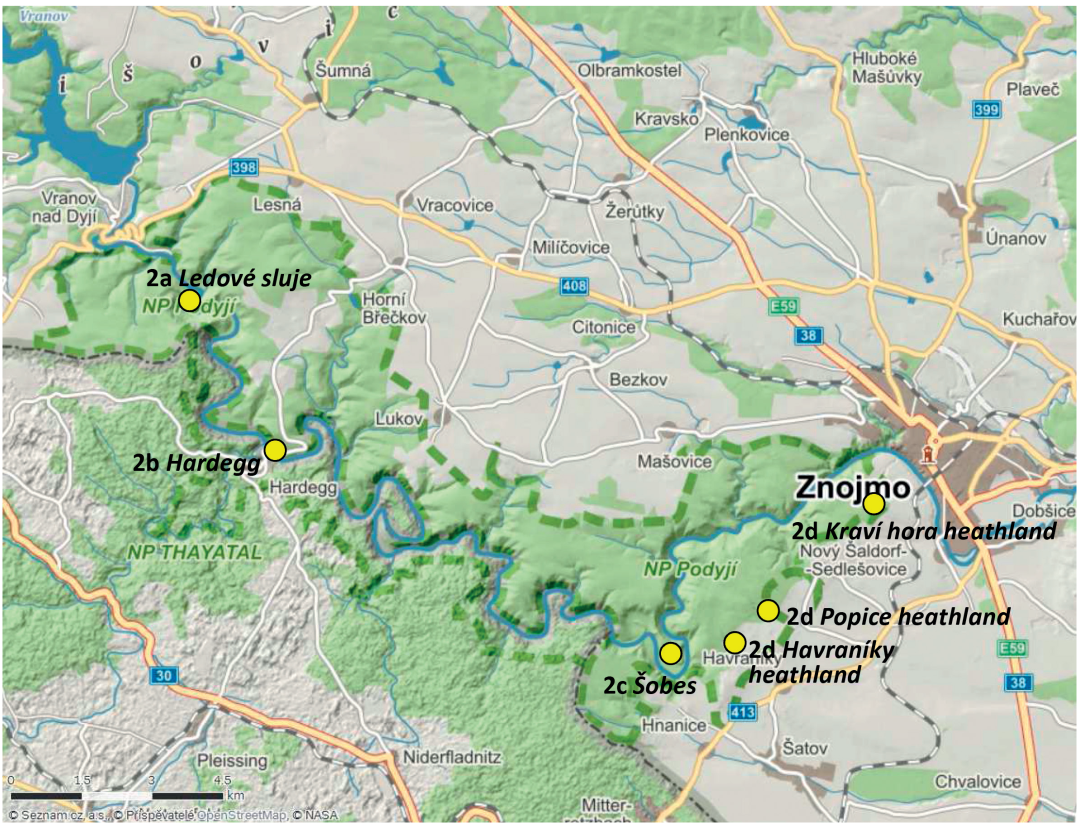
The deforested area of the southern Moravian lowlands, which is adjacent to the eastern border of the National Park, contains thermophilous Pannonian and continental species of steppe, ruderal habitats on loess and inland saline grasslands. The group of species that are found only in this area includes *Alcea biennis*, *Astragalus onobrychis*, *Atriplex oblongifolia*, *Bassia prostrata* (in Austria only), *Carex hordeistichos*, *Cytisus procumbens*, *Iris pumila*, *Peucedanum alsaticum*, *Ranunculus illyricus*, *Salvia austriaca*, *Scabiosa canescens*, *Sclerochloa dura*, *Scorzonera cana* and *Seseli hippomarathrum*. Some thermophilous species occur in this warm and dry eastern area, though they are also found in the river valley in the central and western part of the National Park, e.g. *Armeria elongata*, *Carex supina*, *Rosa marginata*, *R. spinosissima*, *Salvia pratensis* and *Scabiosa ochroleuca*. Another group of thermophilous species confined to areas with base-rich soils is found both in the eastern lowland area and on the marble bedrock around the town of Hardegg in the central-western part of the National

Park, e.g. *Aster amellus*, *Inula ensifolia* and *Polygala major.* A group of species phytogeographically related to the limestone fringes of the Alps is found on the marble outcrops near Hardegg, e.g. *Buphthalmum salicifolium* (the only native locality in the Czech Republic), *Bupleurum longifolium* (now in Austria only), *Euphorbia angulata*, *Laserpitium latifolium* (in Austria only), *Polygala amara* and *Sesleria caerulea*. This marble area also harbours some orchids such as *Cypripedium calceolus*, *Orchis militaris* and *O. purpurea*. Some thermophilous species are confined to the rock outcrops and forest edges in the Dyje Valley, including *Aconitum anthora*, *Aurinia saxatilis* and *Bupleurum affine*. Species of acidic rock outcrops are found in the river valley and in the area of the south-eastern edge of the Bohemian Massif; this group includes *Gagea bohemica*, *Genista pilosa*, *Scleranthus perennis*, *Sedum reflexum* and *Veronica dillenii.*

Montane species such as *Aconitum variegatum*, *Aruncus dioicus*, *Lunaria rediviva*, *Polystichum aculeatum*, *Rosa pendulina* and *Taxus baccata* are found in the shaded parts of the river valley. Montane species of another group, including *Atropa bella-donna*, *Equisetum sylvaticum*, *Hordelymus europaeus*, *Petasites albus*, *Prenanthes purpurea* and *Vicia sylvatica*, occur on the plateaus dominated by beech forest in the western part of the National Park. The deforested plateaus in the central and western part of the National Park contain some wet meadows and patches of wet alder forest with submontane species such as *Bistorta officinalis*, *Carex appropinquata*, *C. elongata*, *C. umbrosa*, *Salix rosmarinifolia*, *Scorzonera humilis*, *Tephroseris crispa* and *Trollius altissimus.*

Excursion sites

The four excursion sites described below feature the major habitats of the Podyjí National Park, including various types of forests in the deep river valley both on acidic bedrock and marble and on dry heathlands with continental species in the eastern part of the park.



Podyjí National Park and the Thayatal National Park in the adjacent area of Austria, indicated by a green dashed line, with excursion sites.

(2a) *Ledové sluje* ridge

Ledové sluje (*Eisleiten* in German, meaning *Ice Holes* or *Ice Caves*) is a system of pseudokarst caves situated in the Dyje Valley between the towns of Vranov nad Dyjí and Hardegg. These caves have long been famous for containing ice until late summer, and their flora was also studied very early (Niessl 1868). In a broader sense, *Ledové sluje* is a local name for the whole ridge where these caves occur.

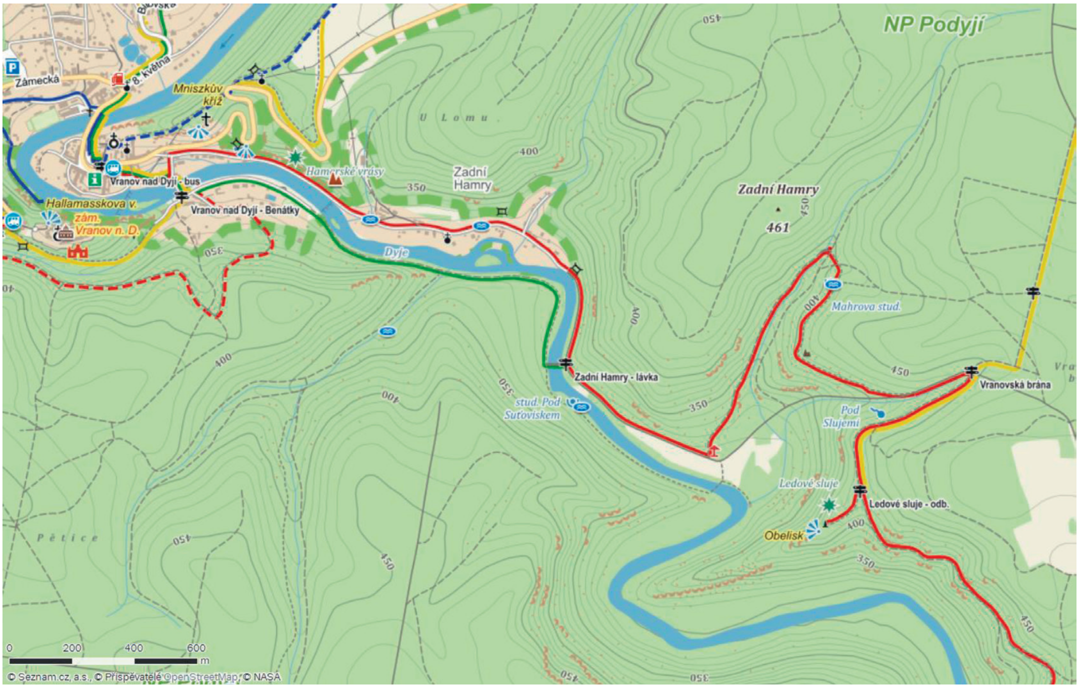
The ridge of *Ledové sluje* is located above the left bank of the Dyje River between the flat hills of *Větrník* (510 m) and *Býčí hora* (514 m). The river flows in deeply entrenched meanders between these two hills at an altitude of ca. 300 m. The ridge is formed of Proterozoic orthogneiss. There are several slope failures on the steep valley slopes which have given rise to about twenty crevice-type caves. The longest cave system is more than 400 m long (Gruna & Reiter 1996). There is a talus slope on the NW-facing slopes of the ridge formed of large gneiss blocks originating from rock falls from the cliffs above.

The *Ledové sluje* ridge is remarkable for its large diversity of habitats, including south- and north-facing slopes, rock outcrops, steep slopes, rock debris and deep soils on the lower slopes and the Dyje terraces. This is reflected both in the species-rich flora and the large number of vegetation types recognized in an area of less than 0.5 km^2 (Gruna & Reiter 1996).

Gneiss outcrops and talus slopes on the Ledové sluje ridge are covered by ravine forest with Tilia cordata, T. platyphyllos, Acer pseudoplatanus, A. platanoides and Carpinus betulus. Photo M. Chytrý.

Vegetation

Most of the *Ledové* sluje area is forested. Mesic habitats with deep cambisols on the middle and lower slopes are occupied by oak-hornbeam forests with *Carpinus betulus* and *Quercus petraea* (association *Galio sylvatici-Carpinetum betuli*, alliance *Carpinion betuli*) and species of mesic broad-leaved forests in the herb layer, e.g. *Campanula persicifolia*, *Cyclamen purpurascens*, *Dactylis polygama*, *Galium odoratum*, *G. sylvaticum*, *Hepatica nobilis*, *Poa nemoralis* and *Stellaria holostea*. Shallower cambisols (up to 40 cm deep) on the upper north-facing slopes support acidophilous oak forests dominated by *Quercus petraea* (association *Luzulo luzuloidis-Quercetum petraeae*, alliance *Quercion roboris*). These open-canopy forests have a species-poor herb layer with calcifuge species such as *Avenella flexuosa*, *Luzula luzuloides*, *Festuca ovina* and *Vaccinium myrtillus*. Their rich moss layer contains *Dicranum scoparium*, *Hypnum cupressiforme*, *Polytrichum formosum*, *P. juniperinum* and other species. In similar topographic situations on south-facing slopes acidophilous oak forests are replaced by thermophilous oak forests (association *Sorbo torminalis-Quercetum*, alliance *Quercion petraeae*). Their canopy is also dominated by *Quercus petraea*, but they contain a number of shrubs (e.g. *Cornus mas*, *Ligustrum vulgare* and *Rosa canina* agg.) and a species-rich herb layer. This is mostly dominated by *Festuca ovina* accompanied by *Anthericum ramosum*, *Bupleurum falcatum*, *Euphorbia cyparissias*, *Hylotelephium maximum*, *Poa nemoralis*, *Polygonatum odoratum*, *Teucrium chamaedrys*, *Trifolium alpestre*, *Vincetoxicum hirundinaria* and other species. Broad-leaved ravine forests (association *Aceri-Tilietum*, alliance *Tilio platyphylli-Acerion*) are found on steep lower slopes with an accumulation of rock debris. They have a species-rich tree layer, including *Acer platanoides*, *A. pseudoplatanus*, *Carpinus betulus*, *Tilia cordata* and *T. platyphyllos*, and a shrub layer with *Corylus avellana*, *Euonymus verrucosus*, *Lonicera xylosteum* and *Ribes uva-crispa*. There is a species-poor herb layer with nutrient-demanding and shade-tolerant forest species such as *Dryopteris filix-mas*, *Galeobdolon montanum*, *Geranium robertianum* and *Urtica dioica*. The moss layer is luxuriant, with most common species including *Dicranum scoparium*, *Hypnum cupressiforme* and *Polytrichum formosum*. Small patches of natural pine forests (association *Hieracio pallidi-Pinetum sylvestris*, alliance *Dicrano-Pinion sylvestris*) are found on the tops and faces of gneiss outcrops. In addition to *Pinus sylvestris*, they also contain some individuals of *Quercus petraea* and *Betula pendula*. Their species-poor herb layer is dominated by *Festuca ovina* and also contains *Avenella flexuosa*, *Genista pilosa* and *Polypodium vulgare*. The moss layer contains *Dicranum scoparium*, *Hypnum cupressiforme*, *Polytrichum piliferum* and a number of lichens including *Parmelia saxatilis*, *Xanthoparmelia conspersa*, *X. pulla* and *X. stenophylla*.



The town of Vranov nad Dyjí and the Ledové sluje ridge in the Dyje Valley in the western part of the Podyjí National Park.

Natural treeless vegetation is found on the open talus slopes and rock faces. The talus slopes have a rich flora of lichens and bryophytes. The commonest macrolichen is *Cladonia rangiferina* and the commonest bryophytes include *Antitrichia curtipendula*, *Dicranum scoparium*, *Hypnum cupressiforme* and *Polytrichum formosum*. Large areas of the talus slopes contain only cryptogamic vegetation with abundant epilithic microlichens. The vascular flora in this habitat is species-poor, including *Dryopteris filix-mas*, *Festuca ovina*, *Poa nemoralis* and *Polypodium vulgare.* Well-insolated rock faces harbour *Aurinia saxatilis*, *Festuca ovina* and *Polypodium vulgare*. In contrast, shaded rocks are covered with moss polsters, mainly *Hypnum cupressiforme*, and contain some ferns growing in crevices, most frequently *Polypodium vulgare* (Kubešová 2003a, 2003b; Kubešová & Chytrý 2005).

Flora

Detailed inventories of the *Ledové sluje* area performed in the early 1990s recorded 163 species of lichens, 28 species of liverworts, 95 species of mosses and 502 species of vascular plants (Gruna & Reiter 1996). The lichen *Endocarpon psorodeum* was found here as the first record in the Czech Republic. Several species of lichens and bryophytes occurring on talus slopes in *Ledové sluje* are more typical of high-altitude areas, but they occur here in places influenced by cold air flowing out of the ice caves. These include the lichens *Cladonia squamosa*, *Fuscidea cyathoides*, *Peltigera aphtosa*, *Pertusaria corallina*, *Rhizocarpon geographicum* and *Umbilicaria polyphylla*, the liverworts *Anastreptophyllum minutum*, *Barbilophozia hatcheri*, *Calypogeia muelleriana*, *Lophoziopsis longidens*, *Porella cordaeana*, *Syzygiella autumnalis* and *Tritomaria quinquedentata*, and the moss *Polytrichastrum alpinum.*

The vascular flora is dominated by Central European and temperate Eurasian species, although sub-Mediterranean species are also relatively common, represented by, for example, *Allium flavum*, *Cornus mas* and *Pseudoturritis turrita*. The occurrence of *Actaea europaea*, *Carex rhizina* and *Rubus saxatilis*, species typical of southern Siberian hemiboreal forests which are rather rare in Central Europe, is particularly remarkable. *Ledové sluje* is an isolated locality for some thermophilous species which are more common in the dry lowlands of southern Moravia east of the town of Znojmo, but largely missing in the Bohemian Massif. In this area, they are confined to sunny slopes and rock outcrops in the river valleys. This group of species includes both sub-Mediterranean and temperate continental species such as *Allium flavum*, *Buglossoides purpurocaerulea*, *Dictamnus albus*, *Iris variegata* (westernmost locality in Moravia) and *Melica picta*. *Aconitum anthora*, a species belonging to a group of closely-related taxa with temperate continental distribution, is found on sunny forest edges on the summit of the *Ledové sluje* ridge. In Moravia, this species is confined to the river valleys of the Bohemian Massif. *Carex cespitosa* and *Veronica maritima*, species of wet continental meadows, are found in a small wetland on the river terrace west of the *Ledové sluje* ridge.

Appendix 2a Selected species of vascular plants in the *Ledové sluje* area.

Abies alba
Acer campestre
Acer platanoides
Acer pseudoplatanus
Aconitum anthora
Actaea spicata
Adoxa moschatellina
Aegopodium podagraria
Agrostis capillaris
Agrostis gigantea (neo)
Agrostis stolonifera
Achillea collina
Achillea styriaca
Actaea europaea
Ajuga genevensis
Ajuga reptans
Alliaria petiolata
Allium flavum
Allium oleraceum
Allium senescens subsp. *montanum*
Alnus glutinosa
Alopecurus pratensis
Anemone nemorosa
Anemone ranunculoides
Angelica sylvestris
Anchusa officinalis
Anthericum ramosum
Anthoxanthum odoratum
Anthriscus sylvestris
Arabidopsis arenosa
Arctium lappa
Arctium minus
Arctium tomentosum
Arenaria serpyllifolia
Arrhenatherum elatius
Asarum europaeum
Asplenium septentrionale
Asplenium trichomanes
Astragalus glycyphyllos
Astrantia major
Athyrium filix-femina
Atropa bella-donna
Aurinia saxatilis
Avenella flexuosa
Avenula pubescens
Ballota nigra
Batrachium fluitans
Berteroa incana
Betonica officinalis
Betula pendula
Brachypodium pinnatum
Brachypodium sylvaticum
Briza media
Bromus benekenii
Bromus hordeaceus
Buglossoides purpurocaerulea
Bupleurum falcatum
Calamagrostis arundinacea
Calamagrostis epigejos
Calluna vulgaris
Caltha palustris
Calystegia sepium
Campanula glomerata
Campanula patula
Campanula persicifolia
Campanula rapunculoides
Campanula rotundifolia
Campanula trachelium
Cardamine amara
Cardamine impatiens
Carduus crispus
Carex acuta
Carex acutiformis
Carex brizoides
Carex buekii
Carex cespitosa
Carex digitata
Carex hartmanii
Carex hirta
Carex leporina
Carex michelii
Carex muricata
Carex pallescens
Carex pilosa
Carex remota
Carex rhizina
Carex spicata
Carex sylvatica
Carpinus betulus
Centaurea jacea
Centaurea triumfetti
Centaurium erythraea

Cerastium arvense
Cerastium glutinosum
Cerastium holosteoides
Chaerophyllum aromaticum
Chaerophyllum temulum
Chelidonium majus
Chenopodium album
Chrysosplenium alternifolium
Circaea lutetiana
Cirsium arvense
Cirsium canum
Cirsium oleraceum
Cirsium palustre
Cirsium vulgare
Clinopodium vulgare
Convallaria majalis
Conyza canadensis (neo)
Cornus mas
Cornus sanguinea
Corydalis intermedia
Corydalis solida
Corylus avellana
Cota tinctoria
Cotoneaster integerrimus
Crataegus laevigata
Crataegus monogyna
Crepis biennis
Crepis paludosa
Cruciata laevipes
Cyclamen purpurascens
Cystopteris fragilis
Cytisus nigricans
Dactylis glomerata
Dactylis polygama
Dactylorhiza majalis
Daphne mezereum
Dentaria bulbifera
Dentaria enneaphyllos
Deschampsia cespitosa
Dianthus carthusianorum
Dianthus deltoides
Digitalis grandiflora
Dryopteris carthusiana
Dryopteris dilatata
Dryopteris filix-mas
Echium vulgare
Elymus caninus
Elymus repens
Epilobium adenocaulon (neo)
Epilobium angustifolium
Epilobium montanum
Equisetum arvense
Equisetum palustre
Equisetum pratense
Erigeron annuus (neo)
Eryngium campestre
Euonymus europaeus
Euonymus verrucosus
Eupatorium cannabinum
Euphorbia cyparissias
Euphorbia dulcis
Euphorbia epithymoides
Euphorbia esula
Fagus sylvatica
Falcaria vulgaris
Fallopia convolvulus
Fallopia dumetorum
Festuca gigantea
Festuca ovina
Festuca pallens
Festuca pratensis
Festuca rubra
Ficaria verna subsp. *verna*
Filago arvensis
Filipendula ulmaria
Filipendula vulgaris
Fourraea alpina
Fragaria moschata
Fragaria vesca
Fraxinus excelsior
Fumaria schleicheri
Gagea lutea
Gagea minima
Galanthus nivalis
Galeobdolon montanum
Galeopsis pubescens
Galium album
Galium aparine
Galium glaucum
Galium odoratum
Galium sylvaticum
Galium uliginosum
Galium valdepilosum
Galium verum
Genista germanica
Genista pilosa
Genista tinctoria
Geranium columbinum
Geranium divaricatum
Geranium pratense
Geranium pusillum
Geranium robertianum
Geranium sanguineum
Geum urbanum
Glechoma hederacea
Glechoma hirsuta
Glyceria maxima
Gnaphalium sylvaticum
Gymnocarpium dryopteris
Hedera helix
Helianthemum grandiflorum subsp. *obscurum*
Hepatica nobilis
Heracleum sphondylium
Herniaria glabra
Hesperis sylvestris
Hieracium laevigatum
Hieracium lachenalii
Hieracium murorum
Hieracium sabaudum
Holcus lanatus
Humulus lupulus
Hylotelephium maximum
Hypericum hirsutum
Hypericum montanum
Hypericum perforatum
Hypochaeris radicata
Impatiens noli-tangere
Impatiens parviflora (neo)
Inula conyzae
Iris variegata
Isopyrum thalictroides
Jasione montana
Juncus bufonius
Juncus conglomeratus
Juncus effusus
Juncus tenuis (neo)
Juniperus communis
Knautia arvensis
Lactuca quercina
Lactuca serriola
Lamium album
Lamium maculatum
Lamium purpureum
Lapsana communis
Larix decidua (planted)
Lathraea squamaria
Lathyrus niger
Lathyrus pratensis
Lathyrus vernus
Lemna minor
Leontodon hispidus
Leucanthemum ircutianum
Libanotis pyrenaica
Ligustrum vulgare
Lilium martagon
Linaria genistifolia
Lonicera xylosteum
Lotus corniculatus
Luzula campestris
Luzula divulgata
Luzula luzuloides
Lychnis flos-cuculi
Lysimachia nummularia
Lysimachia vulgaris
Maianthemum bifolium
Medicago falcata
Melampyrum nemorosum
Melampyrum pratense
Melica nutans
Melica picta
Melica uniflora
Mentha longifolia
Mercurialis perennis
Milium effusum
Moehringia trinervia
Molinia caerulea agg.
Mycelis muralis
Myosotis arvensis
Myosotis palustris

Myosotis ramosissima
Myosotis stricta
Myosotis sylvatica
Myosoton aquaticum
Neottia nidus-avis
Noccaea caerulescens
Omphalodes scorpioides
Origanum vulgare
Oxalis acetosella
Paris quadrifolia
Phalaris arundinacea
Phleum phleoides
Phleum pratense
Phragmites australis
Phyteuma spicatum
Picea abies
Pilosella officinarum
Pimpinella major
Pimpinella saxifraga
Pinus sylvestris
Plantago lanceolata
Plantago major
Poa angustifolia
Poa annua
Poa bulbosa
Poa nemoralis
Poa palustris
Poa pratensis
Poa trivialis
Polygonatum multiflorum
Polygonatum odoratum
Polygonum aviculare agg.
Polypodium vulgare
Populus tremula
Potentilla argentea
Potentilla erecta
Potentilla incana
Potentilla reptans
Prenanthes purpurea
Primula elatior
Primula veris
Prunella vulgaris
Prunus mahaleb
Prunus spinosa
Pseudoturritis turrita
Pulmonaria officinalis agg.
Pyrus communis
Quercus petraea
Ranunculus acris
Ranunculus repens
Reynoutria japonica (neo)
Rhamnus cathartica
Ribes alpinum
Ribes uva-crispa
Rosa canina
Rosa pendulina
Rubus caesius
Rubus fruticosus agg.
Rubus idaeus
Rubus saxatilis
Rumex acetosa
Rumex acetosella
Rumex aquaticus
Rumex conglomeratus
Rumex crispus
Rumex obtusifolius
Salix alba
Salix caprea
Salix cinerea
Salix euxina (= *S. fragilis*)
Salix purpurea
Salix rosmarinifolia
Salix triandra
Salvia glutinosa
Salvia pratensis
Sambucus nigra
Sambucus racemosa
Sanguisorba minor
Sanguisorba officinalis
Sanicula europaea
Saxifraga granulata
Scirpus sylvaticus
Scleranthus perennis
Scorzoneroides autumnalis
Scrophularia nodosa
Securigera varia
Sedum acre
Sedum reflexum
Sedum sexangulare
Senecio germanicus
Senecio viscosus
Seseli osseum
Silene dioica
Silene latifolia subsp. *alba*
Silene nutans
Silene vulgaris
Solidago gigantea (neo)
Solidago virgaurea
Sonchus arvensis
Sonchus oleraceus
Sorbus aria
Sorbus aucuparia
Sorbus torminalis
Spergularia rubra
Stachys recta
Stachys sylvatica
Staphylea pinnata
Stellaria graminea
Stellaria holostea
Stellaria media
Stellaria nemorum
Symphytum officinale
Symphytum tuberosum
Tanacetum corymbosum
Tanacetum vulgare
Taraxacum sect. *Erythrosperma*
Taraxacum sect. *Taraxacum*
Tephroseris crispa
Teucrium chamaedrys
Thesium linophyllon
Thymus pulegioides
Tilia cordata
Tilia platyphyllos
Torilis japonica
Tragopogon orientalis
Trifolium alpestre
Trifolium arvense
Trifolium medium
Trifolium pratense
Trifolium repens
Turritis glabra
Ulmus glabra
Urtica dioica
Vaccinium myrtillus
Valeriana excelsa subsp. *sambucifolia*
Verbascum chaixii subsp. *austriacum*
Verbascum nigrum
Veronica anagallis-aquatica
Veronica arvensis
Veronica chamaedrys
Veronica dillenii
Veronica maritima
Veronica officinalis
Veronica sublobata
Veronica vindobonensis
Viburnum opulus
Vicia cracca
Vicia sepium
Vicia tenuifolia
Vincetoxicum hirundinaria
Viola arvensis
Viola mirabilis
Viola reichenbachiana
Viscaria vulgaris
Viscum album subsp. *abietis*
Viscum album subsp. *austriacum*

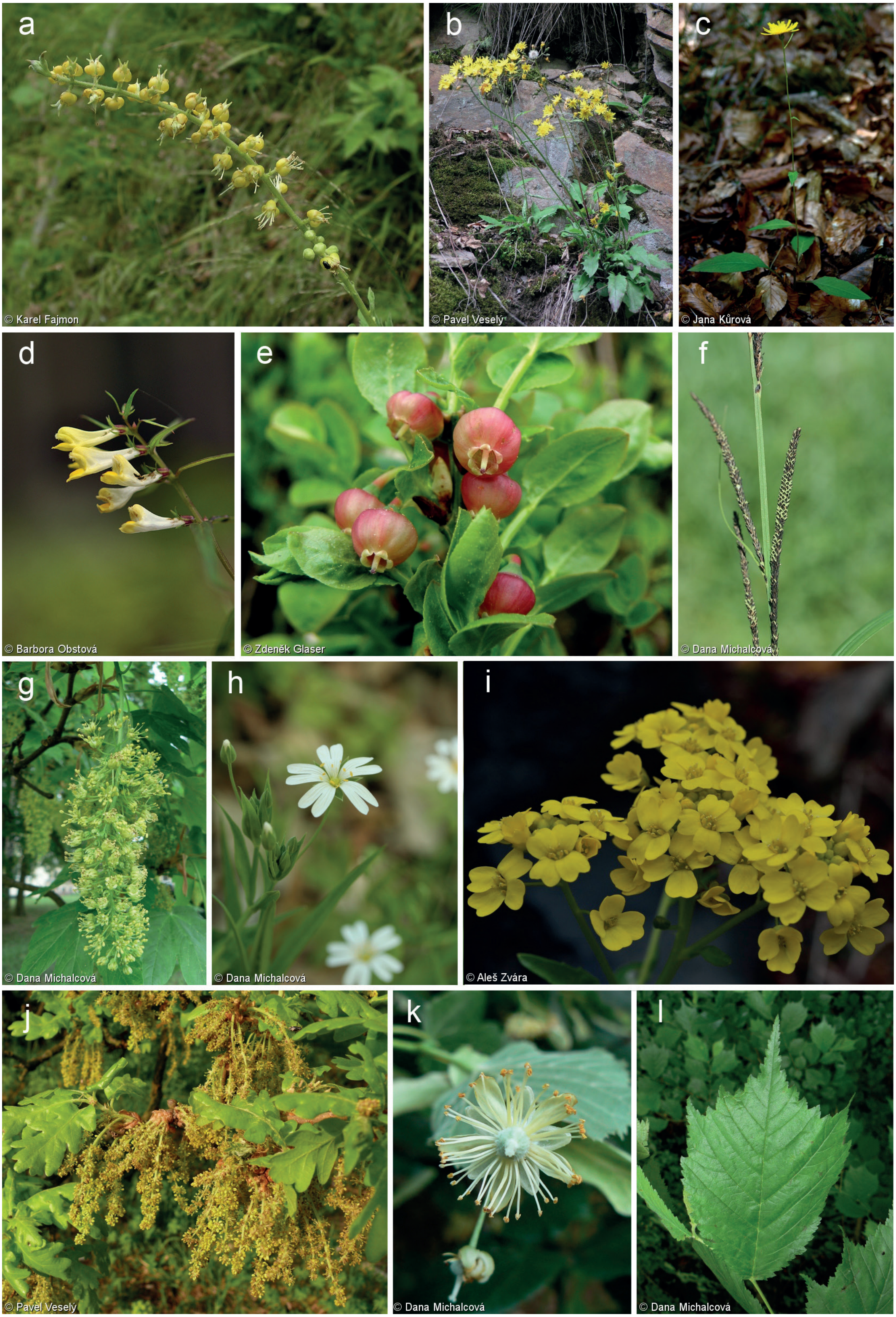


Plate 2a Plants of the *Ledové sluje* ridge in the Podyjí National Park: (a) *Actaea europaea*, (b) *Hieracium murorum*, (c) *Hieracium lachenalii*, (d) *Melampyrum pratense*, (e) *Vaccinium myrtillus*, (f) *Carex buekii*, (g) *Acer pseudoplatanus*, (h) *Stellaria holostea*, (i) *Aurinia saxatilis*, (j) *Quercus petraea*, (k) *Tilia platyphyllos*, (l) *Ulmus glabra*.

(2b) Dyje Valley near Hardegg

The section of the Dyje Valley near the Austrian town of Hardegg is remarkable for the occurrence of crystalline limestone (marble) outcrops in an area otherwise dominated by acidic orthogneiss. Amphibolite also occurs here in places. The patches of bedrock with contrasting chemistry strongly affect the local distribution pattern of plant species and vegetation types. The topographic situation of the Dyje Valley can be seen from Hardegg Viewpoint (*Hardeggská vyhlídka*) on a cliff top above the Dyje Valley. Acidophilous flora and vegetation occurs around this viewpoint, whereas well-developed limestone flora and vegetation occurs on the valley slope called *Hardeggská stráň* ca. 500–700 m SE–SSE from the viewpoint.

The cliffs above the left bank of the Dyje River opposite the Austrian town of Hardegg are formed predominantly of gneiss, though there are also marble outcrops. Photo M. Chytrý.

From Hardegg Viewpoint located on the Czech side of the state border, there is a romantic view of the small town of Hardegg with its castle built on the cliff above the confluence of the Dyje River and its tributary stream called Fugnitz. It was built at the turn of the 12th century as one of the fortresses that protected the Austrian border. A parallel chain of fortresses was built on the Czech (Moravian) side of the border. The castle lost its original purpose in the 17th century and was turned into hunting lodge. After major restoration at the end of 19th century, it became a public museum dedicated to Emperor Maximilian I of Mexico, brother of Emperor Franz Josef I of Austria.

This area is extremely rich in species. More than 600 vascular plant species per 1‘ × 0.6‘ grid square (ca. 1.2 km^2) were recorded during the detailed grid mapping of the flora in the 1990s (Grulich 1997). This number is striking, particularly when we consider the slight human influence in the area. Arable fields and ruderal habitats are almost absent, and even in the past no settlements other than the small town of Hardegg have existed here.

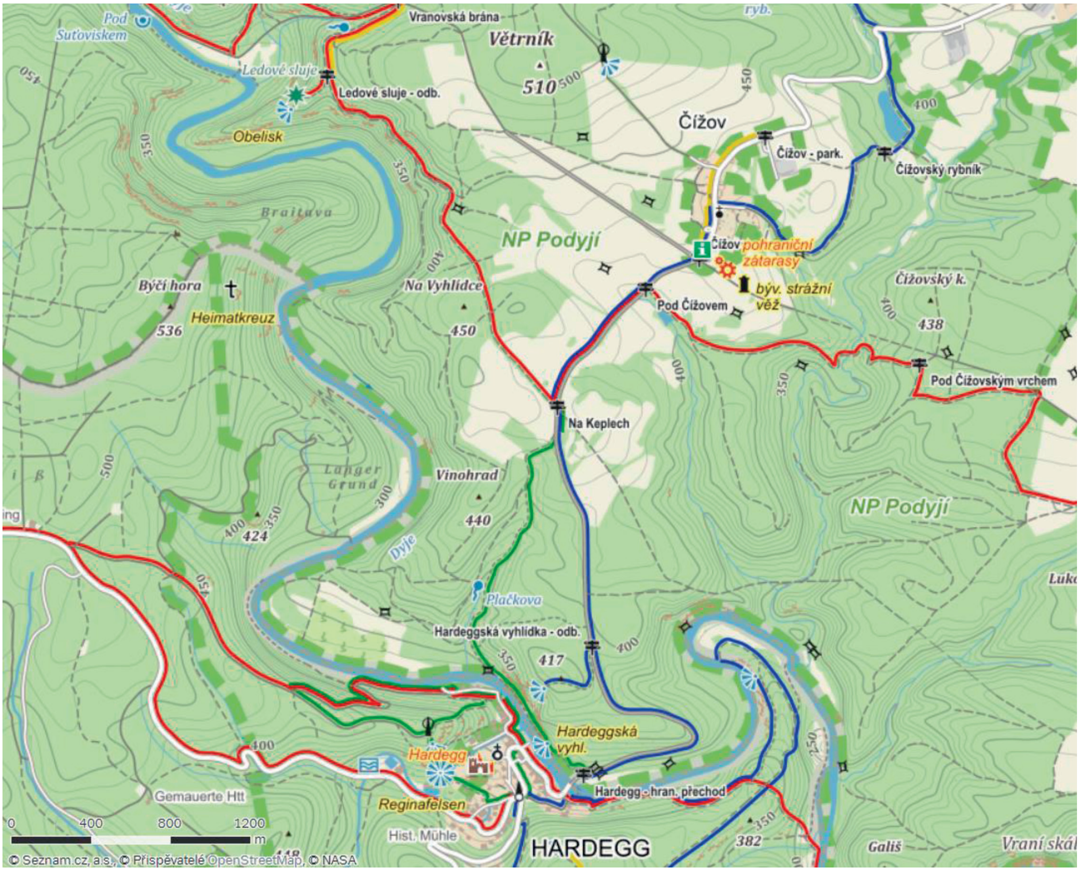
The plateau above the valley is covered by oak-hornbeam forests of the associations *Galio sylvatici-Carpinetum betuli* and *Carici pilosae-Carpinetum betuli* (alliance *Carpinion betuli*), the latter on more base-rich soils. The dominant tree species is *Carpinus betulus*, with *Quercus petraea* and *Tilia cordata* in places. The frequent species of the herb layer include *Carex pilosa*, *Cyclamen purpurascens*, *Dactylis polygama*, *Dentaria bulbifera*, *Hepatica nobilis*, *Pulmonaria obscura* and *Stellaria holostea*. *Abies alba* is remarkable here not only for its presence but also for its natural regeneration.

Cypripedium calceolus grows together with *Corallorhiza trifida*, *Daphne mezereum*, *Euphorbia angulata* and *Hierochloë australis* in a stand of an oak-hornbeam forest on a marble outcrop.

The south-facing slopes with outcrops of amphibolite and amphibolitic gneiss support thermophilous oak forests of the association *Sorbo torminalis-Quercetum* (alliance *Quercion petraeae*) with the acidophilous species *Agrostis vinealis*, *Avenella flexuosa* and *Festuca ovina* in the herb layer. Acidophilous dry grasslands of the association *Festuco pallentis-Aurinietum saxatilis* (alliance *Alysso-Festucion pallentis*) are confined to the gneiss outcrops. *Gagea bohemica* and *Veronica dillenii* occur here on cliff tops and shallow soils next to rock outcrops. Acidophilous oak forests are replaced on marble by basiphilous oak forests, represented here by the associations *Euphorbio-Quercetum* and *Lithospermo purpurocaerulei-Quercetum pubescentis* (alliance *Quercion pubescenti-petraeae*); *Quercus pubescens* is, however, absent from this part of the Dyje Valley due to its isolated position far from the species's continuous distribution in the Pannonian part of southern Moravia. In open places, forest-edge communities of the alliance *Geranion sanguinei* are found with *Buphthalmum salicifolium*, *Dictamnus albus*, *Geranium sanguineum*, *Inula hirta* and *Peucedanum cervaria* along with dry grasslands of the alliance *Festucion valesiacae*, including *Carex humilis*, *Festuca valesiaca*, *Inula ensifolia*, *Orchis militaris*, *Polygala major* and *Stipa pennata*. Grasslands dominated by *Sesleria caerulea*, accompanied by *Aster amellus* and *Hypochaeris maculata* (alliance *Diantho lumnitzeri-Seslerion*), occur rarely on west-facing slopes. Pioneer communities of the association *Cerastietum* (alliance *Alysso alyssoidis-Sedion*) with spring therophytes such as *Arabis auriculata*, *Saxifraga tridactylites* and *Veronica praecox*, are restricted to marble outcrops. White-flowering populations of *Batrachium fluitans* (alliance *Batrachion fluitantis*) are remarkable in the Dyje River in summer.

The open woodland with Quercus robur on former pasture on the south-facing limestone slope of Hardeggská stráň harbours many calcicolous dry-grassland species. Photo M. Chytrý.

The species composition of the forests in this part of the valley is near natural. Planted individuals of Scots pine (*Pinus sylvestris*), Norwegian spruce (*Picea abies*) and European larch (*Larix decidua*) are to be gradually replaced by autochthonous tree species according to the Management Plan for the National Park. The river terraces on the bottom of the Dyje Valley used to be farmed. They were covered mainly with the *Arrhenatherion elatioris* meadows, though also with some arable fields which have been regrassed since the mid-1990s. The meadows will be preserved here as a valuable component of the cultural landscape.



The Dyje Valley near the Austrian town of Hardegg and the Czech village of Čížov in the western-central part of the Podyjí National Park.

Appendix 2b Selected species of vascular plants in the Dyje Valley near Hardegg.

Abies alba
Acer campestre
Aconitum anthora
Adoxa moschatellina
Agrostis vinealis
Achillea nobilis
Achillea pannonica
Ajuga genevensis
Allium flavum
Allium senescens subsp. *montanum*
Alnus glutinosa
Alyssum alyssoides
Anemone ranunculoides
Anemone sylvestris
Anthericum ramosum
Arabidopsis arenosa
Artemisia campestris
Asarum europaeum
Asparagus officinalis
Asperula cynanchica
Asplenium ruta-muraria
Asplenium septentrionale
Aster amellus
Aurinia saxatilis
Avenella flexuosa
Batrachium fluitans
Berberis vulgaris
Brachypodium pinnatum
Bromus benekenii
Buphthalmum salicifolium
Bupleurum falcatum
Calamagrostis arundinacea
Campanula persicifolia
Carex brizoides
Carex buekii
Carex flacca
Carex humilis
Carex michelii
Carex montana
Carex pilosa
Carex supina
Carpinus betulus
Centaurea scabiosa
Centaurea stoebe
Centaurea triumfetti
Cerastium glutinosum
Cerastium semidecandrum
Chamaecytisus ratisbonensis
Clematis recta
Convallaria majalis
Corallorhiza trifida
Cornus mas
Corydalis solida
Cota tinctoria
Cotoneaster integerrimus
Crepis praemorsa
Cyclamen purpurascens
Cypripedium calceolus
Dactylis polygama
Daphne mezereum
Dentaria bulbifera
Dictamnus albus
Echium vulgare
Eryngium campestre
Euonymus europaeus
Euonymus verrucosus
Euphorbia angulata
Euphorbia cyparissias

Plate 2b Plants of the Dyje Valley near Hardegg in the Podyjí National Park: (a) *Cyclamen purpurascens*, (b) *Salvia glutinosa*, (c) *Verbascum chaixii* subsp. *austriacum*, (d) *Carex humilis*, (e) *Quercus robur*, (f) *Ligustrum vulgare*, (g) *Aster amellus*, (h) *Phalaris arundinacea*, (i) *Tanacetum corymbosum*, (j) *Batrachium fluitans*, (k) *Carex pilosa*, (l) *Cornus mas*.

Euphorbia dulcis
Euphorbia epithymoides
Fagus sylvatica
Festuca ovina
Festuca pallens
Festuca valesiaca
Fourraea alpina
Gagea bohemica
Gagea minima
Galanthus nivalis
Galatella linosyris
Galeopsis speciosa
Galium glaucum
Galium odoratum
Galium sylvaticum
Galium valdepilosum
Genista germanica
Genista pilosa
Gentiana cruciata
Geranium phaeum
Geranium sanguineum
Glechoma hirsuta
Helianthemum grandiflorum subsp. *obscurum*
Hepatica nobilis
Hesperis sylvestris
Hieracium umbellatum
Hierochloë australis
Hypericum montanum
Hypochaeris maculata
Inula conyzae
Inula ensifolia
Inula hirta
Inula ×hybrida (= *I. ensifolia* × *I. germanica*)
Inula oculus-christi
Inula salicina
Iris variegata
Isopyrum thalictroides
Juniperus communis
Knautia drymeia
Lactuca quercina
Lactuca viminea
Lappula squarrosa
Lathyrus vernus
Libanotis pyrenaica
Ligustrum vulgare
Lilium martagon
Linaria genistifolia
Lonicera xylosteum
Loranthus europaeus
Luzula divulgata
Luzula luzuloides
Maianthemum bifolium
Medicago falcata
Melampyrum nemorosum
Melica ciliata
Melica picta
Melica uniflora
Melittis melissophyllum
Mercurialis perennis
Microthlaspi perfoliatum
Milium effusum
Minuartia rubra
Neottia nidus-avis
Noccaea caerulescens
Omphalodes scorpioides
Orchis militaris
Orchis purpurea
Origanum vulgare
Orobanche lutea
Phalaris arundinacea
Phleum phleoides
Phyteuma spicatum
Pilosella echioides
Pinus sylvestris
Poa bulbosa
Poa nemoralis
Polygala major
Polygonatum multiflorum
Polygonatum odoratum
Potentilla incana
Potentilla recta
Primula elatior
Primula veris
Prunus fruticosa
Prunus mahaleb
Pulsatilla grandis
Pulsatilla pratensis subsp. *bohemica*
Quercus petraea
Quercus robur
Ranunculus bulbosus
Rumex acetosella
Rumex aquaticus
Salix euxina (= *S. fragilis*)
Salvia glutinosa
Salvia pratensis
Sanicula europaea
Saxifraga tridactylites
Scabiosa ochroleuca
Scleranthus perennis
Scrophularia umbrosa
Sedum album
Sedum reflexum
Senecio germanicus
Seseli osseum
Sesleria caerulea
Silene nutans
Sisymbrium strictissimum (neo)
Sorbus aria
Sorbus torminalis
Stachys recta
Stellaria holostea
Stellaria nemorum
Stipa capillata
Stipa dasyphylla
Stipa pennata
Stipa pulcherrima
Symphytum tuberosum
Tanacetum corymbosum
Taxus baccata
Teucrium chamaedrys
Thesium linophyllon
Thymus praecox
Tilia cordata
Tilia platyphyllos
Trifolium alpestre
Trifolium montanum
Ulmus glabra
Ulmus laevis
Vaccinium myrtillus
Verbascum chaixii subsp. *austriacum*
Verbascum nigrum
Veronica dillenii
Veronica praecox
Veronica prostrata
Veronica spicata
Veronica teucrium
Veronica vindobonensis
Viburnum lantana
Vicia sylvatica
Vicia tenuifolia
Vincetoxicum hirundinaria
Viola mirabilis
Viola tricolor subsp. *saxatilis*
Viscaria vulgaris
Viscum album subsp. *austriacum*

(2c) Šobes meander

Šobes is a promontory in the Dyje Valley surrounded by a large river meander on all sides except for a narrow isthmus in the north-west. It is particularly famous with the public for the vineyard on its SW-facing slope which is one of the oldest in Moravia. Local wines, mainly Welschriesling, Riesling, Pinot Blanc and Pinot Gris, are considered among the best Moravian wines. Šobes was repeatedly settled by people since the Neolithic due to its well-protected location.

Open thermophilous woodland with Quercus petraea and an admixture of Q. pubescens on the granitic isthmus of the Šobes meander. Photo J. Roleček.

The bedrock of Šobes is granite (Batík 1992). The altitude of the Dyje River in this section is about 240 m and the top of Šobes stands at 330 m, resulting in steep slopes with rock outcrops on both sides of the isthmus. All the main types of forest vegetation typical of the granitic part of the Dyje Valley can be seen here because of contrasting slope aspects and variable steepness in a small area (Chytrý & Vicherek 1995).

The upper slopes of the Šobes meander and the adjacent parts of the Dyje Valley, as well as the gently undulating landscape above the valley, are covered by oak forests of *Quercus petraea*. Some individuals of *Q. pubescens* can also be found here, although the site lies outside the continuous distribution of this species in southern Moravia. Of particular interest are the very open woodlands of short oaks on the upper rocky edges of the south-facing valley slopes with the dwarf shrub *Genista pilosa*, the grasses *Avenella flexuosa* and *Festuca ovina* and a well-developed layer of mosses and lichens (association *Genisto pilosae-Quercetum petraeae*, alliance *Quercion petraeae*). They provide a habitat for the European green lizard (*Lacerta viridis*) and Aesculapian snake (*Zamenis longissimus*) which can be frequently seen here. A slightly less dry type of thermophilous oak forest (association *Sorbo torminalis-Quercetum*, alliance *Quercion petraeae*) occurs on less eroded south-facing slopes, and species-poor acidophilous oak forest (the associations *Luzulo luzuloidis-Quercetum petraeae* and *Viscario vulgaris-Quercetum petraeae* of the alliance *Quercion roboris*) occurs on the upper parts of steep north-facing slopes.

The forests in this region were coppiced until the mid-20th century which can still be seen in the multi-stemmed growth of many oak individuals. The dominance of *Quercus petraea* in this area is partly the result of this historical legacy. Coppicing was abandoned in the 1950s and the copppices in easily accessible areas were transformed into high forest, while those on steep valley slopes were left to spontaneous development (Janík et al. 2007). A detailed forestry survey of the former oak coppices left to spontaneous development for more than 50 years at the Lipina site (about 1 km NW of Šobes) indicated that although the tree layer is currently dominated by *Quercus petraea* (with less than 3% of other trees, mainly *Tilia cordata* and *Acer campestre*), natural regeneration in canopy openings is dominated by *Carpinus betulus* and *Acer campestre*, indicating a succession towards a forest with a denser and less uniform tree layer (Janík et al. 2007). Such a successional development may have a negative impact on the light-demanding species in the herb layer of these forests.

The lower slopes of the Dyje Valley near Šobes are covered by oak-hornbeam forests with *Quercus petraea* and *Carpinus betulus* with mesophilous forest species in the herb layer (association *Galio sylvatici-Carpinetum betuli*, alliance *Carpinion betuli*). Ravine forests with *Acer campestre*, *A. platanoides*, *A. pseudoplatanus*, *Carpinus betulus*, *Tilia cordata* and *T. platyphyllos* (association *Aceri-Tilietum*, alliance *Tilio platyphylli-Acerion*) appear where the lower and middle slopes are steeper with rock outcrops or accumulation of rock debris. The loamy-sandy terraces of the Dyje River below the slip-off slopes of the meander harbour patches of *Alnus glutinosa* riparian forests (association *Stellario nemorum-Alnetum glutinosae*, alliance *Alnion incanae*), which is locally replaced by successional woodlands of *Salix euxina* in disturbed places.

There were several watermills on the Dyje River below Šobes until WWII (the site is called *Devět Mlýnů* in Czech or *Neunmühlen* in German, both meaning *Nine Mills*). After the area was enclosed within the prohibited Iron Curtain zone after WWII, the mills were demolished to prevent them from becoming a refuge for people that might enter the prohibited zone illegally. The remnants of millraces and building foundations are visible to this day and several weirs on the river are still functioning. There were hay meadows on the upper river terraces near the watermills, though these were abandoned after the area was closed. The National Park authorities restored management of a mesic meadow (alliance *Arrhenatherion elatioris*) on the river terrace below the Šobes vineyard.

The Šobes meander in the Dyje Valley and the Havraníky heathlands in the eastern part of the Podyjí National Park.

Appendix 2c Selected species of vascular plants in the Šobes meander and adjacent parts of the Dyje Valley.

Acer campestre
Acer negundo (neo)
Acer platanoides
Acer pseudoplatanus
Achillea collina
Achillea pannonica
Achillea setacea
Acinos arvensis
Aconitum anthora
Actaea spicata
Aegopodium podagraria
Aethusa cynapium
Agrimonia eupatoria
Agrostis capillaris
Agrostis vinealis
Ajuga genevensis
Ajuga reptans
Alisma plantago-aquatica
Alliaria petiolata
Allium flavum
Allium oleraceum
Allium senescens subsp. *montanum*
Alnus glutinosa
Alopecurus pratensis
Alyssum montanum
Anemone nemorosa
Anemone ranunculoides
Angelica sylvestris
Antennaria dioica
Anthericum ramosum
Anthoxanthum odoratum
Anthriscus cerefolium
Anthriscus sylvestris
Arabidopsis arenosa
Arabidopsis thaliana

Arctium lappa
Arctium tomentosum
Arenaria serpyllifolia
Aristolochia clematitis
Armeria elongata subsp. *elongata*
Arrhenatherum elatius
Artemisia absinthium
Artemisia campestris
Artemisia vulgaris
Asarum europaeum
Asparagus officinalis
Asperula cynanchica
Asplenium septentrionale
Asplenium trichomanes
Astragalus glycyphyllos
Astrantia major
Athyrium filix-femina
Aurinia saxatilis
Avenella flexuosa
Avenula pubescens
Ballota nigra
Batrachium fluitans
Betonica officinalis
Betula pendula
Biscutella laevigata subsp. *varia*
Brachypodium pinnatum
Brachypodium sylvaticum
Bromus erectus
Bromus hordeaceus
Bromus inermis
Bromus sterilis
Bromus tectorum
Bryonia alba
Buglossoides purpurocaerulea
Bupleurum falcatum
Calamagrostis arundinacea
Calamagrostis epigejos
Calluna vulgaris
Calystegia sepium
Campanula glomerata
Campanula moravica
Campanula patula
Campanula persicifolia
Campanula rapunculoides
Campanula trachelium
Capsella bursa-pastoris
Cardamine amara
Cardamine impatiens
Carduus acanthoides
Carduus crispus
Carex brizoides
Carex buekii
Carex caryophyllea
Carex digitata
Carex hirta
Carex humilis
Carex montana
Carex pallescens
Carex pilosa
Carex praecox
Carex spicata
Carex supina
Carlina acaulis
Carlina vulgaris
Carpinus betulus
Centaurea jacea
Centaurea scabiosa
Centaurea stoebe
Centaurea triumfetti
Centaurium erythraea
Cerastium arvense
Cerastium glutinosum
Cerastium holosteoides
Cerinthe minor
Chaerophyllum aromaticum
Chaerophyllum temulum
Chamaecytisus ratisbonensis
Chelidonium majus
Chenopodium album
Chondrilla juncea
Cichorium intybus
Circaea lutetiana
Cirsium arvense
Cirsium oleraceum
Cirsium palustre
Cirsium vulgare
Clinopodium vulgare
Colchicum autumnale
Convallaria majalis
Convolvulus arvensis
Conyza canadensis (neo)
Cornus mas
Cornus sanguinea
Corydalis cava
Corydalis intermedia
Corydalis solida
Corylus avellana
Cota tinctoria
Cotoneaster integerrimus
Crataegus laevigata
Crataegus monogyna
Crepis biennis
Cruciata laevipes
Cruciata pedemontana
Cyclamen purpurascens
Cytisus nigricans
Cytisus procumbens
Cytisus scoparius
Dactylis glomerata
Dactylis polygama
Danthonia decumbens
Daucus carota
Dentaria bulbifera
Descurainia sophia
Deschampsia cespitosa
Dianthus carthusianorum agg.
Dianthus deltoides
Dictamnus albus
Digitalis grandiflora
Dryopteris carthusiana
Dryopteris filix-mas
Echinochloa crus-galli
Echinops sphaerocephalus
Echium vulgare
Elodea canadensis (neo)
Elymus caninus
Elymus hispidus
Elymus repens
Epilobium adenocaulon (neo)
Epilobium angustifolium
Epilobium hirsutum
Epilobium montanum
Equisetum arvense
Equisetum palustre
Erigeron annuus (neo)
Erodium cicutarium
Eryngium campestre
Euonymus europaeus
Euonymus verrucosus
Euphorbia cyparissias
Euphorbia dulcis
Euphorbia esula
Euphorbia peplus
Fagus sylvatica
Falcaria vulgaris
Fallopia convolvulus
Fallopia dumetorum
Festuca gigantea
Festuca ovina
Festuca pallens
Festuca pratensis
Festuca rubra
Festuca rupicola
Festuca valesiaca
Ficaria verna subsp. *verna*
Filipendula ulmaria
Filipendula vulgaris
Fragaria moschata
Fragaria vesca
Fragaria viridis
Frangula alnus
Fraxinus excelsior
Gagea bohemica
Gagea lutea
Gagea minima
Gagea pratensis
Gagea villosa
Galanthus nivalis
Galatella linosyris
Galeobdolon montanum
Galeopsis pubescens
Galeopsis speciosa
Galeopsis tetrahit
Galinsoga parviflora (neo)
Galium aparine
Galium glaucum
Galium sylvaticum
Galium valdepilosum
Galium verum
Genista pilosa
Genista tinctoria
Geranium phaeum
Geranium pratense

Geranium pusillum
Geranium robertianum
Geranium sanguineum
Geum urbanum
Glechoma hederacea
Glyceria maxima
Glyceria notata
Gnaphalium sylvaticum
Gnaphalium uliginosum
Hackelia deflexa
Hedera helix
Helianthemum grandiflorum subsp. *obscurum*
Helictochloa pratensis
Helichrysum arenarium
Hepatica nobilis
Heracleum sphondylium
Hesperis sylvestris
Hesperis tristis
Hieracium lachenalii
Hieracium laevigatum
Hieracium murorum
Hieracium sabaudum
Hieracium umbellatum
Holcus lanatus
Humulus lupulus
Hylotelephium maximum
Hypericum hirsutum
Hypericum montanum
Hypericum perforatum
Hypochaeris radicata
Impatiens noli-tangere
Impatiens parviflora (neo)
Inula britannica
Inula conyzae
Inula oculus-christi
Inula salicina
Iris pseudacorus
Iris variegata
Isopyrum thalictroides
Jasione montana
Jovibarba globifera
Juncus articulatus
Juncus tenuis (neo)
Juniperus communis
Knautia arvensis
Knautia drymeia
Koeleria macrantha
Lactuca quercina
Lactuca serriola
Lamium album
Lamium amplexicaule
Lamium maculatum
Lamium purpureum
Lapsana communis
Larix decidua (planted)
Lathraea squamaria
Lathyrus pratensis
Lathyrus vernus
Lavatera thuringiaca
Leontodon hispidus
Lepidium draba
Leucanthemum vulgare agg.
Libanotis pyrenaica
Ligustrum vulgare
Lilium martagon
Linaria genistifolia
Lolium perenne
Lonicera xylosteum
Loranthus europaeus
Lotus corniculatus
Luzula campestris
Luzula divulgata
Luzula luzuloides
Lycopus europaeus
Lychnis flos-cuculi
Lysimachia vulgaris
Lythrum salicaria
Malus sylvestris
Malva alcea
Malva moschata
Malva neglecta
Medicago falcata
Medicago lupulina
Melampyrum arvense
Melampyrum pratense
Melica ciliata
Melica nutans
Melica transsilvanica
Melica uniflora
Melilotus officinalis
Mentha arvensis
Mentha longifolia
Mercurialis ovata
Microthlaspi perfoliatum
Moehringia trinervia
Muscari comosum
Mycelis muralis
Myosotis arvensis
Myosotis palustris
Myosotis ramosissima
Myosotis sparsiflora
Myosotis stricta
Myosotis sylvatica
Myosoton aquaticum
Noccaea caerulescens
Odontites luteus
Odontites vernus subsp. *serotinus*
Omphalodes scorpioides
Origanum vulgare
Ornithogalum kochii
Oxalis acetosella
Oxalis stricta (neo)
Pastinaca sativa
Petasites hybridus
Petrorhagia prolifera
Peucedanum cervaria
Peucedanum oreoselinum
Phalaris arundinacea
Phleum phleoides
Phleum pratense
Phlomis tuberosa
Phyteuma spicatum
Picea abies
Picris hieracioides
Pilosella echioides
Pilosella officinarum
Pimpinella major
Pimpinella saxifraga
Pinus sylvestris
Plantago lanceolata
Plantago major
Plantago media
Platanthera bifolia
Poa annua
Poa bulbosa
Poa nemoralis
Poa palustris
Poa pratensis agg.
Poa trivialis
Polygonatum multiflorum
Polygonatum odoratum
Polygonum aviculare agg.
Polypodium vulgare
Populus tremula
Potentilla alba
Potentilla argentea
Potentilla incana
Potentilla recta
Potentilla reptans
Primula veris
Prunella vulgaris
Prunus avium
Prunus fruticosa
Prunus mahaleb
Prunus spinosa
Pseudoturritis turrita
Pulmonaria officinalis agg.
Pulsatilla grandis
Quercus petraea
Quercus pubescens
Ranunculus acris
Ranunculus bulbosus
Ranunculus lanuginosus
Ranunculus repens
Rhamnus cathartica
Rhinanthus minor
Ribes uva-crispa
Robinia pseudoacacia (neo)
Rosa canina
Rosa dumalis
Rosa gallica
Rosa marginata
Rosa spinosissima
Rubus caesius
Rubus fruticosus agg.
Rubus idaeus
Rumex acetosa
Rumex acetosella
Rumex aquaticus
Rumex conglomeratus
Rumex crispus
Rumex obtusifolius

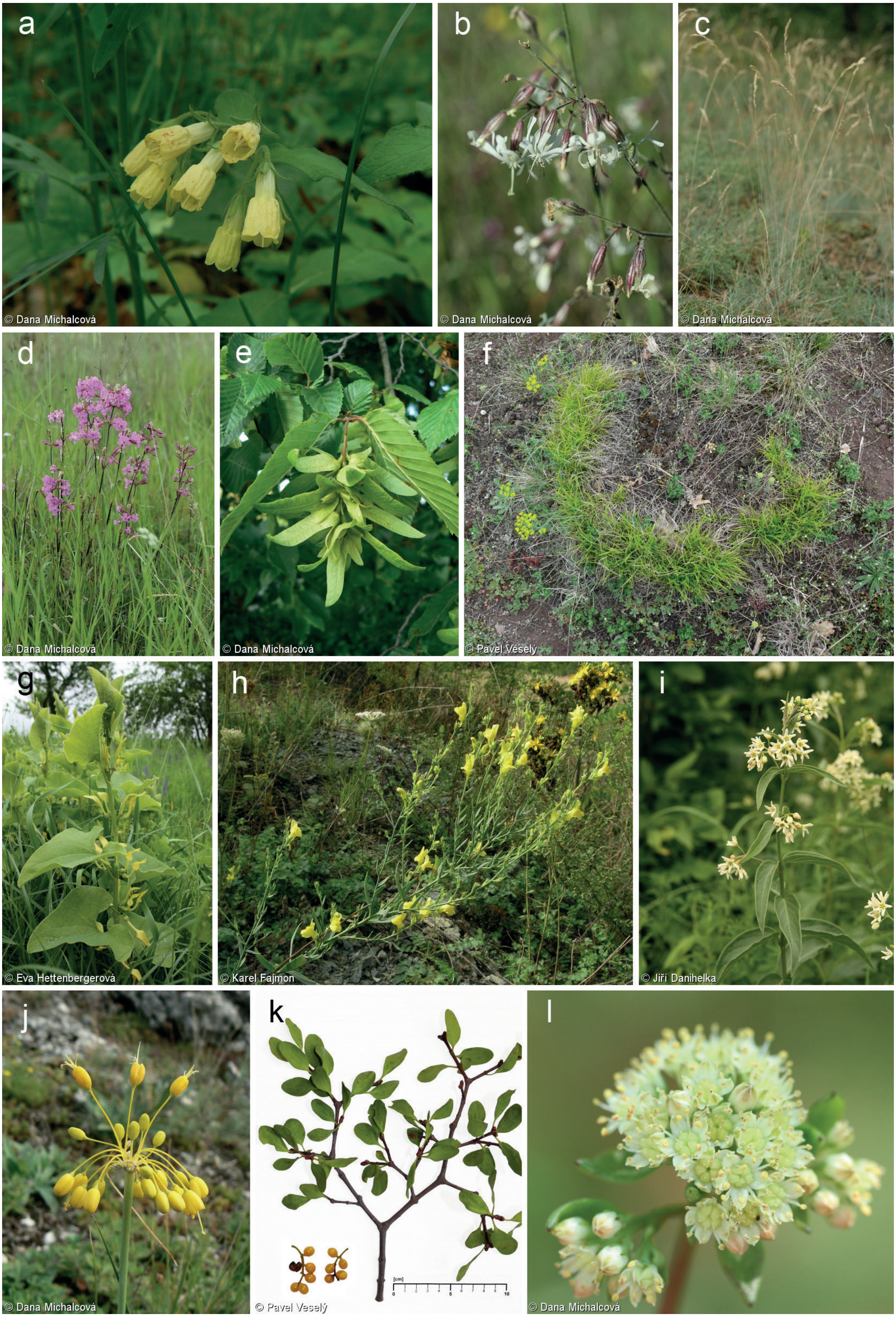


Plate 2c Plants of the Šobes meander in the Podyjí National Park: (a) *Symphytum tuberosum*, (b) *Silene nutans*, (c) *Festuca ovina*, (d) *Viscaria vulgaris*, (e) *Carpinus betulus*, (f) *Carex humilis*, (g) *Aristolochia clematitis*, (h) *Linaria genistifolia*, (i) *Vincetoxicum hirundinaria*, (j) *Allium flavum*, (k) *Loranthus europaeus*, (l) *Hylotelephium maximum*.

Rumex thyrsiflorus (neo)
Salix caprea
Salix euxina (= *S. fragilis*)
Salix viminalis
Salvia nemorosa
Salvia pratensis
Sambucus nigra
Sanguisorba minor
Sanguisorba officinalis
Saponaria officinalis
Saxifraga bulbifera
Saxifraga granulata
Scabiosa canescens
Scabiosa ochroleuca
Scirpus sylvaticus
Scleranthus perennis
Scrophularia nodosa
Securigera varia
Sedum acre
Sedum album
Sedum reflexum
Sedum sexangulare
Selinum carvifolia
Senecio germanicus
Senecio jacobaea
Seseli annuum
Seseli osseum
Silene dioica
Silene latifolia subsp. *alba*
Silene nutans
Silene otites
Silene vulgaris
Sisymbrium strictissimum (neo)
Solidago gigantea (neo)
Solidago virgaurea
Sorbus danubialis
Sorbus aucuparia
Sorbus torminalis
Spergularia rubra
Stachys recta
Stachys sylvatica
Staphylea pinnata
Stellaria graminea
Stellaria holostea
Stellaria media
Stellaria nemorum
Stipa pennata
Symphytum officinale
Symphytum tuberosum
Tanacetum corymbosum
Tanacetum vulgare
Taraxacum sect. *Erythrosperma*
Taraxacum sect. *Taraxacum*
Teucrium chamaedrys
Thesium linophyllon
Thymus praecox
Thymus pulegioides
Tilia cordata
Tilia platyphyllos
Tordylium maximum
Torilis japonica
Tragopogon orientalis
Trifolium alpestre
Trifolium arvense
Trifolium campestre
Trifolium montanum
Trifolium pratense
Trifolium repens
Trisetum flavescens
Turritis glabra
Ulmus glabra
Urtica dioica
Vaccinium myrtillus
Valeriana officinalis
Valeriana stolonifera subsp. *angustifolia*
Valerianella locusta
Verbascum chaixii subsp. *austriacum*
Verbascum lychnitis
Veronica arvensis
Veronica dillenii
Veronica chamaedrys agg.
Veronica officinalis
Veronica persica (neo)
Veronica polita
Veronica prostrata
Veronica serpyllifolia
Veronica spicata
Veronica sublobata
Veronica triphyllos
Veronica verna
Viburnum lantana
Vicia angustifolia
Vicia cracca
Vicia sepium
Vicia tenuifolia
Vincetoxicum hirundinaria
Viola arvensis
Viola hirta
Viola mirabilis
Viola odorata
Viola tricolor subsp. *saxatilis*
Viscaria vulgaris
Viscum album subsp. *austriacum*

(2d) Havraníky-Znojmo heathlands

The gentle slopes of the south-eastern edge of the Bohemian Massif in the eastern part of the Podyjí National Park are formed of granitoids (granite and granodiorite) which are evident as slightly elevated, rather flat outcrops. In places granitoids are covered by Tertiary deposits or loess. Towards the east, sedimentary cover increasingly dominates the landscape and granitoids occur only as small islands.

The largest areas of heathland are found west to south-west of the village of Havraníky, west of the village of Popice and on the extensive flat top of the hill *Kraví hora* between the village of Konice and the town of Znojmo.

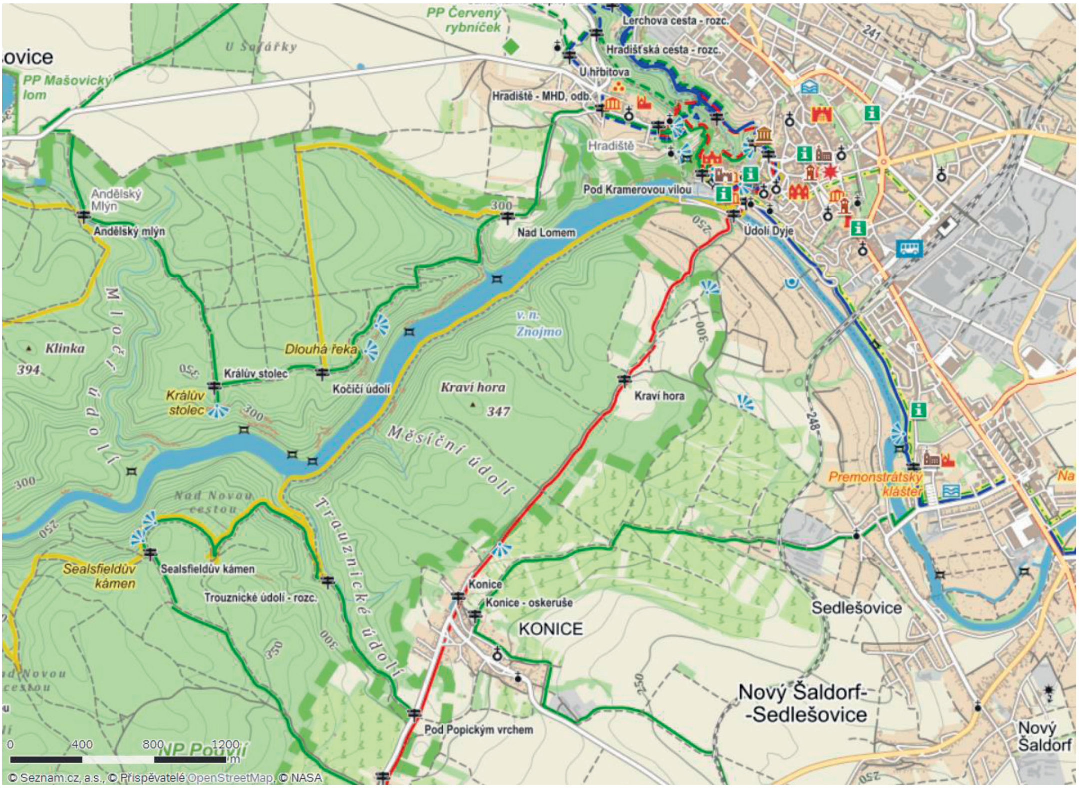
Heathland is an Atlantic vegetation type that becomes increasingly rare in the more continental climate of the dry areas of Central Europe. The Havraníky-Znojmo heathlands, located on the edge of the continental forest-steppe biome, are peculiar for the mixture of typical species of acidophilous sub-Atlantic heathlands and species of continental dry grasslands. The main types of semi-natural vegetation in this area are thermophilous acidophilous grasslands with *Agrostis vinealis*, *Carex humilis*, *Festuca ovina*, *Helictochloa pratensis*, *Potentilla incana* and *Veronica spicata* (association *Potentillo heptaphyllae-Festucetum rupicolae*, alliance *Koelerio-Phleion phleoidis*) and dry heathlands with the same species but dominated by *Calluna vulgaris* (association *Euphorbio cyparissiae-Callunetum vulgaris*, alliance *Euphorbio cyparissiae-Callunion vulgaris*). There are also small patches of pioneer communities with vernal therophytes of the association *Festuco-Veronicetum dillenii* (alliance *Arabidopsion thalianae*) on shallow soils next to rock outcrops (Ambrozek & Chytrý 1990; Chytrý et al. 1997; Chytrý & Vicherek 2003).

The natural vegetation of the area would be a mosaic of thermophilous oak forests with *Quercus petraea*, locally also *Q. pubescens*, and oak-hornbeam forests with *Carpinus betulus* and *Q. petraea*

(Chytrý & Vicherek 1995). The area has, however, probably been deforested since the Neolithic and shallow soils on the granitic bedrock were used as oligotrophic pastures for livestock. There was extensive sheep farming in the 18th and 19th centuries, though most pastures had already been abandoned by the end of the 19th century. Secondary succession of woody vegetation is rather slow on shallow granitic soils in the local dry climate, for which reason an extensive area of former pastures has been preserved as open land to this day. The preservation of grasslands and heathlands throughout the 20th century was supported by occasional grazing, accidental fires and the use of some parts of the area as military training grounds. A large part of the heathland area has, however, been overgrown by forest (Táborská 1999).

Dry Calluna vulgaris heathland with continental dry-grassland species on shallow soil over granite near the village of Havraníky. Photo M. Chytrý.

The expansion of the competitively strong grasses *Arrhenatherum elatius* and *Calamagrostis epigejos*, which began in the mid 1990s, is a serious threat to the heathland biodiversity. The spread of these grasses is probably caused by nitrogen accumulation due to long-term abandonment combined with increased atmospheric deposition (Fiala et al. 2004; Holub et al. 2012). Management experiments in the *Calluna vulgaris* heathlands that began in 1992 are testing whether some of the traditional management practices used in Western European heathlands (burning, sod-cutting with vegetation and topsoil removal, and cutting of the above-ground biomass) are applicable to the dry, continental and species-rich heathlands in the Podyjí National Park (Sedláková & Chytrý 1999; Chytrý et al. 2001). Burning promotes regeneration of *Calluna vulgaris*, both from seed (particularly after strong fire that exposes bare mineral soil) and from vegetative regrowth. Heathland recovery after sod-cutting depends on whether *Calluna* seed germination occurs in the plot. With germination, the community develops towards heathland; without germination it changes into dry grassland. Cutting the above-ground biomass leads to a striking increase in grass cover, followed by a slow recovery of *Calluna*. All these management practices, particularly those involving more pronounced disturbance, lead to an increase in native species richness after about three years, while no alien species spread in this nutrient-poor ecosystem. The National Park staff have been trying to stop the expansion of tall native grasses and associated diversity decline by sheep grazing, mowing and litter removal since the early 1990s (Vild & Stejskal 2013), though so far the results have been unsatisfactory.



The Dyje Valley near the town of Znojmo and the hill Kraví hora.

Appendix 2d Selected species of vascular plants in the dry heathlands near the villages of Popice and Havraníky and on the hilltop of *Kraví hora* near Znojmo.

Achillea collina
Achillea setacea
Agrimonia eupatoria
Agrostis vinealis
Allium flavum
Anthriscus cerefolium
Arabidopsis thaliana
Aristolochia clematitis
Armeria elongata subsp. *elongata*
Arrhenatherum elatius
Artemisia campestris
Asparagus officinalis
Asperula cynanchica
Avenella flexuosa
Berteroa incana
Biscutella laevigata subsp. *varia*
Bromus tectorum
Calluna vulgaris
Carex humilis
Carex supina
Carlina vulgaris
Centaurea stoebe
Cerastium glutinosum
Chamaecytisus ratisbonensis
Chondrilla juncea
Conium maculatum
Cotoneaster integerrimus
Cytisus procumbens
Cytisus scoparius
Danthonia decumbens
Dianthus carthusianorum agg.
Dianthus deltoides
Echium vulgare
Elymus hispidus
Erodium cicutarium
Euphorbia cyparissias
Euphorbia virgata
Festuca ovina
Festuca pallens
Festuca pulchra
Festuca valesiaca
Ficaria calthifolia
Filago arvensis
Filago minima
Filipendula vulgaris
Fragaria viridis
Frangula alnus
Gagea bohemica
Gagea pusilla
Gagea villosa
Galatella linosyris
Galium valdepilosum
Genista pilosa
Genista sagittalis (neo)
Helictochloa pratensis
Helichrysum arenarium
Hieracium umbellatum
Hypochaeris maculata
Hypochaeris radicata
Inula britannica
Iris pumila
Jasione montana
Jovibarba globifera
Koeleria macrantha
Lepidium draba
Linaria genistifolia
Luzula campestris
Melampyrum arvense
Melica transsilvanica
Mercurialis annua
Microthlaspi perfoliatum
Myosotis ramosissima
Myosotis stricta
Nardus stricta
Odontites luteus
Odontites vernus subsp. *serotinus*
Onopordum acanthium
Petrorhagia prolifera

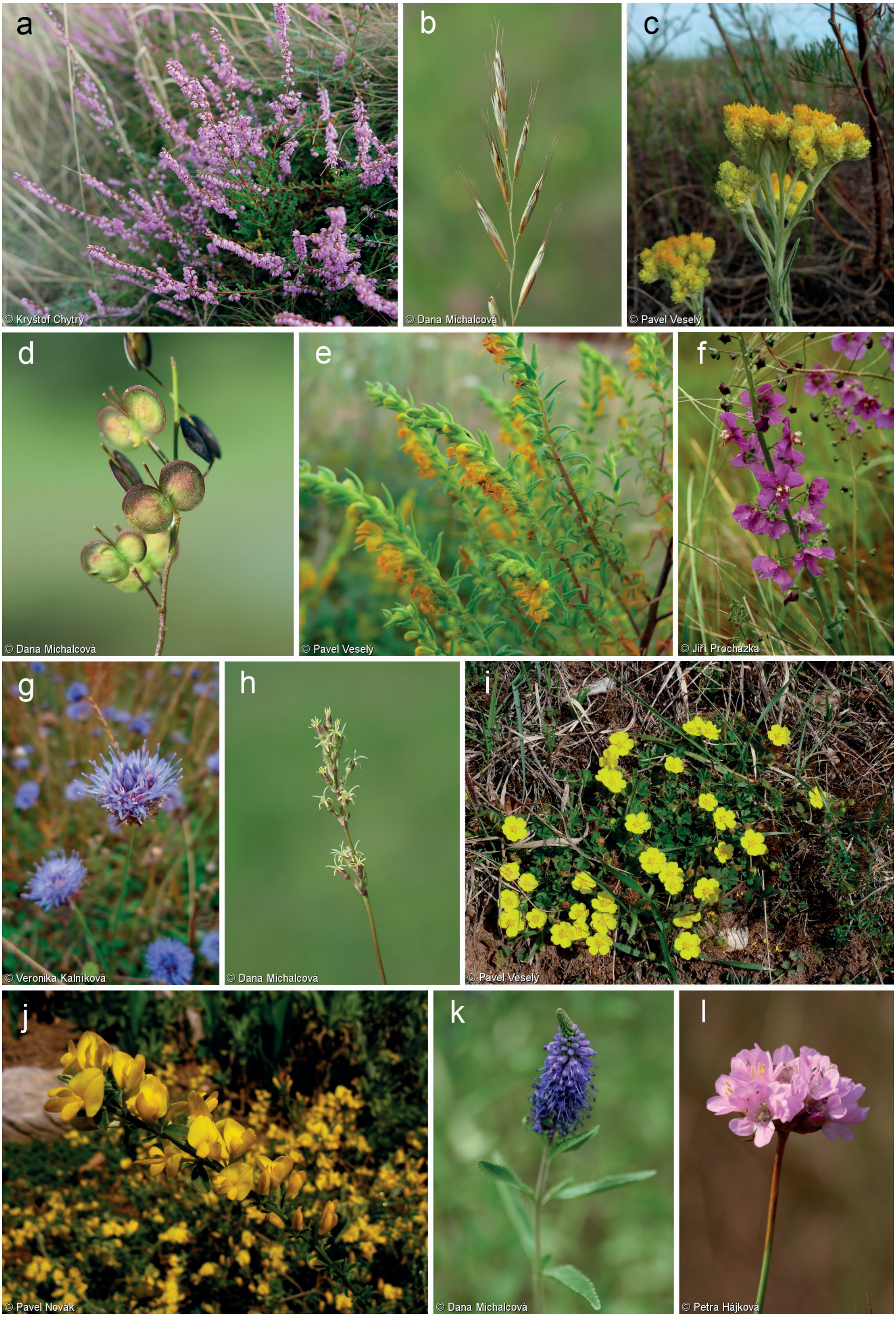


Plate 2d Plant of the Havraníky-Znojmo heathlands: (a) *Calluna vulgaris*, (b) *Helictochloa pratensis*, (c) *Helichrysum arenarium*, (d) *Biscutella laevigata* subsp. *varia*, (e) *Odontites luteus*, (f) *Verbascum phoeniceum*, (g) *Jasione montana*, (h) *Silene otites*, (i) *Potentilla incana*, (j) *Genista pilosa*, (k) *Veronica spicata*, (l) *Armeria elongata* subsp. *elongata*.

Phleum phleoides
Picris hieracioides
Pilosella echioides
Plantago media
Poa bulbosa
Polygonatum odoratum
Potentilla incana
Prunus fruticosa
Pulsatilla grandis
Ranunculus bulbosus
Rhinanthus minor
Rosa gallica
Rosa marginata
Rosa rubiginosa
Rosa spinosissima
Rumex acetosella
Salvia nemorosa
Salvia pratensis
Sanguisorba minor
Saxifraga bulbifera
Saxifraga granulata
Scabiosa canescens
Scabiosa ochroleuca
Scleranthus perennis
Scleranthus polycarpos
Scorzonera cana
Sedum acre
Sedum reflexum
Sedum sexangulare
Senecio jacobaea
Seseli annuum
Seseli hippomarathrum
Seseli osseum
Silene otites
Sisymbrium altissimum (neo)
Stachys recta
Stipa capillata
Stipa pennata
Taraxacum sect. *Erythrosperma*
Teucrium chamaedrys
Thymus praecox
Trifolium alpestre
Trifolium arvense
Trifolium campestre
Trifolium montanum
Trifolium retusum
Valerianella locusta
Verbascum lychnitis
Verbascum phoeniceum
Veronica dillenii
Veronica prostrata
Veronica spicata
Veronica triphyllos
Veronica verna
Veronica vindobonensis
Vicia pannonica subsp. *striata*
Vincetoxicum hirundinaria
Viola canina
Viscaria vulgaris

Spring view of a heathland near Havraníky with yellow flowers of Genista pilosa. Photo M. Chytrý.

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3 Mohelno Serpentinite Steppe

Pavel Daněk

Introduction

The Mohelno Serpentinite Steppe (*Mohelenská hadcová step*) is situated in south-western Moravia near the small town of Mohelno, about 30 km west of Brno, in the low-altitudinal marginal area of the Bohemian-Moravian Highlands. The steppe occupies the south-facing slopes of the Jihlava River Valley which dissects a gently undulating landscape.

The upper part of the south-facing slopes of the Mohelno Serpentinite Steppe with a dry grassland of Stipa dasyphylla in the foreground and open Pinus sylvestris woodland in the background. Photo P. Daněk.

Geology, soils and climate

The area is built of metamorphic rocks (mainly granulite, gneiss and amphibolite) which are locally overlaid by loess. An important feature of this region is the occurrence of serpentinite. This ultrabasic metamorphic rock can also be found in other parts of the Bohemian Massif (e.g. the Slavkovský les Mountains in western Bohemia, the Bohemian Forest foothills in south-western Bohemia and other parts of the Bohemian-Moravian Highlands), though in south-western Moravia, and particularly near Mohelno, the serpentinite effect on vegetation is magnified by the location of its outcrops in a deep river valley. While the gentle slopes allow an accumulation of a soil layer deep enough to suppress the effects of the serpentinite bedrock on vegetation to some extent, the steep slopes of the Jihlava River Valley are being permanently eroded, for which reason the serpentinite bedrock has a stronger influence on the associated flora and fauna.

Serpentinite is an ultrabasic rock characterized by a high magnesium content combined with a relatively low calcium content. Serpentinite soils are usually deficient in nutrients (nitrogen, phosphorus and potassium) and contain large amounts of heavy metals (cobalt, nickel and chromium). In addition to the chemical properties of serpentinite, its physical characteristics are also important.

The Mohelno Serpentinite Steppe with a meander of the Jihlava River in the 1920s and in 2014. The forest has expanded considerably due to the abandonment of grazing. Photo archive of the Department of Botany and Zoology, Masaryk University, and J. Chytrý.

The dark colour and low thermal conductivity of the rock lead to its strong heating during the summer when surface temperatures can reach 50 °C, exceeding the air temperature by more than 20 °C (Hrudička 1937). Although some of these properties are also characteristic of other rock types, their unique combination on serpentinites constitutes stress conditions under which only some species can survive.

In contrast to the sunny south-facing serpentinite slopes with shallow leptosols which host mainly steppic vegetation and pine forests, the opposite north-facing slopes are mostly formed of granulite and are covered by broad-leaved deciduous forests on cambisols.

The climate is relatively warm and dry with mean annual temperatures slightly above 8 °C and the annual precipitation sum of approximately 550 mm.

History of botanical research and nature conservation

The local botanist Carl Roemer found Mohelno's most famous plant species, the fern *Notholaena marantae*, in 1858. In the early 20th century, the flora of the Mohelno serpentinites was studied by Josef Podpěra who drafted the first proposal for the establishment of a nature reserve in 1914. In the 1920s, his work was continued by Jindřich Suza who studied the relationship between bedrock and vegetation and gave a detailed description of local plant communities (Suza 1928). In 1933, a nature reserve was finally established on an area of 50 ha to prevent the steppe from being destroyed by stone mining. Intensive research continued in the reserve, resulting in a series of seven edited volumes published between 1934 and 1948 presenting knowledge in several fields (geology, soil science, climatology, botany and zoology; Veselý 2002).

The nature reserve was re-established in 1952. Its previously ambiguous borders were newly delineated and the steppe was no longer allowed to be used as pasture. Sheep and goat grazing had been a traditional form of management and its abandonment led to successional changes of steppic vegetation towards pine forests. While only 13% of the reserve's area was covered by forests in 1950, this proportion had increased to 62% by the late 1980s (Čechová et al. 1997). Following expert discussion, a decision was taken to cut much of the overabundant pine as well as some alien tree species (*Robinia pseudoacacia* and *Pinus banksiana*). The main phase of the reduction of tree stands took about ten years and was followed by the restoration of sheep and goat grazing in 1997. This traditional form of management has been practiced ever since (Čech 2005).

Construction of the nearby Dukovany Nuclear Power Station and associated Dalešice and Mohelno dams had a significant impact on the local landscape and led to flooding of a 30-km-long section of the Jihlava Valley in 1978. The Mohelno dam, which serves as a reservoir of process water for the nuclear power plant, borders the western part of the Mohelno Serpentinite Steppe. The large amount of water contained in the reservoir affects the mesoclimate of the valley by lowering daily temperature amplitudes and increasing air humidity (Quitt 1996) which might affect vegetation, particularly in the lower parts of the slopes.

Intensive research into the steppe and its surroundings resulted in several botanical studies in the 1990s. Chytrý & Vicherek (1996) described the natural and semi-natural vegetation of the Oslava, Jihlava and Rokytná River Valleys including the unique plant communities of the Mohelno Serpentinite Steppe and other serpentinite outcrops in the Jihlava Valley. Unar (1996) produced a flora inventory of the Mohelno Steppe and Koblížek et al. (1998) characterized the flora of selected localities in the region. The area of the reserve was extended to approximately 110 ha in 2012.

Vegetation and flora

There are several phytogeographically distinct species growing on the steppe. The aforementioned *Notholaena marantae*, a southern European fern, reaches its northern distribution limit here at an isolated site. *Stipa dasyphylla* is a continental Eurasian grass also known from some other southern Moravian localities, but all these occurrences are isolated from the species' continuous distribution range. *Scorzonera austriaca*, a species from the *Asteraceae* family, reaches its north-western distribution limit here.

The upper part of the steppe and the adjacent plateau are covered by dry grasslands (alliance *Festucion valesiacae*) dominated mainly by narrow-leaved tussocky fescues (*Festuca rupicola*, *F. valesiaca*) and feather grasses (*Stipa capillata*, *S. dasyphylla*, *S. pulcherrima*) accompanied by other drought-adapted species (*Carex humilis*, *Dorycnium germanicum*, *Dianthus carthusianorum* agg., *Seseli hippomarathrum*, *Thymus praecox* and *Veronica spicata*). The plateau between the river valley and the town of Mohelno is grazed by sheep. Patches of specific grassland vegetation type dominated by *Festuca pulchra* with the occurrence of the serpentinite specialist *Armeria elongata* subsp. *serpentini* can be found here.

Plants tend to grow much smaller than usual in this part of the steppe, and much attention has been paid to this phenomenon in the past. Rudolf Dvořák described 279 of these 'nanisms' in 170 plant species and attributed them to the low availability of nutrients and water on serpentinite soils (Dvořák 1935). However, since the abandonment of pasture these ecomorphoses have largely disappeared and it is currently believed that they were mainly caused by grazing (Kolář & Vít 2008).

The lower slopes are steep with numerous gullies and serpentinite outcrops. In this part of the reserve, the vegetation of dry grasslands changes to rocky steppes (alliance *Alysso-Festucion pallentis*) with dominant *Festuca pallens* and an admixture of other plants capable of growing on shallow stony soils (*Allium flavum*, *Alyssum montanum*, *Euphorbia seguieriana*, *Linaria genistifolia*, *Melica ciliata*, *Pilosella echioides* and *Seseli osseum*). In late summer, this vegetation is dominated in places by the grass *Bothriochloa ischaemum*.

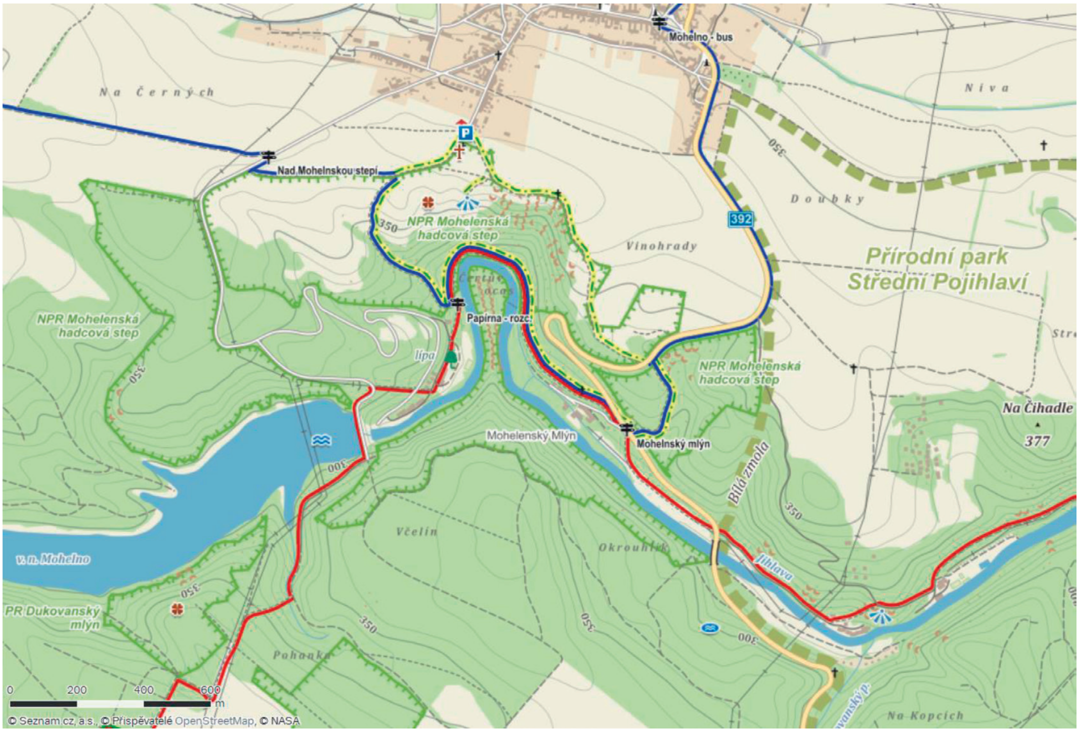
The serpentinite rock outcrops are a habitat of *Notholaena marantae* which grows together with another fern, the serpentinite specialist *Asplenium cuneifolium* (Vicherek 1970). Along with other species confined to rock crevices (*A. ruta-muraria*, *A. trichomanes*, *Sedum album*) they form the association *Notholaeno marantae-Sempervivetum hirti* (alliance *Asplenion cuneifolii*) which can only be found here and on a few serpentinite sites in Austria. Scattered individuals of Scots pine (*Pinus sylvestris*) are common all over the steppe, while some shrubs (*Berberis vulgaris*, *Prunus mahaleb*) form patches of dense scrub.

The eastern part of the reserve is covered by forests. Most of them consist of *Pinus sylvestris* which expanded here after the abandonment of pasture, so the herb layer composition is similar to that of the steppe, though usually less diverse. The potential natural vegetation here is supposed to be a deciduous oak forest dominated by *Quercus petraea* with pine restricted mainly to rock outcrops. These oak forests on serpentinite can still be found elsewhere in the Jihlava Valley and were described as an endemic association *Asplenio cuneifolii-Quercetum petraeae* (Chytrý & Horák 1997), a specific type related to the broad association *Sorbo torminalis-Quercetum* (alliance *Quercion petraeae*). In some places with deeper soils (mostly close to the valley bottom), stands with an admixture or dominance of broad-leaved species (*Acer campestre*, *Carpinus betulus*, *Quercus petraea*, *Tilia cordata*) occur and these forests can be classified as oak-hornbeam forests (association *Galio sylvatici-Carpinetum betuli*, alliance *Carpinion betuli*) if their understorey contains mesophilous forest species (e.g. *Actaea spicata*, *Asarum europaeum*, *Campanula persicifolia*, *Galium odoratum*, *Hepatica nobilis*, *Pulmonaria officinalis* agg.). On the valley floor, close to the river, remnants of floodplain forests of the association *Stellario nemorum-Alnetum glutinosae* (alliance *Alnion incanae*) can be found. These forests are rich in vernal species that flower before tree-leaf flushing (e.g. *Adoxa moschatellina*, *Corydalis solida*, *Ficaria verna* and *Gagea lutea*).

The riverbanks are lined with discontinuous vegetation dominated by the grass *Phalaris arundinacea* accompanied by other hygrophilous species such as *Carex buekii* and *Scrophularia umbrosa* (alliance *Phalaridion arundinaceae*).

***Kozének* Nature Reserve**

Located about 4 km east of the town of Mohelno, the *Kozének* Nature Reserve provides ecological contrasts to the serpentinite steppe. Its gentle slopes on granulite and gneiss are occupied mainly by dry acidophilous grasslands of the alliance *Koelerio-Phleion phleoidis*. This vegetation is dominated by grasses (e.g. *Festuca ovina*, *F. rupicola*, *Helictochloa pratensis* and *Phleum phleoides*) and hosts several endangered species (e.g. *Orchis morio*, *Pulsatilla grandis* and *Saxifraga bulbifera*). In some places thermophilous species are less abundant and the grasslands have different dominants (e.g. *Briza media*, *Carex pallescens*, *Danthonia decumbens* and *Nardus stricta*) characteristic of the nutrient-poor acidophilous *Nardus* grasslands of the alliance *Violion caninae*. These grasslands were historically used as pasture, similarly to the Mohelno Steppe, evidence of which is provided by scattered old individuals of shrubby juniper (*Juniperus communis*). The outer parts of the reserve are covered by hay meadows of the alliance *Arrhenatherion elatioris* dominated by grasses (*Agrostis capillaris*, *Anthoxanthum odoratum*, *Arrhenatherum elatius*, *Festuca rubra*) and including several mesophilous herb species (e.g. *Centaurea jacea*, *Ranunculus acris* and *Rhinanthus minor*).



The Mohelno Serpentinite Steppe in the Jihlava River Valley south of the town of Mohelno.

Acidophilous dry grassland in the Kozének Nature Reserve. Photo D. Zelený.

Appendix 3 Selected species of vascular plants of the Mohelno Serpentinite Steppe.

Species of dry grasslands and rock outcrops

Achillea collina
Acinos arvensis
Agrimonia eupatoria
Agrostis capillaris
Agrostis vinealis
Ajuga genevensis
Allium flavum
Alyssum alyssoides
Alyssum montanum
Anchusa officinalis
Antennaria dioica
Anthericum ramosum
Anthoxanthum odoratum
Anthyllis vulneraria
Arabidopsis thaliana
Arabis hirsuta
Arenaria serpyllifolia agg.
Armeria elongata subsp. *serpentini*
Arrhenatherum elatius
Artemisia campestris
Artemisia vulgaris
Asperula cynanchica
Asplenium cuneifolium
Asplenium ruta-muraria
Asplenium trichomanes
Aster amellus
Astragalus glycyphyllos
Atriplex patula
Ballota nigra
Berberis vulgaris
Berteroa incana
Biscutella laevigata subsp. *varia*
Bothriochloa ischaemum
Brachypodium pinnatum
Briza media
Bromus erectus
Bromus hordeaceus
Bromus japonicus
Bupleurum falcatum
Calamagrostis epigejos
Calluna vulgaris
Campanula patula
Campanula rotundifolia agg.
Capsella bursa-pastoris
Carduus acanthoides
Carduus nutans
Carex caryophyllea
Carex humilis
Carex michelii
Carex muricata
Carex praecox
Carlina acaulis
Carlina vulgaris
Carum carvi
Caucalis platycarpos
Centaurea jacea
Centaurea scabiosa
Centaurea stoebe
Centaurea triumfetti
Cerastium arvense
Cerastium holosteoides
Cerastium pumilum
Chamaecytisus ratisbonensis
Chenopodium album
Chondrilla juncea
Cichorium intybus
Cirsium arvense
Cirsium vulgare
Clinopodium vulgare
Convolvulus arvensis
Conyza canadensis (neo)
Cotoneaster integerrimus
Cuscuta epithymum
Cynodon dactylon
Cynoglossum officinale
Cystopteris fragilis
Cytisus nigricans
Dactylis glomerata
Danthonia decumbens
Descurainia sophia
Dianthus carthusianorum agg.
Dorycnium germanicum
Echium vulgare
Elymus hispidus
Erigeron acris
Erophila verna
Eryngium campestre
Euphorbia cyparissias
Euphorbia epithymoides
Euphorbia seguieriana
Falcaria vulgaris
Festuca ovina
Festuca pallens
Festuca pulchra
Festuca rubra
Festuca rupicola
Festuca valesiaca
Filago arvensis
Filipendula vulgaris
Fragaria viridis
Frangula alnus
Gagea bohemica
Gagea lutea
Galatella linosyris
Galeopsis angustifolia
Galium album
Galium verum
Genista pilosa
Genista tinctoria
Geranium pusillum
Hackelia deflexa
Helianthemum grandiflorum subsp. *obscurum*
Helictochloa pratensis
Herniaria glabra
Hieracium schmidtii
Holosteum umbellatum
Hylotelephium maximum
Hypericum perforatum
Inula conyzae
Juniperus communis
Knautia arvensis
Koeleria macrantha
Koeleria pyramidata
Lactuca serriola
Leontodon hispidus
Lepidium campestre
Leucanthemum vulgare
Ligustrum vulgare
Linaria genistifolia
Lotus corniculatus
Luzula campestris
Medicago falcata
Melica ciliata
Melica transsilvanica
Melilotus officinalis
Muscari comosum
Myosotis arvensis
Myosotis ramosissima
Myosotis stricta
Noccaea caerulescens
Nonea pulla
Notholaena marantae
Odontites vernus subsp. *serotinus*
Oenothera moravica (neo)
Opuntia phaeacantha (neo)
Orchis morio
Origanum vulgare
Orobanche alba
Orobanche coerulescens
Phelipanche arenaria
Phelipanche purpurea
Phleum phleoides
Picris hieracioides
Pilosella echioides
Pilosella officinarum
Pimpinella saxifraga
Pinus sylvestris
Plantago lanceolata
Plantago media
Poa bulbosa
Polypodium vulgare
Potentilla argentea
Potentilla heptaphylla
Potentilla incana
Prunella grandiflora
Prunus fruticosa
Prunus mahaleb
Prunus spinosa
Quercus petraea
Quercus robur
Ranunculus acris
Ranunculus bulbosus
Robinia pseudoacacia (neo)

Plate 3 Plants of the Mohelno Serpentinite Steppe: (a) *Pinus sylvestris*, (b) *Seseli hippomarathrum*, (c) *Notholaena marantae*, (d) *Euphorbia seguieriana*, (e) *Berberis vulgaris*, (f) *Senecio erucifolius*, (g) *Scabiosa canescens*, (h) *Stipa capillata*, (i) *Asplenium cuneifolium*, (j) *Prunus mahaleb*, (k) *Bothriochloa ischaemum*, (l) *Thymus praecox*.

Rosa canina
Rumex acetosella
Salvia pratensis
Sanguisorba minor
Saxifraga bulbifera
Scabiosa canescens
Scabiosa ochroleuca
Scleranthus annuus
Scorzonera austriaca
Securigera varia
Sedum acre
Sedum album
Sedum sexangulare
Senecio erucifolius
Senecio jacobaea
Senecio viscosus
Seseli hippomarathrum
Seseli osseum
Silene otites
Silene vulgaris
Sorbus aucuparia
Stachys recta
Stipa capillata
Stipa dasyphylla
Stipa pennata
Stipa pulcherrima
Stipa tirsa
Taraxacum sect. *Erythrosperma*
Taraxacum sect. *Taraxacum*
Teucrium chamaedrys
Thymus praecox
Tragopogon orientalis
Trifolium alpestre
Trifolium arvense
Trifolium campestre
Trifolium dubium
Trifolium repens
Verbascum chaixii subsp. *austriacum*
Verbascum lychnitis
Verbascum phoeniceum
Verbascum thapsus
Veronica arvensis
Veronica prostrata
Veronica vindobonensis
Veronica spicata
Vicia tenuifolia
Vincetoxicum hirundinaria
Viola rupestris
Viscaria vulgaris

Forest species
Abies alba
Acer campestre
Acer platanoides
Acer pseudoplatanus
Actaea spicata
Adoxa moschatellina
Aegopodium podagraria
Ajuga reptans
Alliaria petiolata
Anemone nemorosa
Angelica sylvestris
Anthriscus sylvestris
Asarum europaeum
Asplenium cuneifolium
Astrantia major
Athyrium filix-femina
Avenella flexuosa
Betula pendula
Brachypodium pinnatum
Brachypodium sylvaticum
Bupleurum falcatum
Calamagrostis arundinacea
Campanula persicifolia
Campanula rapunculoides
Campanula rotundifolia agg.
Campanula trachelium
Cardamine impatiens
Carex digitata
Carex humilis
Carex muricata agg.
Carpinus betulus
Cephalanthera damasonium
Chaerophyllum temulum
Chelidonium majus
Convallaria majalis
Cornus mas
Cornus sanguinea
Corydalis solida
Corylus avellana
Crataegus spp.
Cyclamen purpurascens
Cytisus nigricans
Dactylis polygama
Dryopteris carthusiana
Dryopteris filix-mas
Elymus caninus
Epilobium montanum
Epipactis helleborine
Euonymus europaeus
Euonymus verrucosus
Euphorbia dulcis
Festuca gigantea
Festuca ovina
Ficaria verna subsp. *verna*
Fragaria moschata
Fragaria vesca
Fraxinus excelsior
Galeobdolon montanum
Galium odoratum
Galium sylvaticum
Genista pilosa
Genista tinctoria
Geranium robertianum
Geum urbanum
Hepatica nobilis
Hieracium laevigatum
Hieracium murorum
Hieracium sabaudum
Hypericum montanum
Hypericum perforatum
Impatiens noli-tangere
Impatiens parviflora (neo)
Knautia drymeia
Lactuca viminea
Ligustrum vulgare
Lilium martagon
Lonicera xylosteum
Luzula divulgata
Luzula luzuloides
Melampyrum pratense
Melica nutans
Melica uniflora
Mercurialis perennis
Moehringia trinervia
Monotropa hypophegea
Mycelis muralis
Myosotis sylvatica
Neottia nidus-avis
Noccaea montana
Omphalodes scorpioides
Oxalis acetosella
Phyteuma spicatum
Picea abies
Pilosella officinarum
Pinus sylvestris
Poa angustifolia
Poa nemoralis
Polygonatum multiflorum
Polygonatum odoratum
Polypodium vulgare
Populus tremula
Primula veris
Prunus avium
Pulmonaria obscura
Pulmonaria officinalis
Quercus petraea
Quercus robur
Rhamnus cathartica
Rosa canina
Rubus fruticosus agg.
Sambucus nigra
Scrophularia nodosa
Senecio ovatus
Sesleria caerulea
Silene nutans
Solidago virgaurea
Sorbus aucuparia
Stachys sylvatica
Stellaria holostea
Symphytum tuberosum
Tanacetum corymbosum
Tilia cordata
Tilia platyphyllos
Trifolium alpestre
Ulmus glabra
Urtica dioica
Vaccinium myrtillus
Veronica chamaedrys

Veronica officinalis
Vicia pisiformis
Vincetoxicum hirundinaria
Viola collina
Viola odorata
Viola reichenbachiana
Viola riviniana
Viscaria vulgaris
Viscum album subsp. *austriacum*

Dry grassland with Carex humilis and Dorycnium germanicum in the canopy openings of a pine woodland in the Mohelno Serpentinite Steppe. Photo P. Daněk.

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4 Krumlov-Rokytná Conglomerates

Pavel Novák

4

Introduction

The Krumlov-Rokytná Conglomerates (*Krumlovsko-rokytenské slepence*) National Nature Reserve was established in 2005 to protect the dry grasslands, rock outcrops and forests of the Rokytná River Valley north-east of the town of Moravský Krumlov, about 30 km SW of Brno. The reserve is comprised of two parts which in total cover an area of 87 ha at altitudes between 220 and 340 m. It is situated on the north-western edge of the Pannonian Province in southern Moravia and contains various vegetation types with many rare (especially thermophilous) plant species.

The southern part of the reserve surrounds a meander with the historical town of Moravský Krumlov with its picturesque sixteenth-century Renaissance castle, remains of the old town fortification, several churches and the remarkable Baroque pilgrimage Chapel of St. Florian from 1697 situated on the upper edge of the reserve.

Summer view of dry grassland with blooming Allium senescens subsp. montanum. This vegetation is frequently developed on the red Carboniferous-Permian conglomerate on the steep sunny slopes of the Rokytná Valley above the historical town of Moravský Krumlov. Photo P. Novák.

Geology, soils and climate

The site includes a deep river valley with steep rocky slopes, numerous rock outcrops and small screes. The prevailing bedrock type is the Carboniferous-Permian red conglomerate containing mostly acidic gravel clasts within a matrix of a fine-grained calcareous sediment which has supported the development of mixed acidophilous and basiphilous flora and vegetation. Quaternary alluvial and colluvial sediments occur along the Rokytná River meandering along the valley bottom. Cambisols are the predominant soil type on slopes, while leptosols occur around rock outcrops and fluvisols on the valley bottom. The mean annual temperature is 8–9 °C and annual precipitation sum is about 550 mm.

Vegetation

Deciduous forests dominate the landscape in the Rokytná Valley. Thermophilous and basiphilous oak forests with *Quercus petraea* and *Q. pubescens* occur on steep sunny slopes, containing thermophilous shrubs and small trees such as *Acer campestre*, *Cornus mas*, *Ligustrum vulgare*, *Prunus spinosa* and *Sorbus torminalis*. Their herb layer is characterized by thermophilous basiphilous species including *Buglossoides purpurocaerulea*, *Carex michelii*, *Dictamnus albus* and *Teucrium chamaedrys*. On base-rich soils these forests are classified in the association *Euphorbio-Quercetum* (alliance *Quercion pubescenti-petraeae*) and in places with decalcified soils in the associations *Sorbo torminalis-Quercetum* and rarely also *Genisto pilosae-Quercetum petraeae* (alliance *Quercion petraeae*; Chytrý & Horák 1997). Acidophilous oak forests with *Quercus petraea* (alliance *Quercion roboris*) characterized by a species-poor herb layer with prevailing acidophytes and a well-developed moss layer can be found in isolated patches with acidic soils. Ravine forests of the association *Aceri-Tilietum* (alliance *Tilio platyphylli-Acerion*) with a herb layer of nutrient-demanding forest species such as *Galeobdolon montanum* and *Mercurialis perennis* occur on shaded slopes with stone accumulation. Shaded rock outcrops support small patches of basiphilous lime forests dominated by *Tilia cordata* and *T. platyphyllos*, which harbour several light-demanding relict species such as *Aconitum anthora*, *Saxifraga paniculata* and *Sesleria caerulea* (association *Seslerio albicantis-Tilietum cordatae*, alliance *Tilio platyphylli-Acerion*). Finally, oak-hornbeam forests of the association *Galio sylvatici-Carpinetum betuli* (alliance *Carpinion betuli*) are well developed on mesic cambisols. These forests are the most widespread vegetation type in the reserve. Their tree layer is dominated by *Carpinus betulus* and *Quercus petraea*, with an admixture of other trees such as *Acer campestre* and *Tilia cordata*. The herb layer contains mesophilous forest herbs such as *Galium sylvaticum*, *Hepatica nobilis* and *Symphytum tuberosum* (Neuhäusl & Neuhäuslová 1968). Ash-alder riparian forests, mostly dominated by *Alnus glutinosa*, have developed along the Rokytná River (association *Stellario nemorum-Alnetum glutinosae*, alliance *Alnion incanae*).

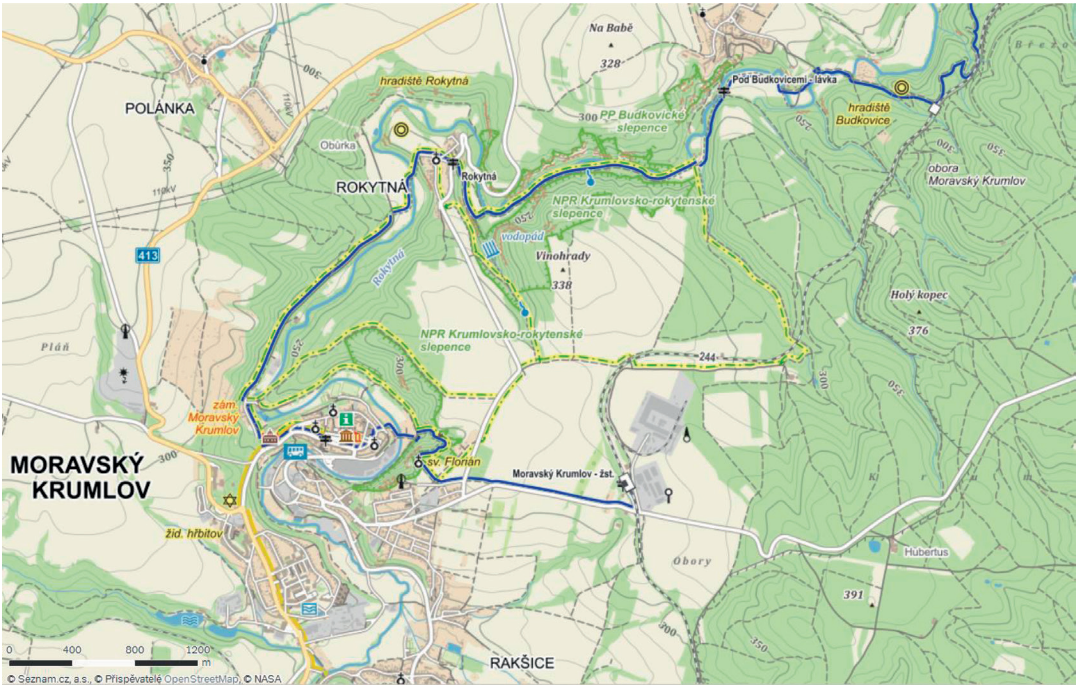
Natural non-forest vegetation occurs on isolated conglomerate outcrops and in their surroundings. Grasslands of *Sesleria caerulea* have developed mainly on north-facing outcrops (association *Saxifrago paniculatae-Seslerietum caeruleae*, alliance *Diantho lumnitzeri-Seslerion*). They contain several light-demanding arcto-alpine, alpine and montane species including, for example, *Arabidopsis petraea* and *Saxifraga paniculata* in addition to *Sesleria caerulea*. They grow together with species of dry grasslands such as *Asperula cynanchica*, *Bupleurum falcatum* and *Thymus praecox*. Patches of low-shrub vegetation dominated by *Cotoneaster integerrimus* (association *Junipero communis-Cotoneasteretum integerrimi*, alliance *Berberidion vulgaris*) have developed in similar habitats. Sparse vegetation with ferns (particularly *Asplenium trichomanes* and *Polypodium vulgare*) and bryophytes often grows on shaded rock outcrops. Vegetation of species-rich dry grasslands with *Carex humilis*, *Festuca valesiaca* and *Stipa* spp. has developed on sunny slopes (alliances *Alysso-Festucion pallentis* and *Festucion valesiacae*). Eroded rock terraces with very shallow soil are habitats of sparse short-growing herbaceous vegetation with spring ephemerals (e.g. *Erophila verna* and *Saxifraga tridactylites*), succulents (e.g. *Sedum album* and *S. sexangulare*) and mosses (e.g. *Racomitrium canescens*, *Rhytidium rugosum*, *Thuidium abietinum*, *Tortella inclinata* and *Tortula ruralis*). Herbaceous forest-fringe vegetation with *Geranium sanguineum* (alliance *Geranion sanguinei*) and low scrub with *Prunus fruticosa* and *Rosa spinosissima* (association *Prunetum fruticosae*, alliance *Prunion fruticosae*) is found in ecotones between rock-outcrop grasslands and tall scrub or thermophilous oak forests (Vězda 1950; Chytrý & Vicherek 1996).

Flora

The flora of the reserve comprises about 550 taxa of vascular plants. The most abundant population of the neoendemic species *Dianthus moravicus* (*D.* sect. *Plumaria*) in its entire geographic range is of particular importance. This pink-flowering species occurs at only seven localities, all in deep valleys of the Dyje, Jihlava, Rokytná and Želetavka Rivers in south-western Moravia (Kovanda 1982). The flora of the reserve also contains some sub-Mediterranean species which reach their northern distribution limit here, such as *Cleistogenes serotina*, *Fumana procumbens*, *Medicago monspeliaca* and *M. pros-*

trata. Similarly to other areas with base-rich rock outcrops in southern Moravia, subcontinental and sub-Mediterranean elements are mixed in the flora of the reserve. The former group includes *Carex supina*, *Festuca valesiaca* and *Stipa capillata*; the latter group is represented by, for example, *Dictamnus albus* and the above-mentioned species at their northern distribution limit. The flora of the whole of south-western Moravia is characterized by several species with wider distribution in the Eastern Alps (Suza 1944). This group is represented in the reserve by, for example, *Cyclamen purpurascens* and *Fourraea alpina.* The former is a geophyte of mesic forests flowering in late summer.

In the spring, the reserve is characterized by the blooming of rich populations of dry grassland species such as *Gagea bohemica*, *Iris pumila*, *Pulsatilla grandis* and *P. pratensis*. The vernal aspect of oak-hornbeam, scree and alluvial forests is also well developed with numerous ephemeroids such as *Anemone nemorosa*, *A. ranunculoides*, *Corydalis solida*, *Isopyrum thalictroides*, *Omphalodes scorpioides* and *Scilla bifolia*. Flowering populations of *Dianthus moravicus*, *Genista pilosa* and *Ranunculus illyricus* are characteristic of the dry grasslands and rock outcrops in late spring. Numerous species bloom in the summer, including *Allium flavum*, *A. senescens* subsp. *montanum*, *Artemisia campestris*, *Fumana procumbens*, *Medicago prostrata* and *Seseli osseum*. The flora of the reserve includes almost all species of the genus oak (*Quercus*) that occur naturally in the Czech Republic, including the thermophilous sub-Mediterranean species *Quercus cerris* and *Q. pubescens* (Vězda 1950; Chytrý & Vicherek 1996).



The Rokytná Valley near the town of Moravský Krumlov and the village of Rokytná and the western part of Krumlov Wood.

Appendix 4 Selected species of vascular plants of the Krumlov-Rokytná Conglomerates.

Acer campestre
Acer platanoides
Acinos arvensis
Aconitum anthora
Aegopodium podagraria
Agrostis capillaris
Agrostis vinealis
Achillea millefolium agg.
Alliaria petiolata
Allium flavum
Allium senescens subsp. *montanum*
Alyssum montanum
Anthericum ramosum
Anthriscus sylvestris
Arabidopsis petraea
Arabidopsis thaliana
Arrhenatherum elatius
Artemisia campestris
Asperula cynanchica
Asperula tinctoria
Asplenium septentrionale
Asplenium trichomanes
Betula pendula
Bothriochloa ischaemum
Brachypodium pinnatum
Brachypodium sylvaticum
Bromus sterilis
Buglossoides purpurocaerulea
Bupleurum falcatum

Outcrops of Carboniferous-Permian conglomerate in the Rokytná Valley near Moravský Krumlov with Iris pumila and the Baroque chapel of St. Florian in the background. Photo J. Roleček.

Calamagrostis epigejos
Campanula bononiensis
Campanula moravica
Campanula persicifolia
Campanula rapunculoides
Carex caryophyllea
Carex digitata
Carex humilis
Carex michelii
Carex muricata agg.
Carex praecox
Carex supina
Carpinus betulus
Centaurea stoebe
Cirsium arvense
Cleistogenes serotina
Convolvulus arvensis
Conyza canadensis (neo)
Cornus mas
Cornus sanguinea
Corylus avellana
Cotoneaster integerrimus
Crataegus monogyna
Cyclamen purpurascens
Cynoglossum officinale
Cytisus procumbens
Dactylis glomerata
Dactylis polygama
Dictamnus albus
Digitalis grandiflora
Dorycnium germanicum
Echium vulgare
Elymus hispidus
Erophila verna
Eryngium campestre
Euonymus verrucosus
Euphorbia cyparissias
Euphorbia epithymoides
Falcaria vulgaris
Festuca ovina
Festuca pallens
Festuca rupicola
Festuca valesiaca
Fourraea alpina
Fragaria vesca
Fragaria viridis
Fraxinus excelsior
Fumana procumbens
Gagea bohemica
Galeobdolon montanum
Galium album
Galium glaucum
Galium valdepilosum
Galium verum
Genista pilosa
Geranium robertianum
Geranium sanguineum
Geum urbanum
Helictochloa pratensis
Hieracium murorum
Hieracium sabaudum
Hypericum perforatum
Impatiens glandulifera (neo)
Impatiens parviflora (neo)
Inula hirta
Inula oculus-christi
Iris pumila
Isopyrum thalictroides
Jovibarba globifera
Koeleria macrantha
Lathyrus niger
Ligustrum vulgare
Linaria genistifolia
Loranthus europaeus
Luzula luzuloides
Medicago falcata
Medicago monspeliaca
Medicago prostrata
Melampyrum pratense
Melica ciliata
Melica transsilvanica
Minuartia setacea
Muscari comosum
Myosotis stenophylla
Myosotis sylvatica
Omphalodes scorpioides
Origanum vulgare
Phleum phleoides
Picris hieracioides
Pilosella officinarum

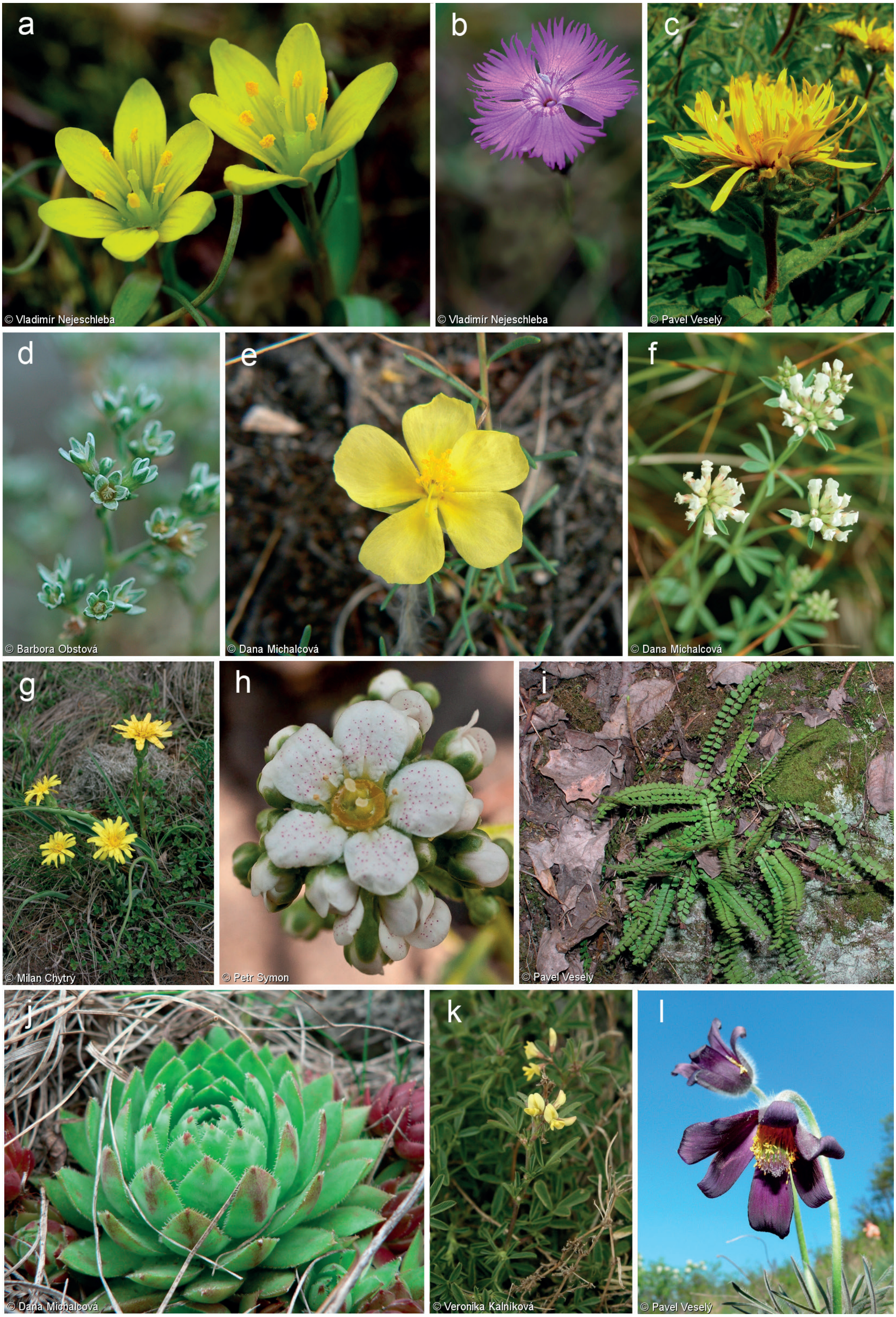


Plate 4 Plants of the Krumlov-Rokytná Conglomerates: (a) *Gagea bohemica*, (b) *Dianthus moravicus*, (c) *Inula hirta*, (d) *Scleranthus perennis*, (e) *Fumana procumbens*, (f) *Dorycnium germanicum*, (g) *Scorzonera austriaca*, (h) *Saxifraga paniculata*, (i) *Asplenium trichomanes*, (j) *Jovibarba globifera*, (k) *Medicago prostrata*, (l) *Pulsatilla pratensis* subsp. *bohemica*.

Pimpinella saxifraga
Plantago lanceolata
Plantago media
Poa angustifolia
Poa annua
Poa bulbosa
Poa nemoralis
Polycnemum majus
Polygonatum odoratum
Polypodium vulgare
Potentilla incana
Primula veris
Prunus avium
Prunus fruticosa
Prunus mahaleb
Prunus spinosa
Pulmonaria mollis
Pulmonaria officinalis
Pulsatilla grandis
Pulsatilla pratensis subsp. *bohemica*
Quercus cerris
Quercus petraea
Quercus pubescens
Quercus robur
Ranunculus acris
Ranunculus bulbosus
Ranunculus illyricus
Rhamnus cathartica
Robinia pseudoacacia (neo)
Rosa canina agg.
Rosa spinosissima
Salvia nemorosa
Salvia pratensis
Saxifraga paniculata
Saxifraga tridactylites
Scabiosa canescens
Scabiosa ochroleuca
Scilla bifolia
Scleranthus perennis
Scorzonera austriaca
Scrophularia nodosa
Securigera varia
Sedum acre
Sedum album
Sedum reflexum
Sedum sexangulare
Seseli hippomarathrum
Seseli osseum
Sesleria caerulea
Setaria viridis
Solidago virgaurea
Sorbus aria agg.
Sorbus torminalis
Stachys recta
Staphylea pinnata
Stipa capillata
Stipa dasyphylla
Stipa pennata
Stipa pulcherrima
Stipa tirsa
Tanacetum corymbosum
Tephroseris integrifolia
Teucrium chamaedrys
Thymus pannonicus
Thymus praecox
Tilia cordata
Tilia platyphyllos
Torilis japonica
Trifolium alpestre
Trifolium arvense
Urtica dioica
Verbascum chaixii subsp. *austriacum*
Verbascum phoeniceum
Veronica officinalis
Veronica teucrium
Veronica vindobonensis
Vicia cracca
Vicia pisiformis
Vincetoxicum hirundinaria
Viola hirta
Viola mirabilis
Viola odorata
Viola riviniana
Viscaria vulgaris

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5 Krumlov Wood

Pavel Novák

Introduction

Krumlov Wood (*Krumlovský les*) is a large forested area situated between Moravský Krumlov, Vedrovice, Moravské Bránice and Ivančice on an elevated plateau between the Rokytná and Jihlava Rivers, about 25 km SW of Brno. It covers an area of about 30 km^2 at altitudes of 250–415 m. Acidic granitoids predominate in this area, though they are covered by loess deposits in some places at the margins of the wood. The climate of the region is relatively dry and warm with a mean annual temperature of 8–9 °C and annual precipitation sum of about 550 mm. Most of the area of the wood is covered by species-poor acidophilous oak forests on the granitoid bedrock, while thermophilous basiphilous oak forests and oak-hornbeam forests occur on loess. A large part of Krumlov Wood is fenced and serves as a game preserve for red deer. The flora of the wood is relatively rich in species, particularly in the loess-covered areas. The occurrence of thermophilous elements such as *Drymocallis rupestris*, *Inula ensifolia*, *Mercurialis ovata* and *Rosa spinosissima* and species of intermittently wet meadows and light forests such as *Cnidium dubium*, *Dianthus superbus* and *Euphorbia angulata* is important. The northernmost locality of the acidophilous perialpine species *Carex fritschii* is found in the wood.

Extensive oak forest near the north-western margin of Krumlov Wood with a herb layer dominated by Convallaria majalis and Poa nemoralis. Photo P. Novák.

In the past the wood served as a source of firewood and, in part, as a wood-pasture, and was mostly managed as a coppice-with-standards. In the 20th century, the coppices were mostly converted into high forests resulting in increased shading of the herb layer and decline of light-demanding species. An experiment was established here in 1999 with the aim of converting high forest back into coppice-with-standards with the use of thinning management (Utinek 2004). As a result, light-demanding oligotrophic species increased in the herb layer of the thinned experimental plots (Vild et al. 2013).

Excursion site

There is a suitable excursion site outside the game preserve in Krumlov Wood in its north-western part about 2 km from the town of Moravský Krumlov, near Moravský Krumlov railway station. In this part of the wood, loess deposits cover the Permo-Carboniferous conglomerates and granitoids of the Brno Massif which occur at the surface in only small patches. A small patch of the Devonian limestone is also found here. The prevailing soil type is cambisol.

Mesophilous forests dominate this area. There are two forest types on loess. The first type is slightly acidophilous oak forest dominated by *Quercus petraea* occurring in locally drier habitats (alliance *Carpinion betuli*). Its herb layer consists of mesophilous forest herbs (e.g. *Stellaria holostea* and *Viola riviniana*), species of thermophilous oak forests (*Carex michelii*, *Chamaecytisus ratisbonensis* and *Lathyrus niger*) and species of acidophilous oak forests (e.g. *Festuca ovina* and *Luzula luzuloides*). The second type is mesophilous oak forest with *Quercus petraea* of the association *Melico pictae-Quercetum roboris* (= *Potentillo albae-Quercetum* auct., alliance *Quercion petraeae*). The occurrence of species of *Molinia* meadows (e.g. *Dianthus superbus*, *Galium boreale* and *Serratula tinctoria*) is characteristic of its herb layer. Species-poor acidophilous oak forest (association *Luzulo luzuloidis-Quercetum petraeae*, alliance *Quercion roboris*) is common on shallow soils on granitoid bedrock. Its herb layer is usually sparse, containing common forest acidophytes (e.g. *Hieracium* spp., *Luzula luzuloides* and *Veronica officinalis*), and the moss layer is well developed. Species-rich oak-hornbeam forest (association *Galio sylvatici-Carpinetum betuli*, alliance *Carpinion betuli*) has developed on a small limestone outcrop. It contains several basiphilous and thermophilous elements such as *Clematis recta*, *Crepis praemorsa* and *Viola mirabilis*. Slopes on the Permo-Carboniferous conglomerate are covered by thermophilous oak forests of the association *Sorbo torminalis-Quercetum* (alliance *Quercion petraeae*) and rarely also *Euphorbio-Quercetum* (alliance *Quercion pubescenti-petraeae*; Novák 2013).

The Rokytná Valley near the town of Moravský Krumlov and the village of Rokytná and the western part of Krumlov Wood.

The flora of this part of Krumlov Wood is relatively rich in species due to its heterogeneous geological substrate. The late vernal and summer aspect of the slightly acidophilous oak forest and the oak forest with species of *Molinia* meadows is remarkably diverse. The occurrence of rare light-demanding species of open forests, such as *Antennaria dioica*, *Clematis recta*, *Crepis praemorsa*, *Dianthus superbus*, *Hierochloë australis* and *Pulmonaria mollis*, is of great importance for nature

Plate 5 Plants of Krumlov Wood: (a) *Dianthus superbus*, (b) *Neottia nidus-avis*, (c) *Fragaria moschata*, (d) *Pulmonaria mollis*, (e) *Clematis recta*, (f) *Lathyrus niger*, (g) *Antennaria dioica*, (h) *Carex digitata*, (i) *Campanula persicifolia*, (j) *Convallaria majalis*, (k) *Anemone nemorosa*, (l) *Serratula tinctoria*.

conservation. The epiphytic hemiparasite *Loranthus europaeus* is almost omnipresent on oaks in the whole of Krumlov Wood (Novák 2013).

Appendix 5 Selected species of vascular plants on the excursion site in Krumlov Wood.

Acer campestre
Acer platanoides
Aegopodium podagraria
Agrostis capillaris
Agrostis stolonifera
Achillea millefolium agg.
Ajuga reptans
Alliaria petiolata
Anemone nemorosa
Antennaria dioica
Anthriscus sylvestris
Artemisia vulgaris
Asarum europaeum
Astragalus glycyphyllos
Betonica officinalis
Betula pendula
Brachypodium sylvaticum
Bromus sterilis
Calamagrostis arundinacea
Calamagrostis epigejos
Campanula persicifolia
Campanula rapunculoides
Cardamine impatiens
Carex caryophyllea
Carex digitata
Carex michelii
Carex montana
Carex muricata agg.
Carex pilosa
Carpinus betulus
Cephalanthera damasonium
Chaerophyllum temulum
Chamaecytisus ratisbonensis
Chelidonium majus
Clematis recta
Clinopodium vulgare
Conyza canadensis (neo)
Cornus sanguinea
Corylus avellana
Convallaria majalis
Crepis praemorsa
Dactylis polygama
Dentaria bulbifera
Deschampsia cespitosa
Dianthus superbus
Euonymus europaeus
Euphorbia angulata
Euphorbia dulcis
Fallopia convolvulus
Festuca heterophylla
Festuca ovina
Fragaria moschata
Fragaria vesca
Frangula alnus
Fraxinus excelsior
Galeopsis tetrahit agg.
Galium album
Galium aparine
Galium boreale
Galium odoratum
Galium sylvaticum
Genista germanica
Genista tinctoria
Geranium robertianum
Hepatica nobilis
Heracleum sphondylium
Hieracium lachenalii
Hieracium maculatum
Hieracium murorum
Hieracium sabaudum
Hierochloë australis
Hylotelephium maximum
Hypericum perforatum
Impatiens parviflora (neo)
Juncus tenuis (neo)
Lapsana communis
Lathyrus niger
Lathyrus vernus
Ligustrum vulgare
Lonicera xylosteum
Loranthus europaeus
Luzula luzuloides
Lysimachia nummularia
Maianthemum bifolium
Melampyrum nemorosum
Melampyrum pratense
Melica nutans
Melittis melissophyllum
Moehringia trinervia
Mycelis muralis
Myosotis sylvatica
Neottia nidus-avis
Pilosella officinarum
Pinus sylvestris
Plantago major
Poa annua
Poa nemoralis
Polygonatum multiflorum
Polygonatum odoratum
Prunella vulgaris
Prunus avium
Prunus spinosa
Pulmonaria mollis
Pulmonaria officinalis
Quercus petraea
Quercus robur
Ranunculus lanuginosus
Rhamnus cathartica
Robinia pseudoacacia (neo)
Rosa canina agg.
Rubus fruticosus agg.
Rubus idaeus
Rumex acetosella
Scrophularia nodosa
Selinum carvifolia
Serratula tinctoria
Silene nutans
Sorbus torminalis
Stachys sylvatica
Stellaria holostea
Symphytum tuberosum
Tanacetum corymbosum
Tilia cordata
Torilis japonica
Urtica dioica
Veronica chamaedrys
Vicia cracca
Vicia pisiformis
Vicia sepium
Vincetoxicum hirundinaria
Viola canina
Viola mirabilis
Viola riviniana
Viscaria vulgaris

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6 Moravian Karst

Lubomír Tichý

Introduction

The Moravian Karst (*Moravský kras*) to the north of Brno is a narrow limestone strip about 25 km long extending over an area of about 92 km^2, consisting of a few plateaus separated by deep valleys. The altitude ranges from 220 m in the south to 610 m in the north. There are more than 1100 caves, mostly in the central and northern part of the karst area. Five caves are open to the public, four situated in the northern part and one (*Výpustek*) in the Josefov Valley in the central part of the Moravian Karst.

Geology and geomorphology

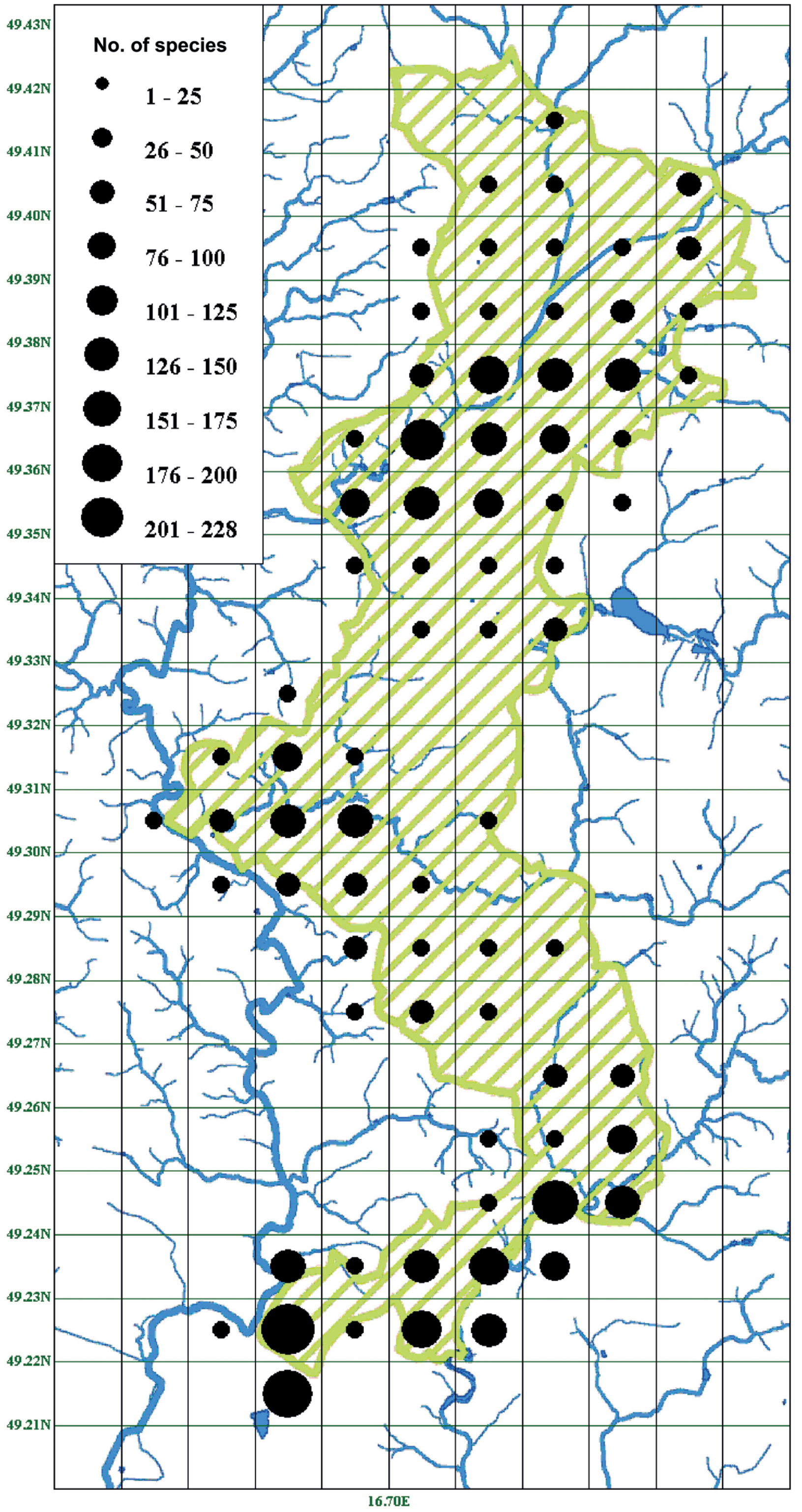
The Moravian Karst is formed mostly of Middle to Upper Devonian limestone with a maximum thickness estimated at 1000 m, covering the Proterozoic granodiorite of the Brno Massif. In the east, the limestone is covered by flysch facies of the Lower Carboniferous age. The Moravian Karst is characterized by extensive underground drainage systems with many sinkholes, caves, springs, limestone pavements and other karstic landforms (Musil 1993). The famous Macocha abyss in the northern part of the karst is the deepest gorge of the light-hole type in Central Europe. The northern part of the Moravian Karst is drained by the Punkva River which flows in part through underground channels and along the bottom of the Macocha abyss. The famous Punkva Caves, which are open to the public through an entrance in the valley of *Pustý žleb*, are an extension of the longest cave system in the Czech Republic, the Amateur Cave, whose corridors of contiguous caves are over 35 km long. A visit to the Punkva Caves includes a walk on foot followed by a boat ride along the underground section of the Punkva River.

Climate

The climate of the southern part of the Moravian Karst near Brno is warmer and drier, with a mean annual temperature of 8–9 °C, mean January temperature of –2 to –3 °C, mean July temperature of 18–19 °C and an annual precipitation sum of 500–550 mm. The northern part is cooler and wetter with a mean annual temperature of 6–7 °C, mean January temperature of –3 to –4 °C, mean July temperature of 16–17 °C and an annual precipitation sum of 600–650 mm. Specific mesoclimatic conditions are found in deep valleys (*Suchý* žleb, *Pustý žleb*, Josefov Valley and Říčka Valley) where topographic shading generates daytime temperature inversions. Unique temperature characteristics are found in Macocha where the difference between the top and bottom of the abyss is about 10 °C in the warm period of the year (Litschmann et al. 2012).

History of botanical research

An overview of historical studies from the Moravian Karst was provided in a bibliography by Vaněčková & Grüll (1967). The first comprehensive analysis of the flora and vegetation of the area was published by the excellent taxonomist, bryologist and plant geographer Josef Podpěra (Podpěra 1928). He summarized the previous floristic research in this area, described a number of localities of thermophilous flora, and noted the occurrence of montane species in the northern part of the Moravian Karst. Later on the vegetation of the Moravian Karst was described in a broader context by Jan Šmarda (Šmarda 1967; Šmarda & Šmarda 1968). Dry grasslands were studied in detail by Unar (1975) and Unar & Grüll (1984), wet meadows by Balátová-Tuláčková et al. (1987) and forests by Michalcová (2009). The Czechoslovak Botanical Society organized a Summer School of Field Botany in the Moravian Karst in 1980 which involved more than 100 participants. The plant records obtained during this event were summarized by Vaněčková et al. (1997).



Frequency of thermophilous vascular plant species in the Moravian Karst (grid cells of approx. 1.2 × 1.1 km^2) compiled from both historical and recent data (Nejezchlebová 2007). Hatched area indicates the Protected Landscape Area Moravský kras.

Vegetation and flora

The great natural diversity of the Moravian Karst is due to its varied relief, geology, and climatic conditions, ancient human activities and its location on the boundary between areas of Hercynian and Pannonian flora. The Moravian Karst is a potentially woodland area. The vegetation is naturally open only at a few sites on rock outcrops and talus slopes. Thermophilous flora, represented primarily by species of dry grasslands and thermophilous oak forests, occurs mainly in the southern part of the karst, on the Hercynian-Pannonian biogeographical boundary, and on the south-facing slopes of the deep valleys in the middle and northern part of the karst area.

The varied landscape supports a high diversity of natural and semi-natural vegetation, from dry grasslands on south-facing rock outcrops to submontane ravine, scree and alder forests at the valley bottoms. The potential natural vegetation of the southern part of the karstic area consists of thermophilous oak forests on steep south-facing slopes (association *Euphorbio-Quercetum*, alliance *Quercion pubescenti-petraeae*) and oak-hornbeam forests (associations *Galio sylvatici-Carpinetum betuli*, *Carici pilosae-Carpinetum betuli* and *Primulo veris-Carpinetum betuli* of the alliance *Carpinion betuli*) on plateaus and gentle slopes. In the valleys of the central and northern part of the karst area (Josefov Valley, *Suchý žleb* and *Pustý žleb*), upper parts of north-facing slopes are also covered by mesotrophic beech forests (associations *Galio odorati-Fagetum sylvaticae*, *Mercuriali perennis-Fagetum sylvaticae* and *Carici pilosae-Fagetum sylvaticae* of the alliance *Fagion sylvaticae*). Species-rich beech forests of the association *Cephalanthero damasonii-Fagetum sylvaticae* (alliance *Sorbo-Fagion sylvaticae*) with several orchid species (e.g. *Cephalanthera damasonium*, *C. rubra*, *Corallorhiza trifida*, *Cypripedium calceolus* and *Epipactis helleborine*) can be found on the upper edges of the valley slopes. The area occupied by thermophilous forests on the steep south-facing slopes continually decreases toward the northern part of the Moravian Karst, where the adjacent plateaus are generally situated at higher altitudes.

The deep valleys of the Moravian Karst are characterized by the inversion of vegetation belts (Šmarda 1967). The bottoms of dry karstic valleys and their lower slopes are covered by ravine forests (alliance *Tilio platyphylli-Acerion*) with some montane species, while the bottoms of river valleys support alder forests (association *Stellario nemorum-Alnetum glutinosae*, alliance *Alnion incanae*). In contrast, south-facing upper slopes are covered by thermophilous oak forests (association *Euphorbio-Quercetum*, alliance *Quercion pubescenti-petraeae*) with patches of dry grasslands (alliances *Alysso-Festucion pallentis* and *Festucion valesiacae*) and thermophilous herbaceous vegetation of forest edges (alliance *Geranion sanguinei*). The north-facing upper slopes with rock outcrops are locally covered by patches of lime forest (association *Seslerio albicantis-Tilietum cordatae*, alliance *Tilio platyphylli-Acerion*) with relict occurrences of some montane to subalpine species such as *Sesleria caerulea* and *Saxifraga paniculata*. The limestone bedrock with numerous caves and underground streams results in a rare occurrence of wetlands in the karst area.

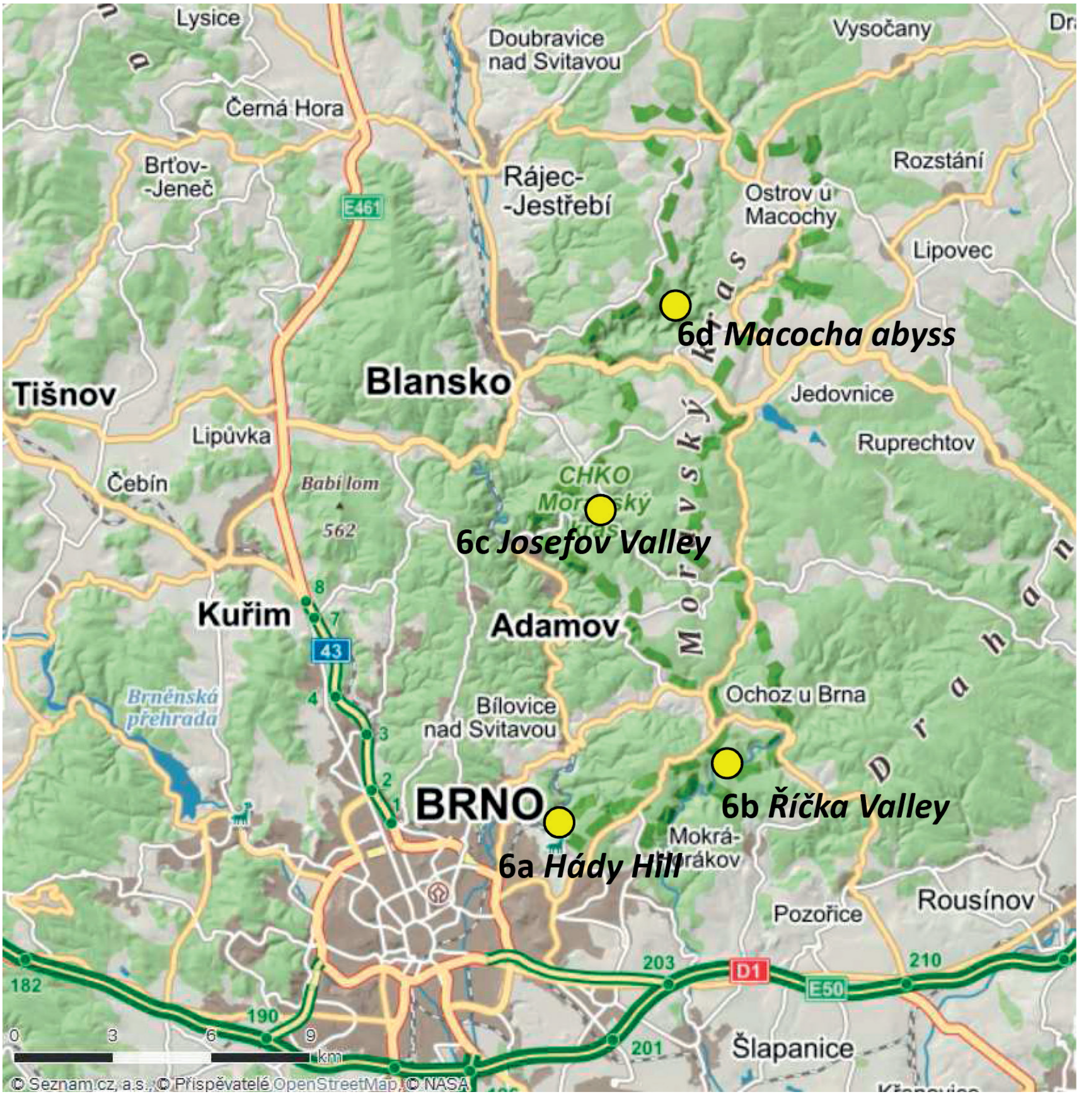
An interesting phenomenon in caves open to the public is the formation of bryophyte and algal communities around cave lights (Kubešová 2001).

Nature conservation

The *Moravský kras* Protected Landscape Area was established in 1956 as the second PLA in the Czech Republic. There are 17 Nature Reserves and Nature Monuments, of which six are in the national category. The core zone of strict protection covers 17 % of the area. However, valuable management-dependent grasslands at some sites have been abandoned and subsequently become overgrown by tall forbs and scrub. Active management of some protected areas began in the late 1990s. Sheep grazing was restored in large grassland areas around the villages of Lažánky and Sloup in the northern part of the karst. Encroaching shrubs were cut on other sites (*Balcarka*, *Velký Hornek* and *Lysá hora*) and the grasslands on Hády Hill at the southernmost edge of the Moravian Karst began to be mown regularly. However, the increasing spread of invasive plants, nutrient accumulation, forest management supporting mainly coniferous or mixed plantations, and the absence of management on many sites are all the reasons why many endangered species occur in small and, in some cases, declining populations.

Mining and the reclamation of limestone quarries

There are three active limestone mining sites and several abandoned quarries in the Moravian Karst. The largest quarries are near the village of Mokrá (active; about 50 ha) and at Hády Hill (abandoned; about 20 ha), both in the southern part of the karst area. These quarries are unique from the biodiversity point of view due to large areas of bare limestone bedrock which is a rare habitat in the Moravian landscape. In most cases, the edges of these quarries directly border species-rich communities of deciduous forests and dry grasslands which provide propagules for the colonization of these habitats. Large areas on the quarry floor are waterlogged, providing a habitat for aquatic and wetland biota. In the future, previously mined areas may become interesting places with high species diversity. The Hády quarry is a good example of such environmental potential, as almost twenty years after mining activities came to an end it is a valuable area designated as a Site of Community Importance within the Natura 2000 network with several nature reserves in the immediate surroundings.



The Moravian Karst with excursion sites and the boundary of the Moravský kras Protected Landscape Area (green dashed line).

(6a) Hády Hill

Introduction

Hády Hill (423 m a.s.l.) is a landmark on the north-eastern edge of the city of Brno. This limestone headland of the Moravian Karst harbours diverse habitats on south-facing slopes, the abandoned quarry, the summit plateau and the adjacent deeply-cut valley of the Svitava River. It is located right on the most important biogeographical border of Moravia between the areas of Hercynian and Pannonian flora. This habitat diversity is reflected in the great diversity of its flora and vegetation types (Tichý 2000; Tichý & Štefka 2000).

The abandoned limestone quarries on the southern slope of Hády Hill are managed by Land Trust Hády, an NGO aiming at the ecological restoration of this area. Below the quarry, dry grasslands and shrublands develop on former arable fields. Photo L. Tichý.

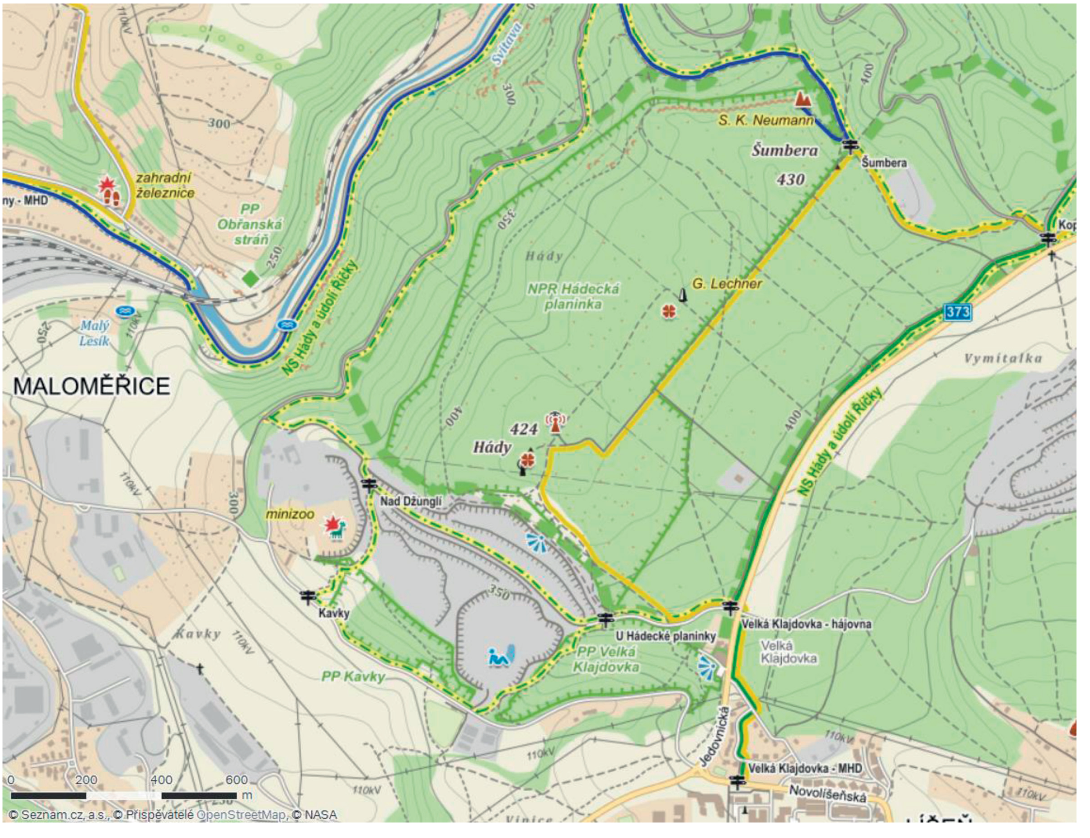
Vegetation

The prevailing forest vegetation type on the summit plateau of Hády Hill is oak-hornbeam forest of the association *Galio sylvatici-Carpinetum betuli* (alliance *Carpinion betuli*) with mesophilous species such as *Asarum europaeum*, *Campanula rapunculoides*, *Convallaria majalis*, *Dactylis polygama*, *Galium odoratum*, *G. sylvaticum*, *Polygonatum multiflorum*, *Pulmonaria obscura*, *Melica uniflora* and *Poa nemoralis*. The south-facing slopes and west-facing rocky edges of the *Hády* plateau are covered by patches of a more thermophilous (Pannonian) type of oak-hornbeam forest (association *Primulo veris-Carpinetum*, alliance *Carpinion betuli*) and thermophilous oak forest (association *Euphorbio-Quercetum*, alliance *Quercion pubescenti-petraeae*) with *Quercus pubescens*, *Sorbus torminalis*, *Cornus mas*, *Crataegus* spp., *Ligustrum vulgare* and *Rosa* spp. in the tree and shrub layers, and *Brachypodium pinnatum*, *Buglossoides purpurocaerulea*, *Carex michelii*, *Centaurea triumfetti*, *Dactylis polygama*, *Dictamnus albus*, *Inula hirta*, *Stachys recta*, *Viola hirta* and *Teucrium chamaedrys* in the herb layer. Patches of the Carpathian type of the oak-hornbeam forests with *Carex pilosa* (association *Carici pilosae-Carpinetum*, alliance *Carpinion betuli*), on the western limit of its distribution here, can be found in places.

The southern edge of the Hády plateau and a large part of the steep south-facing slopes are partly covered with a mosaic of shrub vegetation (alliances *Berberidion vulgaris* and *Prunion fruticosae*) and dry grasslands of the association *Polygalo majoris-Brachypodietum pinnati* (alliance *Cirsio-Brachypodion pinnati*). Some parts of the west-facing slopes with screes are covered by ravine forests (association *Aceri-Tilietum*, alliance *Tilio platyphylli-Acerion*) with *Galeobdolon montanum*, *Geranium* *robertianum*, *Lathyrus vernus* and *Mercurialis perennis*. The granodiorite bedrock of the lower parts of the Svitava Valley results in the occurrence of acidophilous oak forests with *Festuca ovina*, *Genista tinctoria* and *Luzula luzuloides* (association *Luzulo luzuloidis-Quercetum petraeae*, alliance *Quercion roboris*).

Flora

A total of almost 500 species of vascular plants have been recorded on Hády Hill in an area of about 1 km^2. Thermophilous species occur in steppe remnants on the south-facing slope. They are represented by, for example, *Anthericum ramosum*, *Aster amellus*, *Astragalus danicus*, *Centaurea triumfetti*, *Galatella linosyris*, *Orobanche alba*, *Peucedanum alsaticum*, *Polygala major*, *Pulsatilla grandis*, *Salvia nemorosa*, *Stipa pennata*, *S. pulcherrima* and *Thymus pannonicus*. Some species including *Campanula sibirica*, *Cytisus procumbens*, *Echium maculatum* and *Inula ensifolia* reach their north-western distribution limit in southern Moravia. Mesophilous species of broad-leaved deciduous forests are represented by *Anemone nemorosa*, *Carex pilosa*, *Daphne mezereum*, *Euphorbia amygdaloides*, *Hepatica nobilis* and *Lilium martagon*. The west-facing rocky limestone edge of the Hády plateau hosts some other phytogeographically important species such as *Inula hirta* and *Scrophularia vernalis*.



Hády Hill on the north-eastern edge of the city of Brno and the southern edge of the Moravian Karst.

Human impact

The former agricultural landscape of the southern slope of Hády, with small arable fields, gardens, thickets and pastures, began changing its appearance due to spontaneous succession at the beginning of the 20th century. However, the most intensive changes have occurred within the last fifty years. A large limestone quarry was opened on the site of the former steppe pastures. Two new housing estates with more than 40,000 inhabitants have been built in close proximity to Hády Hill which has become a recreational area for this growing population. Mining for lime and cement production in the Hády quarry came to an end in 1998. Since then, the site has been gradually reclaimed. Remnants of the steppe vegetation have fortunately been preserved in nearby areas and many nationally endangered species have dispersed spontaneously to the quarry. The application of soft reclamation techniques such as mulching and the sowing of regional seed mixtures collected from adjacent grasslands has helped to restore dry grasslands on the quarry terraces (Tichý 2012).

Land Trust Hády

This professional non-government organization is a private owner and important stakeholder in the area. It manages more than 50 ha of the southern slope of Hády Hill including three nature reserves and the entire abandoned quarry. The main aim of this non-governmental organization is nature protection, scientific research and environmental education. It has proposed and implemented environmentally friendly reclamation of the quarry and established several educational walks with information panels. It regularly manages grasslands by mowing and grazing and organizes applied research. In 2011, it established an eco-centre with a few alpacas and sheep (*Lamacentrum Hády*) to promote the relationship between people and nature.

Appendix 6a Selected species of vascular plants on Hády Hill.

Acinos arvensis
Agrimonia eupatoria
Agrostis stolonifera
Achillea millefolium agg.
Ailanthus altissima (neo)
Ajuga genevensis
Ajuga chamaepitys
Ajuga reptans
Allium flavum
Allium oleraceum
Allium senescens subsp. *montanum*
Alyssum alyssoides
Anagallis arvensis
Anemone nemorosa
Anemone sylvestris
Anthericum ramosum
Anthriscus sylvestris
Anthyllis vulneraria
Arabidopsis thaliana
Arabis sagittata
Arenaria serpyllifolia agg.
Arrhenatherum elatius
Artemisia campestris
Artemisia pontica
Artemisia vulgaris
Asarum europaeum
Asparagus officinalis
Asperula cynanchica
Aster amellus
Astragalus glycyphyllos
Astragalus onobrychis
Atriplex oblongifolia
Atriplex sagittata
Avenula pubescens
Berberis vulgaris
Berteroa incana
Betonica officinalis
Bothriochloa ischaemum
Brachypodium pinnatum
Brachypodium sylvaticum
Bromus erectus
Bromus hordeaceus
Bromus sterilis
Bromus tectorum
Buglossoides purpurocaerulea
Bunias orientalis (neo)
Bupleurum falcatum
Calamagrostis epigejos
Campanula glomerata
Campanula moravica
Campanula rapunculoides
Campanula sibirica
Campanula trachelium
Cardamine impatiens
Carex digitata
Carex hirta
Carex humilis
Carex michelii
Carex muricata agg.
Carex pilosa
Carex praecox
Carex sylvatica
Carlina biebersteinii subsp. *brevibracteata*
Centaurea jacea subsp. *angustifolia*
Centaurea scabiosa
Centaurea stoebe
Centaurea triumfetti
Centaurium pulchellum
Cerastium brachypetalum
Cerastium glutinosum
Chaerophyllum temulum
Chamaecytisus ratisbonensis
Chondrilla juncea
Cichorium intybus
Cirsium pannonicum
Clematis recta
Clinopodium vulgare
Consolida regalis
Convallaria majalis
Cornus mas
Cornus sanguinea
Cota austriaca
Cotoneaster integerrimus
Crataegus laevigata
Crataegus monogyna
Crepis praemorsa
Crepis foetida subsp. *rhoeadifolia*
Cuscuta epithymum
Cynoglossum officinale
Cytisus nigricans
Cytisus procumbens
Dactylorhiza incarnata
Datura stramonium (neo)
Descurainia sophia
Deschampsia cespitosa
Dianthus pontederae
Dictamnus albus
Dorycnium germanicum
Echium maculatum
Echium vulgare
Elymus hispidus
Elymus repens
Epilobium dodonaei
Epipactis palustris
Equisetum ×meridionale (*E. ramosissimum* × *E. variegata*)
Equisetum ×moorei (*E. hyemale* × *E. ramosissimum*)
Equisetum palustre
Equisetum ramosissimum
Erophila verna
Eryngium campestre
Erysimum durum
Euonymus verrucosus
Euphorbia cyparissias
Euphorbia epithymoides
Euphorbia esula
Euphorbia exigua
Euphorbia helioscopia
Euphrasia stricta

Falcaria vulgaris
Fallopia convolvulus
Festuca rubra
Festuca rupicola
Festuca valesiaca
Fragaria moschata
Fragaria vesca
Fragaria viridis
Fumaria officinalis
Galatella linosyris
Galeobdolon montanum
Galium album
Galium glaucum
Galium odoratum
Galium sylvaticum
Galium valdepilosum
Galium verum
Genista germanica
Genista tinctoria
Gentianopsis ciliata
Geranium pratense
Geranium robertianum
Geranium sanguineum
Glechoma hederacea
Helianthemum grandiflorum subsp. *obscurum*
Helictochloa pratensis
Hepatica nobilis
Hieracium lachenalii
Hieracium maculatum
Hieracium murorum
Hieracium racemosum
Hieracium sabaudum
Holosteum umbellatum
Hylotelephium maximum
Hypericum hirsutum
Hypericum perforatum
Impatiens parviflora (neo)
Inula conyzae
Inula ensifolia
Inula hirta
Iris variegata
Isatis tinctoria
Juncus articulatus
Juncus inflexus
Knautia kitaibelii
Koeleria macrantha
Lactuca serriola
Lactuca viminea
Lathyrus hirsutus (neo)
Lathyrus latifolius
Lathyrus niger
Lathyrus sylvestris
Lathyrus vernus
Leontodon hispidus
Lepidium campestre
Ligustrum vulgare
Linaria genistifolia
Linaria vulgaris
Linum austriacum
Linum tenuifolium
Lonicera xylosteum
Loranthus europaeus
Lycopsis arvensis
Maianthemum bifolium
Medicago falcata
Medicago lupulina
Medicago minima
Melampyrum arvense
Melampyrum nemorosum
Melica ciliata
Melica nutans
Melica transsilvanica
Melica uniflora
Melilotus albus
Melilotus officinalis
Melittis melissophyllum
Microrrhinum minus
Myosotis ramosissima
Myosotis sylvatica
Neottia nidus-avis
Onobrychis arenaria
Orchis purpurea
Origanum vulgare
Ornithogalum kochii
Orobanche caryophyllacea
Orobanche kochii
Orobanche picridis
Papaver dubium agg.
Papaver rhoeas
Peucedanum alsaticum
Peucedanum cervaria
Phelipanche purpurea
Phleum phleoides
Phleum pratense
Phragmites australis
Picris hieracioides
Pilosella bauhini
Pilosella leucopsilon
Pilosella officinarum
Pimpinella major
Pimpinella saxifraga
Plantago media
Poa angustifolia
Poa annua
Poa compressa
Poa nemoralis
Polycnemum majus
Polygala comosa
Polygala major
Polygonatum multiflorum
Polygonatum odoratum
Portulaca oleracea
Potentilla argentea
Potentilla heptaphylla
Potentilla incana
Potentilla recta
Potentilla reptans
Potentilla verna
Primula veris
Prunella grandiflora
Prunella laciniata
Prunella vulgaris
Prunus fruticosa
Prunus mahaleb
Prunus spinosa
Puccinellia distans
Pulmonaria mollis
Pulmonaria officinalis
Pulsatilla grandis
Pyrus pyraster
Quercus cerris
Quercus petraea
Quercus pubescens
Quercus robur
Ranunculus bulbosus
Ranunculus polyanthemos
Ranunculus repens
Reseda lutea
Rhamnus cathartica
Rosa canina
Rosa dumalis
Rosa gallica
Rosa micrantha
Rosa rubiginosa
Rosa spinosissima
Salvia nemorosa
Salvia pratensis
Sanguisorba minor
Scabiosa ochroleuca
Scrophularia nodosa
Securigera varia
Sedum acre
Sedum album
Sedum sexangulare
Senecio jacobaea
Seseli osseum
Sherardia arvensis
Silene latifolia subsp. *alba*
Silene nutans
Silene otites
Silene vulgaris
Solidago virgaurea
Sorbus aria agg.
Sorbus aucuparia
Sorbus domestica
Sorbus torminalis
Stachys annua
Stachys palustris
Stachys recta
Stellaria holostea
Stipa capillata
Stipa pennata
Stipa pulcherrima
Symphytum officinale
Tanacetum corymbosum
Teucrium chamaedrys
Thesium dollineri
Thesium linophyllon
Thymus pannonicus

Plate 6a Plants of Hády Hill near Brno: (a) *Rosa spinosissima*, (b) *Linum tenuifolium*, (c) *Inula ensifolia*, (d) *Anemone sylvestris*, (e) *Anthyllis vulneraria*, (f) *Echium maculatum*, (g) *Prunella grandiflora*, (h) *Rosa micrantha*, (i) *Buglossoides purpurocaerulea*, (j) *Quercus pubescens*, (k) *Iris variegata*, (l) *Dictamnus albus*.

Thymus praecox
Tragopogon dubius
Trifolium alpestre
Turritis glabra
Ulmus minor
Valerianella locusta
Verbascum chaixii subsp. *austriacum*
Verbascum lychnitis
Veronica prostrata
Veronica spicata
Veronica sublobata
Veronica teucrium
Veronica vindobonensis
Vicia angustifolia
Vicia dumetorum
Vicia sylvatica
Vicia tenuifolia
Vincetoxicum hirundinaria
Viola collina
Viola hirta
Viola mirabilis
Viola reichenbachiana

(6b) Říčka Valley

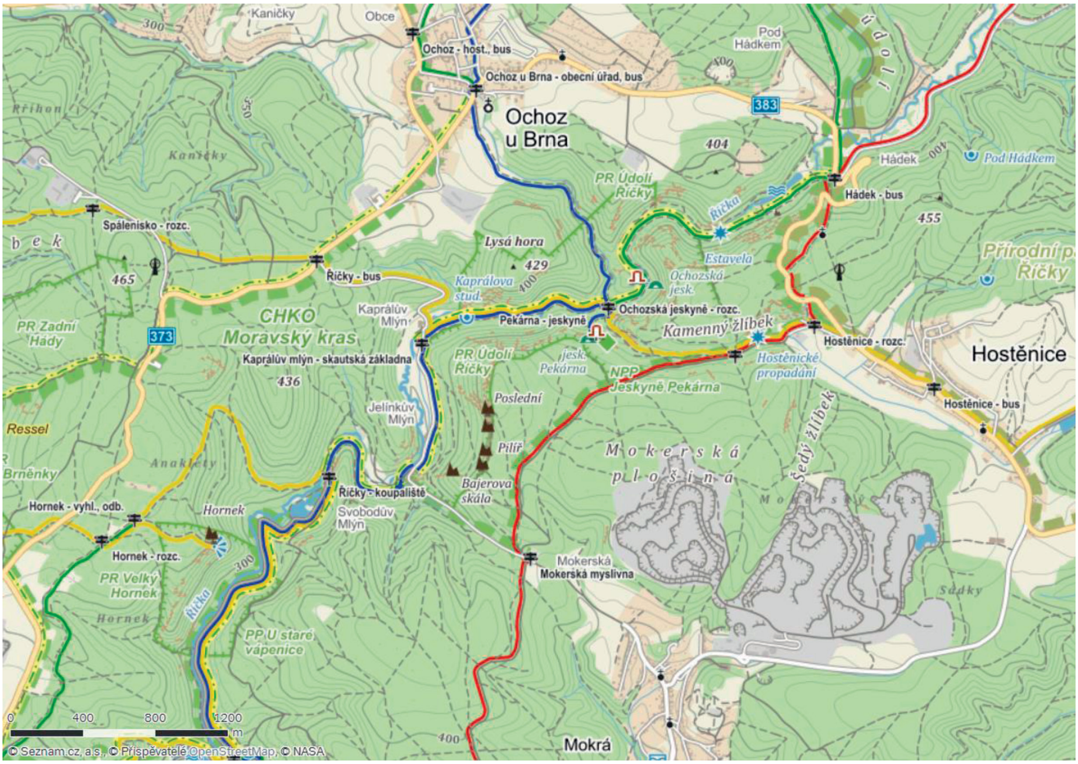
Introduction

The picturesque valley of the small stream known as Říčka crosses the southern part of the Moravian Karst. The altitudinal difference between the valley bottom and the adjacent plateaus is more than 200 m. Steep limestone slopes, mostly facing to the south or north, support the occurrence of contrasting vegetation types in a small area. Most of the area is covered by abandoned coppice forests which are between 80 and 120 years old. There are also several caves, of which Ochoz Cave (*Ochozská jeskyně*) is the longest. It was open to the public until 1990. Pekárna Cave is known as an important archaeological site, a famous shelter for Palaeolithic people. A large part of the valley is protected in nature reserves.

The Pekárna Cave in the Říčka Valley is an important palaeontological and archaeological site. Photo M. Chytrý.

Vegetation

The vegetation is a mosaic of thermophilous oak forests (association *Euphorbio-Quercetum*, alliance *Quercion pubescenti-petraeae*) on steep upper parts of south-facing slopes, oak-hornbeam forests (association *Carici pilosae-Carpinetum*, alliance *Carpinion betuli*) on more gentle slopes, ravine forests (associations *Aceri-Tilietum* and *Arunco dioici-Aceretum pseudoplatani*, alliance *Tilio platyphylli-Acerion*) on the lower parts of steep slopes and alluvial alder forests (association *Stellario nemorum-Alnetum glutinosae*, alliance *Alnion incanae*) on the valley bottom and alluvial terraces. Small patches of dry grasslands and thermophilous forest-fringe vegetation (alliances *Festucion valesiacae* and *Geranion sanguinei*) can be found on some steep south-facing slopes and at the top of some limestone outcrops. Steep north-facing rocky slopes support patches of species-rich rock-outcrop lime forests (association *Seslerio albicantis-Tilietum cordatae*, alliance *Tilio platyphylli-Acerion*) and grasslands with *Sesleria caerulea* (association *Saxifrago paniculatae-Seslerietum caeruleae*, alliance *Diantho lumnitzeri-Seslerion*).



The Říčka Valley south of the village Ochoz u Brna in the southern part of the Moravian Karst.

Flora

Many thermophilous species in the Říčka Valley occur here on their regional distribution limit, e.g. *Cytisus procumbens*, *Inula oculus-christi*, *Iris graminea*, *I. variegata* and *Pulsatilla grandis*. Other important thermophilous species include *Dictamnus albus*, *Euphorbia salicifolia*, *Galatella linosyris*, *Inula ensifolia*, *Prunus fruticosa* and *Rosa spinosissima.* The bottom of the valley is permanently shaded, for which reason it is relatively cold and provides habitats to submontane species such as *Aconitum lycoctonum*, *Geranium phaeum*, *Lunaria rediviva* and *Primula elatior. Sesleria caerulea* grasslands on north-facing rock outcrops contain *Berberis vulgaris*, *Cotoneaster integerrimus* and *Saxifraga paniculata.* Semi-natural forest vegetation is species-rich, with several species of orchids including *Cephalanthera damasonium*, *C. rubra*, *Corallorhiza trifida*, *Epipactis helleborine* and *Listera ovata.*

Appendix 6b Selected species of vascular plants in the Říčka Valley.

Acinos arvensis
Aconitum lycoctonum
Actaea spicata
Adonis vernalis
Adoxa moschatellina
Ajuga genevensis
Ajuga reptans
Allium flavum
Allium oleraceum
Allium senescens subsp. *montanum*
Alopecurus pratensis
Alyssum alyssoides
Anemone nemorosa
Anthericum ramosum
Anthriscus sylvestris
Arenaria serpyllifolia agg.
Arrhenatherum elatius
Arum cylindraceum
Asarum europaeum
Asperula cynanchica
Asplenium trichomanes
Aster amellus
Astragalus glycyphyllos
Astrantia major
Avenula pubescens
Berberis vulgaris

Betonica officinalis
Bothriochloa ischaemum
Brachypodium sylvaticum
Bromus benekenii
Bromus erectus
Buglossoides purpurocaerulea
Bupleurum falcatum
Caltha palustris
Campanula glomerata
Campanula moravica
Campanula persicifolia
Campanula rapunculoides
Campanula trachelium
Cardamine amara
Cardamine pratensis
Carex caryophyllea
Carex digitata
Carex michelii
Carex montana
Carex muricata agg.
Carex pilosa
Carex praecox
Carex sylvatica
Centaurea scabiosa
Centaurea stoebe
Cephalanthera damasonium
Cerastium brachypetalum
Cerinthe minor
Chamaecytisus ratisbonensis
Cichorium intybus
Circaea ×intermedia
(*C. alpina* × *C. lutetiana*)
Cirsium oleraceum
Clematis recta
Clinopodium vulgare
Colchicum autumnale
Convallaria majalis
Cornus mas
Cornus sanguinea
Crepis paludosa
Cuscuta epithymum
Daphne mezereum
Dentaria bulbifera
Dianthus carthusianorum
Dictamnus albus
Dryopteris filix-mas
Echium vulgare
Elymus caninus
Elymus hispidus
Equisetum hyemale
Eryngium campestre
Euonymus europaeus
Euonymus verrucosus
Euphorbia amygdaloides
Euphorbia cyparissias
Euphorbia epithymoides
Falcaria vulgaris
Festuca arundinacea
Festuca gigantea
Festuca heterophylla
Festuca rupicola
Festuca valesiaca
Filipendula ulmaria
Fourraea alpina
Fragaria moschata
Gagea lutea
Gagea villosa
Galanthus nivalis
Galatella linosyris
Galeobdolon montanum
Galeopsis pubescens
Galium album
Galium odoratum
Galium pumilum
Galium sylvaticum
Genista tinctoria
Geranium palustre
Geranium phaeum
Geranium pratense
Geranium robertianum
Geranium sanguineum
Glechoma hederacea
Glechoma hirsuta
Helianthemum grandiflorum
subsp. *obscurum*
Helictochloa pratensis
Hepatica nobilis
Hieracium lachenalii
Hieracium murorum
Hieracium sabaudum
Hordelymus europaeus
Hylotelephium maximum
Hypericum hirsutum
Hypericum montanum
Hypericum perforatum
Inula ensifolia
Inula hirta
Inula oculus-christi
Iris pumila
Iris variegata
Isopyrum thalictroides
Juglans regia
Knautia arvensis
Knautia drymeia
Koeleria macrantha
Lactuca quercina
Lamium maculatum
Lathraea squamaria
Lathyrus niger
Lathyrus vernus
Ligustrum vulgare
Lilium martagon
Listera ovata
Lonicera xylosteum
Lunaria rediviva
Lythrum salicaria
Maianthemum bifolium
Melampyrum cristatum
Melampyrum nemorosum
Melica ciliata
Melica nutans
Melica picta
Melica transsilvanica
Melica uniflora
Melittis melissophyllum
Mercurialis perennis
Milium effusum
Muscari comosum
Mycelis muralis
Neottia nidus-avis
Origanum vulgare
Paris quadrifolia
Peucedanum cervaria
Phleum phleoides
Phyteuma spicatum
Pilosella cymosa
Pilosella officinarum
Pimpinella major
Pimpinella saxifraga
Plantago media
Platanthera bifolia
Poa angustifolia
Poa nemoralis
Poa palustris
Poa trivialis
Polycnemum majus
Polygonatum multiflorum
Polygonatum odoratum
Potentilla incana
Potentilla verna
Primula elatior
Primula veris
Prunus spinosa
Pulmonaria mollis
Pulmonaria obscura
Pulsatilla grandis
Pyrus pyraster
Quercus petraea
Quercus pubescens
Ranunculus auricomus agg.
Ranunculus bulbosus
Ranunculus lanuginosus
Ranunculus polyanthemos
Rhamnus cathartica
Rosa spinosissima
Salvia nemorosa
Salvia pratensis
Salvia verticillata
Sanguisorba minor
Sanguisorba officinalis
Sanicula europaea
Scabiosa ochroleuca
Scirpus sylvaticus
Scrophularia nodosa
Scrophularia umbrosa
Securigera varia
Sedum album
Senecio jacobaea
Seseli osseum
Silene vulgaris
Sorbus aria agg.
Sorbus torminalis
Stachys palustris

Plate 6b Plants of the Říčka Valley in the Moravian Karst: (a) *Allium ursinum*, (b) *Melica transsilvanica*, (c) *Euonymus verrucosus*, (d) *Platanthera bifolia*, (e) *Cornus mas*, (f) *Dentaria bulbifera*, (g) *Staphylea pinnata*, (h) *Astrantia major*, (i) *Sanicula europaea*, (j) *Galanthus nivalis*, (k) *Lilium martagon*, (l) *Aconitum lycoctonum*.

Stachys recta
Stachys sylvatica
Staphylea pinnata
Stellaria holostea
Symphytum tuberosum
Tanacetum corymbosum
Teucrium chamaedrys
Thalictrum minus
Thymus pannonicus
Thymus praecox
Trifolium alpestre
Trifolium medium
Ulmus glabra
Valerianella carinata
Valerianella locusta
Verbascum chaixii subsp. *austriacum*
Veronica chamaedrys
Veronica prostrata
Veronica spicata
Veronica teucrium
Veronica vindobonensis
Vicia lathyroides
Vicia tetrasperma
Vincetoxicum hirundinaria
Viola hirta
Viola mirabilis
Viola reichenbachiana
Viola riviniana
Viscum album

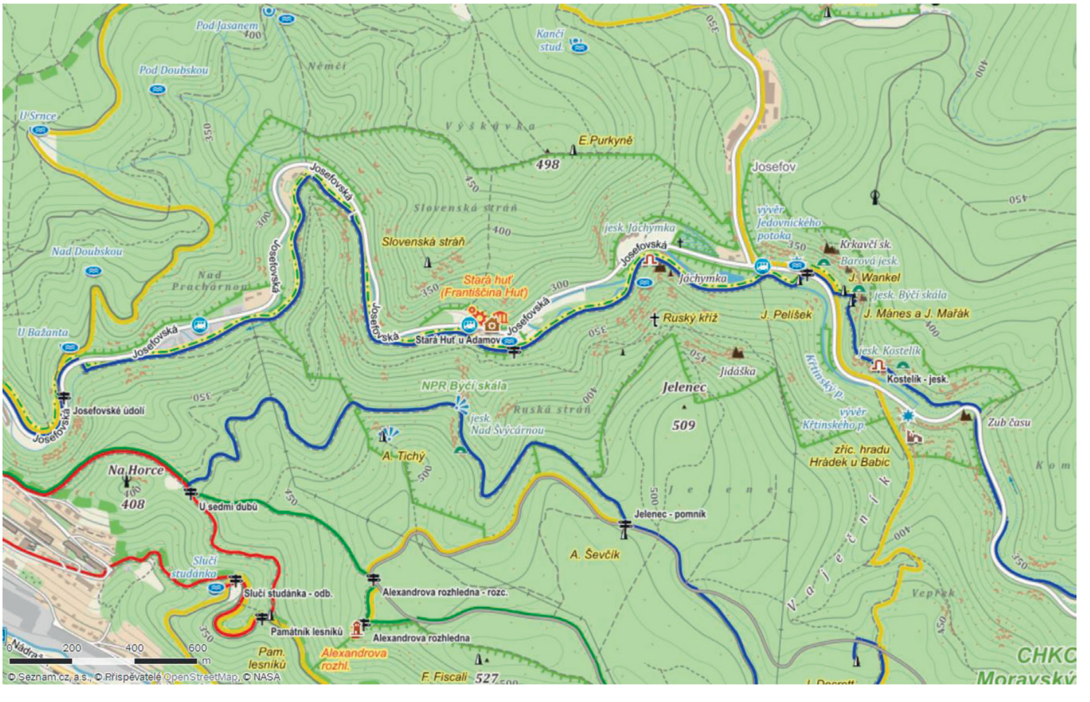
(6c) Josefov Valley

Introduction

The Josefov Valley (*Josefovské údolí*) crosses the central part of the Moravian Karst. The name of this valley was derived from the small settlement Josefov located in its central part. The whole valley is easily accessible by the road from Adamov to Křtiny. Therefore, the vegetation on the valley bottom is not so well preserved as in the Říčka Valley, though the valley slopes are mainly covered by natural or semi-natural vegetation. The Josefov Valley was formed by the stream *Křtinský potok*, which flows partly underground.

Vegetation

The valley slopes are covered by oak-hornbeam forests (abandoned coppice forests of the association *Galio sylvatici-Carpinetum betuli*, alliance *Carpinion betuli*), beech forests (alliance *Fagion sylvaticae*), ravine forests (alliance *Tilio platyphylli-Acerion*) and patches of grasslands. The most important patches of dry grasslands, forest-fringe vegetation and shrublands are developed on the south-facing slope called *Slovenská stráň* in the central part of the valley and its immediate surroundings. The valley is characterized by the inversion of vertical vegetation belts, with more montane types occurring at lower elevations and lowland types at higher elevations.



Josefov Valley between the towns of Adamov and Křtiny in the central part of the Moravian Karst.

The Josefov Valley in the central part of the Moravian Karst is covered by thermophilous oak forests on south-facing slopes and beech forests on north-facing slopes. Photo L. Tichý.

Flora

The deep limestone valley of the stream *Křtinský potok* with steep slopes and rock outcrops provides diverse conditions for many elements of karstic flora. The flora of the warmest slopes with patches of rocky steppe and open oak forests is related to the forest-steppe area south of Brno, though some species typical of the southern part of the Moravian Karst are missing here. Thermophilous species found in the Josefov Valley include *Allium senescens* subsp. *montanum*, *Anthericum ramosum*, *Arabis auriculata*, *Carex humilis*, *Centaurea stoebe*, *Cornus mas*, *Euonymus verrucosus*, *Euphorbia epithymoides*, *Fourraea alpina*, *Lactuca viminea*, *Stipa pennata* and *Teucrium chamaedrys.*

In contrast, the valley bottom hosts a number of montane species including *Aconitum lycoctonum*, *Aruncus dioicus*, *Circaea alpina*, *Polygonatum verticillatum*, *Prenanthes purpurea*, *Ribes alpinum* and *Rosa pendulina.* The mesic forests contain, for example, *Cephalanthera damasonium*, *Daphne mezereum*, *Dentaria bulbifera*, *D. enneaphyllos*, *Euphorbia amygdaloides*, *Hieracium lachenalii*, *H. murorum*, *Lonicera xylosteum*, *Melittis mellisophyllum*, *Neottia nidus-avis*, *Platanthera bifolia*, *P. chlorantha* and *Polygonatum multiflorum*. Rocks are overgrown by mosses and ferns, including the locally rare species *Asplenium viride*, *Polypodium interjectum* and *Woodsia ilvensis*.

Caves

Býčí skála (*Bull Rock*), the largest cave in the Josefov Valley, is a famous archaeological site. The cave is not open to the public. Beginning in 1867, a part of the cave was explored by the amateur archaeologist Jindřich Wankel who found a bronze statuette of a bull here and in 1871–1873 excavated a large accumulation of artefacts thought to be a ritual burial with human offerings from the Hallstatt culture (older Iron Age, 5th century BC). The site contained animal and material offerings, crops, textiles, ceramic and metal vessels, jewellery, glass and amber beads (Přichystal & Náplava 1995). There are several smaller caves in the Josefov Valley including *Evina jeskyně*, *Kostelík* and *Jáchymka*. *Výpustek* is the only cave open to the public. This cave was significantly altered by phosphate extraction in the early 20th century, during which skeletons of cave bears were found in the cave sediments.

The Czechoslovak Army established an explosives storage in the cave in the 1930s and Nazis established an underground factory here during WWII. An underground fallout shelter and a secret command post were created in the cave by the Czechoslovak Army in the 1960s. Historical military infrastructure is currently on display to tourists.

Františka Iron Mill

Iron ore was mined in the Josefov Valley already in the Hallstatt period (750–400 years BC). From the Middle Ages to the 19th century, beech forests were gradually cut and fired in piles covered with moistened clay (kilns) to produce charcoal necessary for increasing iron production. The *Františka* Iron Mill with its high charcoal furnace operated between the mid-18th century and the second half of the 19th century. It is now a fully restored industrial monument. It can be found in the central part of the Josefov Valley near the town of Adamov. The former *Kameňák* pattern-shop and residential building contain an exhibition of the Technical Museum in Brno devoted to metallurgy. Melting in replica furnaces takes place every year (Souchopová et al. 2002).

Pilgrimage church in Křtiny

Křtiny is a small town in the central part of the Moravian Karst and a starting point for trips to the Josefov Valley. It is an old Marian site dominated by a Baroque pilgrimage complex with the Church of the Holy Name of Mary designed by the Czech architect of Italian descent Jan Blažej Santini Aichel in the 18th century.

Býčí skála Cave in the Josefov Valley in the central part of the Moravian Karst with patches of thermophilous vegetation on the limestone cliffs above the main entrance. Photo L. Tichý.

Plate 6c Plants of the Josefov Valley in the Moravian Karst: (a) *Anthericum ramosum*, (b) *Daphne mezereum*, (c) *Circaea alpina*, (d) *Prenanthes purpurea*, (e) *Polygonatum verticillatum*, (f) *Isopyrum thalictroides*, (g) *Galium odoratum*, (h) *Ribes alpinum*, (i) *Polypodium interjectum*, (j) *Stipa pennata*, (k) *Adoxa moschatellina*, (l) *Aruncus dioicus*.

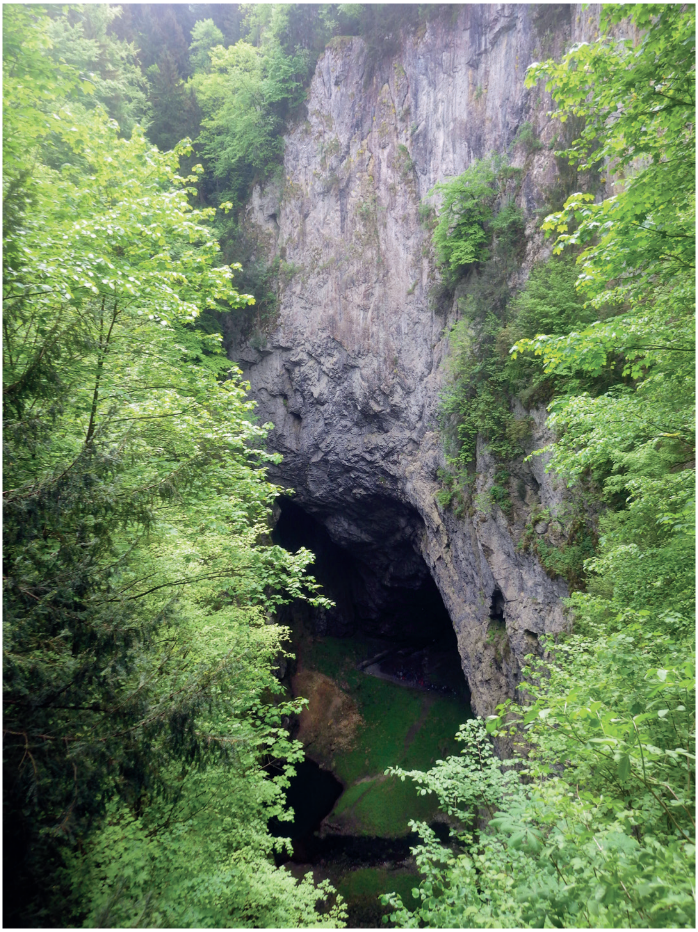
Appendix 6c Selected species of vascular plants in the Josefov Valley (according to Jamborová 1980).

Acinos arvensis
Aconitum lycoctonum
Actaea spicata
Adoxa moschatellina
Ajuga genevensis
Ajuga reptans
Allium senescens subsp. *montanum*
Allium ursinum
Alyssum alyssoides
Anemone nemorosa
Anemone ranunculoides
Anthericum ramosum
Arabis auriculata
Arenaria serpyllifolia
Aruncus dioicus
Asarum europaeum
Asperula cynanchica
Asplenium ruta-muraria
Asplenium trichomanes
Asplenium viride
Astragalus glycyphyllos
Astrantia major
Athyrium filix-femina
Berberis vulgaris
Brachypodium pinnatum
Brachypodium sylvaticum
Buglossoides purpurocaerulea
Bupleurum falcatum
Caltha palustris
Campanula persicifolia
Campanula rapunculoides
Campanula trachelium
Carex digitata
Carex humilis
Carex pilosa
Carex sylvatica
Centaurea scabiosa
Centaurea stoebe
Cephalanthera damasonium
Cephalanthera longifolia
Cephalanthera rubra
Chaerophyllum aromaticum
Circaea alpina
Circaea lutetiana
Clinopodium vulgare
Convallaria majalis
Corallorhiza trifida
Cornus mas
Corylus avellana
Cotoneaster integerrimus
Cruciata laevipes
Cynoglossum officinale
Cystopteris fragilis
Cytisus nigricans
Daphne mezereum
Dentaria bulbifera
Dentaria enneaphyllos
Digitalis grandiflora
Dryopteris filix-mas
Echium vulgare
Eryngium campestre
Euonymus verrucosus
Euphorbia amygdaloides
Euphorbia cyparissias
Euphorbia epithymoides
Festuca ovina
Festuca pallens
Festuca rupicola
Festuca valesiaca
Fourraea alpina
Galium album
Galium odoratum
Galium sylvaticum
Genista tinctoria
Geranium palustre
Geranium robertianum
Geranium sanguineum
Helianthemum grandiflorum subsp. *obscurum*
Hieracium lachenalii
Hieracium sabaudum
Hylotelephium maximum
Hypericum hirsutum
Hypericum maculatum
Hypericum montanum
Hypericum perforatum
Hypericum tetrapterum
Isopyrum thalictroides
Jasione montana
Juniperus communis
Knautia arvensis
Lactuca viminea
Lathyrus niger
Lathyrus pratensis
Lilium martagon
Linaria genistifolia
Lonicera xylosteum
Lunaria rediviva
Maianthemum bifolium
Melampyrum nemorosum
Melampyrum pratense
Melica transsilvanica
Melittis melissophyllum
Mycelis muralis
Neottia nidus-avis
Nonea pulla
Pilosella officinarum
Pimpinella major
Pimpinella saxifraga
Pinus sylvestris
Platanthera bifolia
Platanthera chlorantha
Poa nemoralis
Polygonatum multiflorum
Polygonatum odoratum
Polygonatum verticillatum
Polypodium interjectum
Polypodium vulgare
Potentilla incana
Potentilla argentea
Potentilla verna
Prenanthes purpurea
Primula elatior
Primula veris
Rhamnus cathartica
Ribes alpinum
Salvia nemorosa
Salvia pratensis
Sanguisorba minor
Saxifraga paniculata
Scabiosa ochroleuca
Scrophularia nodosa
Securigera varia
Sedum album
Seseli osseum
Sesleria caerulea
Silene nutans
Silene vulgaris
Solidago virgaurea
Sorbus aria agg.
Sorbus torminalis
Stachys palustris
Stachys recta
Stachys sylvatica
Stipa pennata
Symphytum officinale
Symphytum tuberosum
Tanacetum corymbosum
Teucrium chamaedrys
Thalictrum aquilegiifolium
Thymus glabrescens
Trifolium alpestre
Verbascum chaixii subsp. *austriacum*
Verbascum lychnitis
Verbascum nigrum
Veronica chamaedrys
Veronica teucrium
Vicia sylvatica
Vincetoxicum hirundinaria
Viola hirta

(6d) Macocha abyss and the nearby karst valleys

Introduction

The Macocha abyss and the nearby valleys *Pustý žleb* (meaning *Desolate Gully*) and *Suchý žleb* (meaning *Dry Gully*) is the most frequently visited part of the Moravian Karst attracting about 300,000 visitors annually. The view of the abyss from one of two platforms is extremely spectacular. The depth of the abyss from the upper viewing platform to the surface of the small lake at the bottom of Macocha is 138 m. The estimated depth of the lake is about 50 m. The mean daily temperature difference between the top and bottom of the abyss in warm periods is more than 9 °C (Litschmann et al. 2012) which significantly increases the environmental heterogeneity. Many other karstic features can be seen here in addition to the abyss and the caves. The streams *Bílá voda* and *Sloupský potok* enter the Amateur Cave (*Amatérská jeskyně*, 34 km long) and Punkva Caves (*Punkevní jeskyně*) and form the underground Punkva River downstream of their confluence. Long sections of the valley bottoms are dry in both valleys.

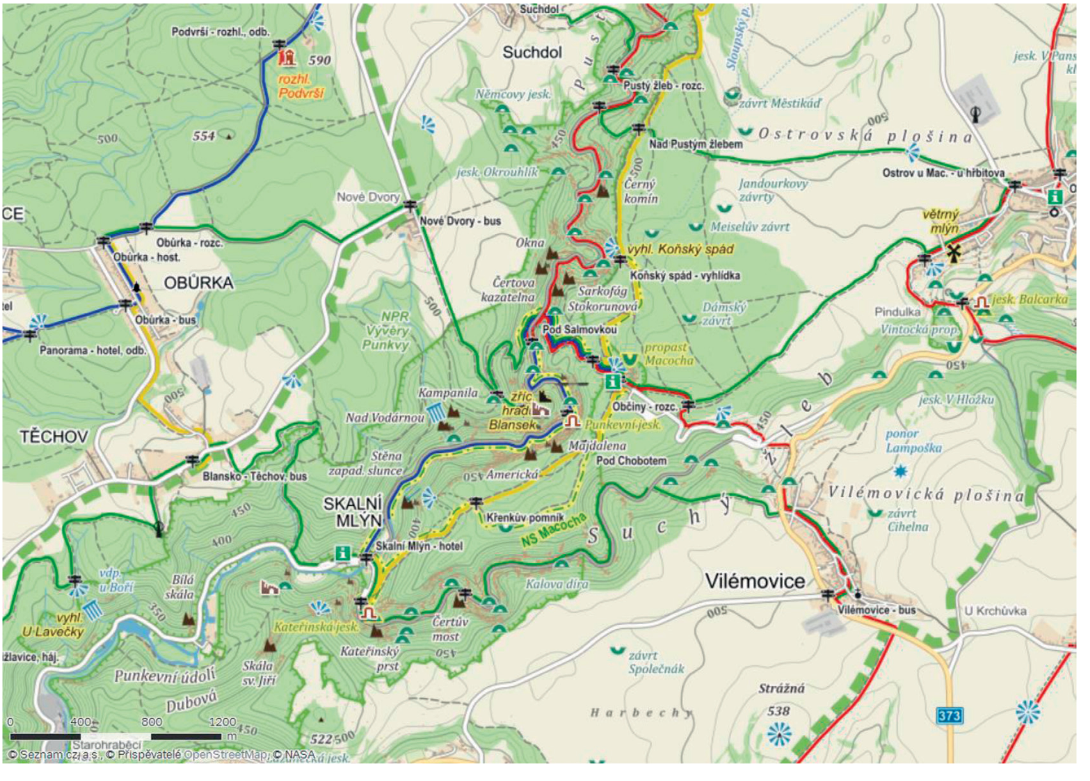


The Macocha abyss in the northern part of the Moravian Karst. Photo Z. Lososová

Vegetation

An inversion of altitudinal vegetation belts can be seen in the *Suchý* žleb and *Pustý žleb* gorges. Beech and ravine forests (alliances *Fagion sylvaticae* and *Tilio platyphylli-Acerion*) prevail on the bottoms, while oak-hornbeam forests (alliance *Carpinion betuli*) occupy the upper part of the valleys. Small patches of dry grasslands of the alliance *Festucion valesiacae* occur on the steep south-facing slope near the ruin of Blansek Castle and on the opposite slopes of *Pustý žleb*. There is also a patch of thermophilous oak forest (association *Euphorbio-Quercetum*, alliance *Quercion pubescenti-petraeae*) near the Blansek Castle.

Dry grasslands on a limestone slope near Vilémovice in the northern part of the Moravian Karst. Photo M. Chytrý.



The area around the Macocha abyss with the deep karst valleys of Pustý žleb and Suchý žleb in the northern part of the Moravian Karst.

Flora

The flora of the valleys of *Pustý žleb* and *Suchý žleb* represents a mixture of montane species (e.g. *Actaea europaea*, *Lunaria rediviva*, *Petasites albus* and *Primula elatior*), dealpine species (e.g. *Saxifraga paniculata* and *Sesleria caerulea*), regionally rare ferns typical of shaded limestone outcrops (e.g. *Asplenium scolopendrium*, *A. viride* and *Polypodium interjectum*) and thermophilous species (*Pyrus pyraster*, *Stipa pennata*, *Teucrium chamaedrys*, *Trifolium alpestre*, *Verbascum chaixii* subsp. *austriacum*, *Veronica teucrium* and *Vincetoxicum hirundinaria*).

The flora of the Macocha abyss is also relatively diverse: 247 taxa of vascular plants have been recorded here (Sutorý 2009). *Cortusa matthioli* growing on cliffs and talus slopes near the bottom is the most remarkable plant species. It occurs in the limestone areas of the Alps and the Carpathians and its isolated occurrence in Macocha represents its single locality in the Czech Republic.

Appendix 6d Selected species of vascular plants of the Macocha abyss and the valleys of *Suchý* žleb and *Pustý žleb* (according to Zachoval 1986).

Acinos arvensis
Aconitum lycoctonum
Actaea spicata
Agrimonia eupatoria
Agrostis stolonifera
Ajuga genevensis
Ajuga reptans
Alliaria petiolata
Allium senescens subsp. *montanum*
Allium oleraceum
Alyssum alyssoides
Anemone nemorosa
Anemone ranunculoides
Anemone sylvestris
Angelica sylvestris
Anthericum ramosum
Aquilegia vulgaris
Arabis hirsuta
Arenaria serpyllifolia
Asarum europaeum
Asperula cynanchica
Asperula tinctoria
Asplenium scolopendrium
Asplenium trichomanes
Asplenium viride
Astrantia major
Biscutella laevigata subsp. *varia*
Brachypodium pinnatum
Brachypodium sylvaticum
Bromus benekenii
Bromus erectus
Buglossoides purpurocaerulea
Bupleurum falcatum
Campanula persicifolia
Campanula rapunculoides
Campanula rotundifolia agg.
Campanula trachelium
Cardamine amara
Carex caryophyllea
Carex digitata
Carex humilis
Carex montana
Carex pilosa
Carex sylvatica
Carlina acaulis
Centaurea scabiosa
Centaurea stoebe
Cephalanthera damasonium
Cirsium eriophorum
Clinopodium vulgare
Convallaria majalis
Cornus mas
Cornus sanguinea
Cotoneaster integerrimus
Cruciata verna
Cuscuta epithymum
Cyclamen purpurascens
Cypripedium calceolus
Cytisus nigricans
Daphne mezereum
Dentaria bulbifera
Digitalis grandiflora
Dryopteris carthusiana
Dryopteris filix-mas
Echium vulgare
Epipactis atrorubens
Epipactis helleborine
Euonymus verrucosus
Euphorbia cyparissias
Euphorbia epithymoides
Festuca altissima
Festuca gigantea
Festuca pallens
Filipendula ulmaria
Galeobdolon montanum
Galium odoratum
Galium pumilum
Galium sylvaticum
Genista tinctoria
Geranium phaeum
Geranium robertianum
Geranium sanguineum
Helianthemum grandiflorum subsp. *obscurum*
Hordelymus europaeus
Hylotelephium maximum
Inula conyzae
Inula salicina
Jovibarba globifera
Lathyrus vernus
Libanotis pyrenaica
Lilium martagon
Lunaria rediviva
Maianthemum bifolium
Melampyrum nemorosum
Melica ciliata
Melica transsilvanica
Mercurialis perennis
Moneses uniflora
Mycelis muralis
Neottia nidus-avis
Origanum vulgare
Paris quadrifolia
Phleum phleoides
Picea abies
Pilosella bauhini
Pimpinella major
Pimpinella saxifraga
Platanthera bifolia
Platanthera chlorantha
Polygala vulgaris
Polygonatum multiflorum
Polygonatum odoratum
Polypodium interjectum
Polystichum aculeatum
Potentilla incana
Primula elatior
Primula veris
Prunus fruticosa
Ranunculus bulbosus
Rhamnus cathartica
Ribes alpinum
Rosa pendulina
Salvia pratensis
Salvia verticillata
Sanguisorba minor
Sanicula europaea
Saxifraga paniculata
Scabiosa ochroleuca
Securigera varia
Sedum album

Seseli annuum
Seseli hippomarathrum
Seseli osseum
Sesleria caerulea
Sorbus aria agg.
Sorbus torminalis
Stachys germanica
Stachys palustris
Stachys recta
Stipa pennata
Tanacetum corymbosum
Teucrium chamaedrys
Thymus praecox
Tragopogon dubius
Tragopogon orientalis
Trifolium alpestre
Trifolium montanum
Verbascum chaixii subsp. *austriacum*
Verbascum lychnitis
Veronica chamaedrys
Veronica teucrium
Vincetoxicum hirundinaria
Viola hirta
Viola reichenbachiana
Viola riviniana

Ravine forest in the karst valley Pustý žleb in the northern part of the Moravian Karst. Photo M. Chytrý.

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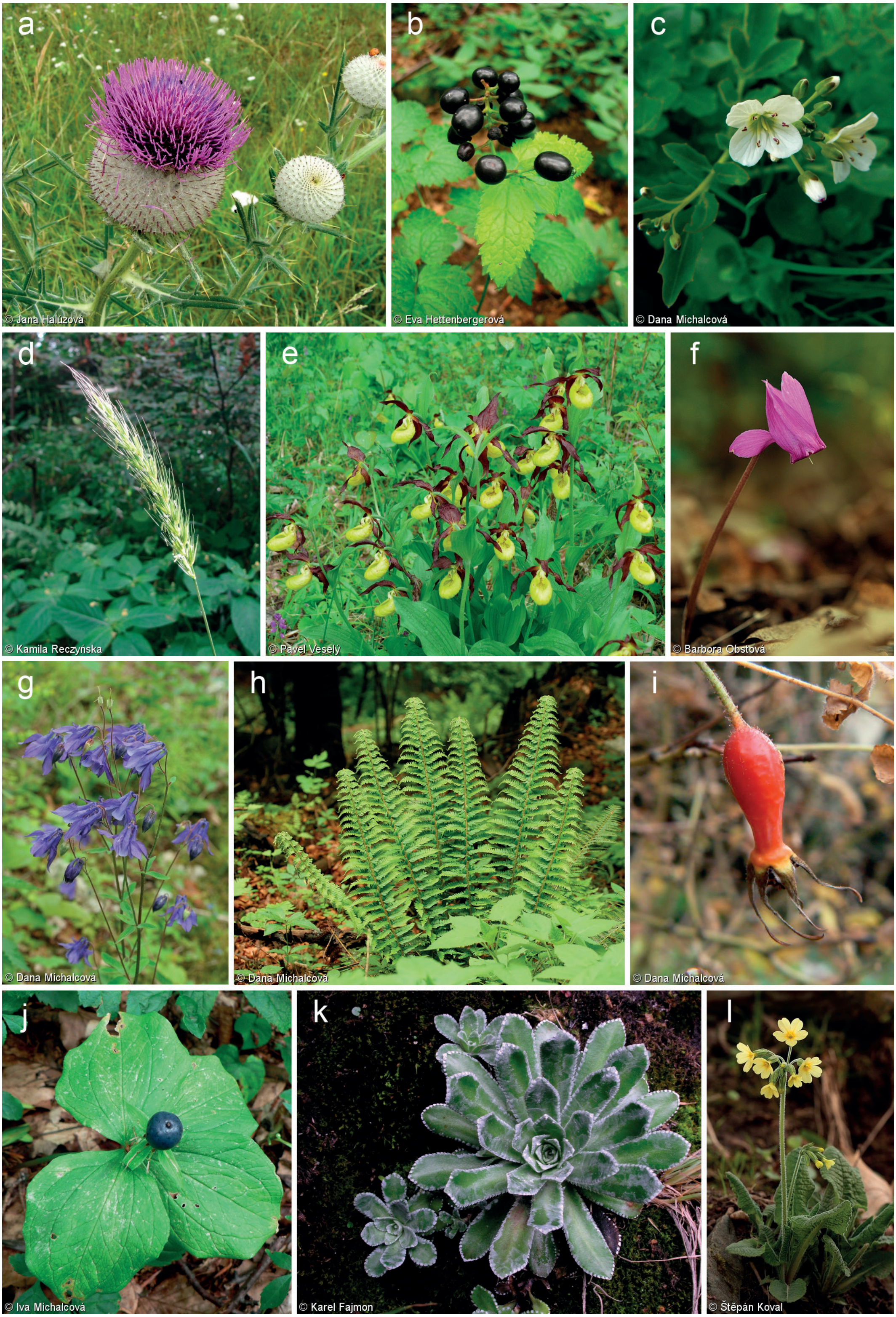

Plate 6d Plants of the Macocha abyss and the nearby valleys in the Moravian Karst: (a) *Cirsium eriophorum*, (b) *Actaea spicata*, (c) *Cardamine amara*, (d) *Hordelymus europaeus*, (e) *Cypripedium calceolus*, (f) *Cyclamen purpurascens*, (g) *Aquilegia vulgaris*, (h) *Polystichum aculeatum*, (i) *Rosa pendulina*, (j) *Paris quadrifolia*, (k) *Saxifraga paniculata*, (l) *Primula elatior*.

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7 Pouzdřany Steppe and Kolby Wood

Jan Roleček

Introduction

The Pouzdřany Steppe and Kolby Wood are parts of the National Nature Reserve *Pouzdřanská step-Kolby.* The reserve is situated in southern Moravia above the village of Pouzdřany, about 25 km south of Brno and 6 km west of the town of Hustopeče.

The Pouzdřany Steppe and Kolby Wood represent one of the best-preserved remnants of subcontinental forest-steppe in the Czech Republic. Despite its limited area (47 ha), the reserve harbours much of the species richness of Pannonian forest-steppe flora and fauna that have retreated from many sites in the region in recent centuries.

The surrounding hilly landscape belongs to the southernmost edge of the Central Moravian Carpathians. There is a spectacular view from the hilltop of the Pouzdřany Steppe of the Pavlov Hills across the lower Dyje area, partly flooded by the Nové Mlýny reservoirs built in the 1970s–1980s. The fringes of the Bohemian-Moravian Highlands enclose the view to the west, while the lowlands of the Pannonian Basin stretch to the south-east. The bedrock is mostly formed of Palaeogene calcareous claystones and sandstones of the Carpathian flysch, partly covered by Pleistocene loess. The mean annual temperature in the area is about 9 °C and annual precipitation sum about 550 mm.

Panoramic view of the Pouzdřany Steppe with a mosaic of dry grasslands and shrublands and Kolby Wood on the plateau and shady slopes. The white dots in the background are individuals of Crambe tataria in bloom established on ex-arable land. The strips of shrubs indicate the former agricultural use of some of the grasslands. Photo J. Roleček.

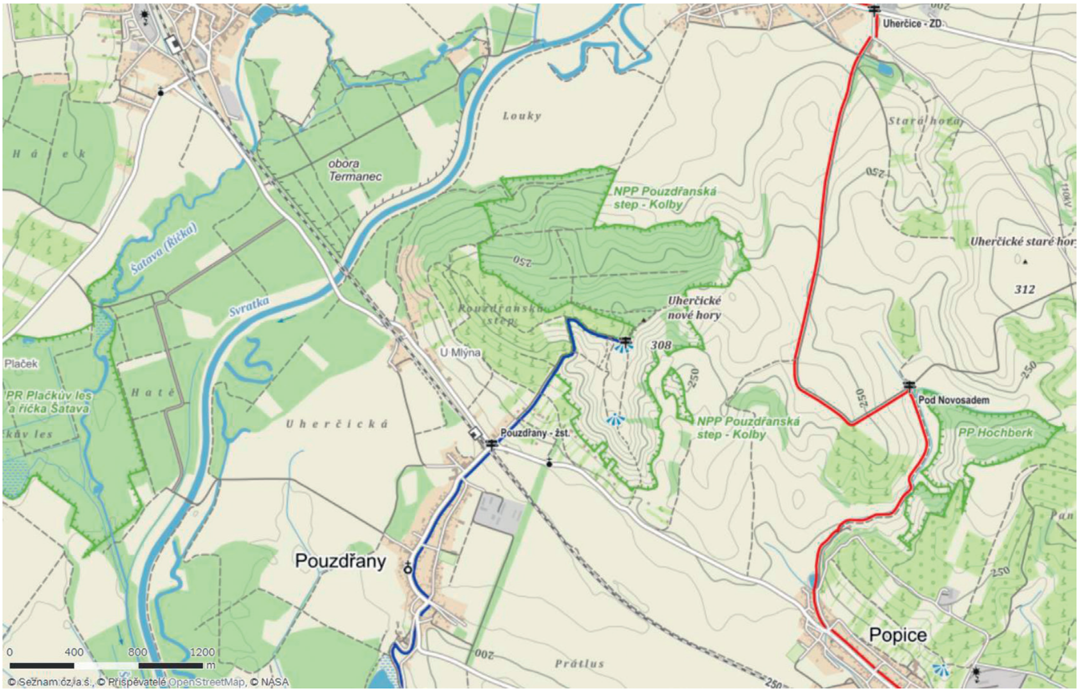
Vegetation and flora of the Pouzdřany Steppe

The origin and long-term dynamics of forest-steppe vegetation in the region has been insufficiently studied. The climate of the region supports forest vegetation on non-extreme sites. However, the richness of steppe species and occurrence of some rare species with disjunct distributions, together with some recent palaeoecological evidence (Kuneš et al. 2015), support the hypothesis of Holocene continuity of forest-steppe vegetation in southern Moravia. We do not know much about the factors responsible for the long-term persistence of forest-steppe in this region, though certain dynamic factors including ancient human activity, herbivore grazing and fires probably played a role. Recent successional changes of dry grasslands in the absence of management also confirm the dependence of southern Moravian forest-steppe ecosystems on regular disturbance. Active conservation measures are required in nature reserves to maintain their diversity. Some of the most valuable grassland patches in the Pouzdřany Steppe are mown, and trees and shrubs have been removed in recent years. A population of the European rabbit (*Oryctolagus cuniculus*) has been introduced to provide essential disturbance. Parts of the steppe also burn irregularly due to accidental fires.

Many slopes in the Pouzdřany Steppe area were terraced for vineyards, orchards or arable fields in the past. Some of them were used to plant *Glycyrrhiza glabra* to produce liquorice from its sweet root. There was also a large field on the flat hilltop of the Pouzdřany Steppe. Most of the agricultural land around the steppe was abandoned in the second half of the 20th century and left to spontaneous succession. A space-for-time substitution study has shown that, within a few years, the ex-arable land around the steppe developed into perennial dry grassland in which weedy species continuously decreased, valuable steppe species increased, and total species richness also increased (Sojneková & Chytrý 2015).

Stipa pulcherrima dominates the dry grasslands on the south-facing slopes of the Pouzdřany Steppe. Photo M. Chytrý.

The current vegetation of the reserve is composed of dry grasslands (alliances *Festucion valesiacae* and *Cirsio-Brachypodion pinnati*) with scattered shrubs and solitary trees and a mesic forest (alliance *Carpinion betuli*). The species-rich dry grasslands on sunny slopes (association *Koelerio macranthae-Stipetum joannis*, alliance *Festucion valesiacae*) are dominated by feather grasses (mostly *Stipa pennata* and *S. pulcherrima*), narrow-leaved fescues (*Festuca valesiaca* and *F. rupicola*), *Koeleria macrantha* and *Carex humilis*. Many drought-tolerant herbs and dwarf shrubs are admixed, e.g. *Campanula sibirica*, *Cytisus procumbens*, *Galium glaucum*, *Potentilla incana*, *Teucrium chamaedrys* and *Thymus pannonicus*. In disturbed places on deeper soils (abandoned fields, tourist paths and the surroundings of rabbit colonies), vegetation of the association *Astragalo exscapi-Crambetum tatariae* (alliance *Festucion valesiacae*) has developed that is rich in rare competitively-poor steppe species such as *Astragalus exscapus*, *Crambe tataria*, *Glaucium corniculatum* and *Jurinea mollis*. In more mesic sites, broad-leaved dry grasslands (association *Polygalo majoris-Brachypodietum pinnati*, alliance *Cirsio-Brachypodion pinnati*) with less drought-tolerant species (*Adonis vernalis*, *Centaurea scabiosa*, *Geranium sanguineum*, *Orchis militaris*, *Peucedanum cervaria* and *Viola hirta*) occur. Scattered shrubs and solitary trees include *Crataegus monogyna*, *Prunus fruticosa*, *P. spinosa*, *Quercus pubescens* and *Ulmus minor* (Podpěra 1928; Vicherek & Unar 1971; Ambrozek 1989). The occurrence of a small population of the Pannonian endemic *Artemisia pancicii* is the most valuable from the floristic point



Pouzdřany Steppe and Kolby Wood near the village of Pouzdřany.

of view. This putative glacial relict has a few localities across Pannonia: three in Moravia and others in eastern Austria and in the sandy area of Deliblatska peščara in north-eastern Serbia (Ehrendorfer 1964; Danihelka & Marhold 2003; see also locality 12 *Špidláky* Nature Reserve).

Vegetation and flora of Kolby Wood

Kolby Wood on the plateau and north-facing slopes provides a fine example of Central European mesic oak-hornbeam forest (association *Primulo veris-Carpinetum betuli*, alliance *Carpinion betuli*). The closed canopy is dominated by *Quercus petraea*, *Acer campestre* and *Carpinus betulus*, with *Ligustrum vulgare*, *Euonymus verrucosus* and *Crataegus laevigata* in the shrub layer. The species-rich herb layer is characteristic with a colourful spring aspect with *Anemone nemorosa*, *A. ranunculoides*, *Corydalis cava*, *C. solida*, *Isopyrum thalictroides* and *Viola mirabilis*. Later in the year, *Convallaria majalis*, *Dactylis polygama*, *Galium odoratum*, *Melica uniflora*, *Poa nemoralis* and other nemoral species become dominant. On sunny forest edges, forest-steppe species are more abundant, including *Quercus pubescens* and a herb layer with *Brachypodium pinnatum*, *Buglossoides purpurocaerulea*, *Carex michelii*, *Dictamnus albus*, *Euphorbia epithymoides*, *Geranium sanguineum*, *Iris variegata*, *Peucedanum cervaria* and *Polygonatum odoratum* (Podpěra 1928).

Appendix 7 Selected species of vascular plants of the Pouzdřany Steppe and Kolby Wood.

Pouzdřany Steppe
Acer campestre
Acinos arvensis
Adonis flammea
Adonis vernalis
Agrimonia eupatoria
Agrostis capillaris
Achillea collina
Achillea pannonica
Ajuga chamaepitys
Ajuga genevensis
Alliaria petiolata
Allium oleraceum
Allium rotundum
Allium scorodoprasum
Alyssum alyssoides
Anemone sylvestris
Anthericum ramosum
Anthoxanthum odoratum
Anthriscus sylvestris
Anthyllis vulneraria
Arabidopsis thaliana
Arenaria serpyllifolia agg.
Aristolochia clematitis
Arrhenatherum elatius
Artemisia absinthium
Artemisia pancicii
Artemisia pontica
Asparagus officinalis
Asperula cynanchica
Aster amellus
Astragalus austriacus
Astragalus glycyphyllos
Astragalus exscapus
Astragalus onobrychis
Avenula pubescens

Betonica officinalis
Betula pendula
Bothriochloa ischaemum
Brachypodium pinnatum
Briza media
Bromus erectus
Bromus inermis
Bromus japonicus
Buglossoides incrassata subsp. *splitgerberi*
Buglossoides purpurocaerulea
Bupleurum falcatum
Bupleurum rotundifolium
Calamagrostis epigejos
Camelina microcarpa
Campanula bononiensis
Campanula glomerata
Campanula persicifolia
Campanula sibirica
Campanula rapunculoides
Carex caryophyllea
Carex humilis
Carex michelii
Carex montana
Carex muricata agg.
Carex praecox
Carex supina
Carlina biebersteinii subsp. *brevibracteata*
Caucalis platycarpos
Centaurea jacea
Centaurea scabiosa
Centaurea stoebe
Centaurea triumfetti
Cerastium arvense
Cerinthe minor
Chaerophyllum bulbosum
Chaerophyllum temulum
Chamaecytisus ratisbonensis
Chamaecytisus austriacus
Chondrilla juncea
Clematis recta
Clematis vitalba
Clinopodium vulgare
Conringia orientalis
Cornus mas
Cornus sanguinea
Corylus avellana
Crambe tataria
Crataegus monogyna
Crataegus laevigata
Crepis praemorsa
Crepis foetida subsp. *rhoeadifolia*
Cruciata verna
Cynoglossum officinale
Cytisus nigricans
Cytisus procumbens
Dactylis glomerata
Daucus carota
Dianthus pontederae
Dictamnus albus
Diplotaxis muralis
Dorycnium germanicum
Echium vulgare
Elymus caninus
Elymus hispidus
Elymus repens
Erigeron acris
Erodium cicutarium
Erophila verna agg.
Eryngium campestre
Erysimum diffusum
Erysimum odoratum
Erysimum repandum
Euonymus europaeus
Euphorbia cyparissias
Euphorbia epithymoides
Euphorbia exigua
Euphorbia falcata
Euphorbia virgata
Falcaria vulgaris
Festuca pulchra
Festuca rupicola
Festuca valesiaca
Ficaria verna subsp. *verna*
Filipendula vulgaris
Fragaria viridis
Fumaria schleicheri
Fumaria vaillantii
Galatella linosyris
Galium aparine
Galium album
Galium glaucum
Galium tricornutum
Galium verum
Genista tinctoria
Geranium robertianum
Geranium sanguineum
Geum urbanum
Glaucium corniculatum
Glycyrrhiza glabra
Helianthemum grandiflorum subsp. *obscurum*
Helichrysum arenarium
Helictochloa pratensis
Heracleum sphondylium
Hieracium umbellatum
Holosteum umbellatum
Humulus lupulus
Hylotelephium maximum
Hypericum perforatum
Inula ensifolia
Inula germanica
Inula hirta
Inula oculus-christi
Inula salicina
Inula ×stricta (*I. ensifolia* × *I. salicina*)
Iris pumila
Iris variegata
Jurinea mollis
Knautia arvensis
Koeleria macrantha
Lactuca quercina
Lactuca serriola
Lamium album
Lappula squarrosa
Lathyrus pannonicus subsp. *collinus*
Lathyrus tuberosus
Lavatera thuringiaca
Lepidium draba
Ligustrum vulgare
Lilium martagon
Linaria vulgaris
Linaria genistifolia
Linum flavum
Linum hirsutum
Linum tenuifolium
Lithospermum officinale
Lotus corniculatus
Lycium barbarum (neo)
Lycopsis arvensis
Medicago falcata
Melampyrum arvense
Melampyrum cristatum
Melica ciliata
Melica transsilvanica
Microthlaspi perfoliatum
Muscari comosum
Muscari neglectum
Muscari tenuiflorum
Nigella arvensis
Nonea pulla
Odontites luteus
Odontites vernus subsp. *serotinus*
Ononis spinosa
Orchis militaris
Origanum vulgare
Ornithogalum kochii
Orobanche alsatica
Orobanche caryophyllacea
Oxytropis pilosa
Papaver maculosum
Peucedanum alsaticum
Peucedanum cervaria
Phelipanche arenaria
Phelipanche purpurea
Phleum phleoides
Phlomis tuberosa
Picris hieracioides
Pilosella auriculoides
Pilosella bauhini
Pilosella densiflora
Pilosella kalksburgensis
Pilosella officinarum
Pilosella rothiana
Pimpinella saxifraga
Plantago lanceolata
Plantago media

Plate 7 Plants of the Pouzdřany Steppe and Kolby Wood: (a) *Thymus pannonicus*, (b) *Astragalus austriacus*, (c) *Campanula bononiensis*, (d) *Melampyrum cristatum*, (e) *Stipa pulcherrima*, (f) *Inula germanica*, (g) *Asarum europaeum*, (h) *Corydalis cava*, (i) *Carex digitata*, (j) *Acer campestre*, (k) *Tilia cordata*, (l) *Anemone ranunculoides*.

Solitary individuals of Quercus pubescens on the upper slopes of the Pouzdřany Steppe. Photo M. Chytrý.

Poa angustifolia
Poa bulbosa
Poa nemoralis
Polycnemum arvense
Polygala major
Polygonatum odoratum
Populus tremula
Potentilla alba
Potentilla incana
Potentilla patula
Potentilla recta
Primula veris
Prunus fruticosa
Prunus spinosa
Pulmonaria mollis
Pulsatilla grandis
Pyrus pyraster
Pulsatilla pratensis subsp. *bohemica*
Quercus petraea
Quercus pubescens
Quercus robur
Ranunculus auricomus agg.
Ranunculus polyanthemos
Rapistrum perenne
Reseda lutea
Reseda luteola
Rosa canina
Rosa dumalis
Rosa gallica
Rosa spinosissima
Salsola tragus
Salvia nemorosa
Salvia pratensis
Salvia verticillata
Sambucus nigra
Sanguisorba minor
Saponaria officinalis
Scabiosa ochroleuca
Sclerochloa dura
Scorzonera austriaca
Scorzonera cana
Scorzonera hispanica
Scorzonera purpurea
Securigera varia
Sedum acre
Senecio jacobaea
Serratula tinctoria
Seseli hippomarathrum
Seseli osseum
Seseli pallasii
Sherardia arvensis
Silene nutans
Silene otites
Silene vulgaris
Sisymbrium loeselii (neo)
Stachys annua
Stachys recta
Stipa capillata
Stipa pennata
Stipa pulcherrima
Tanacetum corymbosum
Teucrium chamaedrys
Thalictrum minus
Thesium dollineri
Thesium linophyllon
Thymus glabrescens
Thymus pannonicus
Tragopogon dubius
Tragopogon orientalis
Trifolium alpestre
Trifolium medium
Trifolium montanum
Trifolium rubens
Trinia glauca
Ulmus minor
Valeriana stolonifera subsp. *angustifolia*
Verbascum chaixii subsp. *austriacum*
Veronica praecox
Veronica prostrata
Veronica spicata
Veronica teucrium
Veronica vindobonensis
Vicia cracca
Vicia tenuifolia
Vincetoxicum hirundinaria
Viola ambigua
Viola hirta
Viola suavis (neo)
Viola tricolor subsp. *saxatilis*

Kolby Wood
Acer campestre
Acer pseudoplatanus
Adonis vernalis
Achillea collina
Ajuga genevensis
Alliaria petiolata
Allium oleraceum
Allium ursinum
Anemone nemorosa
Anemone ranunculoides
Anemone sylvestris
Anthericum ramosum
Anthriscus sylvestris
Asarum europaeum
Astragalus glycyphyllos
Betula pendula
Brachypodium pinnatum
Brachypodium sylvaticum
Bromus benekenii
Bromus japonicus
Buglossoides purpurocaerulea
Calamagrostis arundinacea
Campanula persicifolia
Campanula rapunculoides
Campanula trachelium
Cardamine impatiens
Carex digitata
Carex michelii
Carex montana
Carex muricata agg.
Carpinus betulus
Centaurea triumfetti
Chaerophyllum bulbosum
Chaerophyllum temulum
Clematis recta
Clematis vitalba
Clinopodium vulgare
Convallaria majalis
Cornus mas
Cornus sanguinea
Corydalis cava
Corydalis pumila
Corylus avellana
Crataegus monogyna
Crataegus laevigata
Cruciata verna
Dactylis polygama
Dictamnus albus
Elymus caninus
Euonymus europaeus
Euonymus verrucosus
Euphorbia cyparissias
Euphorbia epithymoides
Festuca heterophylla
Ficaria verna subsp. *verna*
Filipendula vulgaris
Fragaria vesca
Fragaria moschata
Fraxinus excelsior
Galanthus nivalis
Galium aparine
Galium odoratum
Galium sylvaticum
Genista tinctoria
Geranium robertianum
Geranium sanguineum
Geum urbanum
Hesperis sylvestris
Hieracium lachenalii
Hieracium laevigatum
Hieracium murorum
Hieracium sabaudum
Hypericum hirsutum
Hypericum perforatum
Inula salicina
Iris graminea
Iris variegata
Isopyrum thalictroides
Lactuca quercina
Lamium album
Lathyrus niger
Lathyrus vernus
Ligustrum vulgare
Lilium martagon
Lonicera caprifolium (neo)
Malus sylvestris
Melampyrum pratense
Melampyrum cristatum
Melampyrum nemorosum
Melica nutans
Melica uniflora
Melittis melissophyllum
Milium effusum
Moehringia trinervia
Neottia nidus-avis
Nigella arvensis
Nonea pulla
Odontites vernus subsp. *serotinus*
Omphalodes scorpioides
Peucedanum cervaria
Phyteuma spicatum
Poa nemoralis
Polygonatum multiflorum
Polygonatum odoratum
Populus tremula
Primula veris
Prunus spinosa
Pulmonaria mollis
Pulmonaria officinalis agg.
Pyrus pyraster
Quercus cerris
Quercus petraea
Quercus pubescens
Quercus robur
Ranunculus auricomus agg.
Rosa canina
Rosa dumalis
Salix caprea
Sambucus nigra
Silene nutans
Solidago virgaurea
Sorbus domestica
Sorbus torminalis
Staphylea pinnata
Stellaria holostea
Symphytum tuberosum
Tanacetum corymbosum
Teucrium chamaedrys
Tilia cordata
Tilia platyphyllos
Ulmus glabra
Ulmus laevis
Ulmus minor
Valeriana stolonifera subsp. *angustifolia*
Veronica vindobonensis
Viburnum lantana
Viburnum opulus
Vicia dumetorum
Vicia pisiformis
Vicia sylvatica
Vinca minor
Vincetoxicum hirundinaria
Viola hirta
Viola mirabilis
Viola reichenbachiana
Viola riviniana

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8 Pavlov Hills

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Introduction

The Pavlov Hills (*Pavlovské vrchy*, also known as *Pálava* in Czech, *Pollauer Berge* in German) are a range of limestone hills in southern Moravia situated between the Dyje River (*Thaya* in German) and the Czech-Austrian border near the town of Mikulov. They are located about 30–40 km south of the southern margin of the city of Brno. The area is 11 km long and 2–3 km wide. The altitudinal difference between the *Nové Mlýny* reservoir near the village of Dolní Věstonice (170 m) and the top of Děvín Hill (549 m) is almost 380 m.

The Pavlov Hills from the Pouzdřany Steppe. The Roman soldiers from the military camps on the foothills of the Pavlov Hills called these hills Mons Veneris, because the silhouette of the hills reminded them of the lying goddess Venus. Photo M. Chytrý.

The northernmost hilltop with the ruins of the 14th century castle *Děvičky* (also called *Dívčí hrady* in Czech or *Maidenstein* in German) stands out above the village of Pavlov. The next hill to the south is the highest of the hills, *Děvín* (549 m), which is separated from the hill *Obora* (483 m) in the south-west by the narrow gorge called *Soutěska*. The hill *Růžový vrch*, with another castle ruin on the top, and the hill *Stolová hora* (459 m), with a prominent plateau, form the central part of the range. The hills *Turold* (385 m) and *Svatý kopeček* (363 m), the latter with a Baroque chapel on its top, surround the town of Mikulov from the north and the east, respectively. The southernmost hill *Šibeničník* (238 m) is situated south of the town near the border with Austria. The hills *Schweinbarther Berg*, *Höhlenstein* and *Falkensteiner Berge* in the adjacent part of Lower Austria belong to the same range.

The Pavlov Hills are included in the *Pálava* Protected Landscape Area (PLA), which was established in 1976. The area became a UNESCO Biosphere Reserve ten years later. Individual limestone hills and other valuable sites within the PLA are protected as National Nature Reserves (NNR), Nature Reserves (NR) and Nature Monuments (NM). There are two NNRs (*Děvín-Kotel-Soutěska* and *Tabulová*), three NRs (*Turold*, *Svatý kopeček* and *Šibeničník*) und four NMs (*Kočičí skála*, *Růžový kopec*, *Anenský vrch* and *Lom Janičův vrch*). Both NNRs, NR *Turold* and NR *Svatý kopeček* are also Sites of Community Importance within the Natura 2000 network.

Geology and soils

The landscape of the Pavlov Hills is strongly modulated, with outcrops and cliffs of pure, hard and white limestone of Upper Jurassic origin called *Ernstbrunn* limestone. Sedimentation of *Ernstbrunn* limestone was preceded by sedimentation of grey calcareous claystone and clay limestone called *Klentnice* layers. The Pavlov Hills are situated at the margin of the flysch zone of the Eastern Alps and Western Carpathians. The flysch beds consist of strongly folded Lower Tertiary claystone, sandstone and conglomerate. Large blocks of Jurassic and Lower Cretaceous rocks were torn from their Jurassic ground (now situated up to 2 km below the surface) during the periods of orogenetic activity in the Tertiary and re-deposited over the younger flysch beds (Čtyroký 1990; Čtyroký et al. 1995).

In the Lower Badenian period (Upper Tertiary), the Pavlov Hills were surrounded by a warm sea. Pieces of Jurassic rock present in the littoral gravel from that period indicate that limestone may have already been denuded at that time. A strong subsidence formed the Vienna Basin 15 million years ago. During the following 9 million years, layers of maritime and lacustrine sediments up to 3 km thick were deposited on its bottom.

Loess and debris, also comprising re-deposited Tertiary clay and fossil soils, were deposited on the footslopes of the Pavlov Hills during the Quaternary. A complete sequence of loess sedimentation from the last two glacials and two interglacials, with buried chernozem horizons, can be observed in abandoned clay pits near the village of Dolní Věstonice (Fuchs et al. 2013).

The prevailing soil types are calcareous leptosols (rendzinas), chernozems and luvisols. Rendzinas were formed over hard *Ernstbrunn* limestone; they are shallow and dry, of neutral to moderately alkaline reaction. They are covered mainly with dry grasslands and open thermophilous oak forests. Chernozems are found on loess deposits on the foothills of the Pavlov Hills. Luvisols occur on moderately inclined hillsides covered with Mesozoic and Tertiary calcareous clays, slope deposits or decalcified loess. These soils are deep and have a more balanced water supply; they are mostly covered with forest.

The Pavlov Hills north of the town of Mikulov and the Dyje floodplain near Lednice with excursion sites. The green dashed line indicates the Pálava Protected Landscape Area.

Climate

The climate of the Pavlov Hills is subcontinental. The mean annual temperatures in this part of southern Moravia are 9–10 °C. The mean temperature in the growing season (April–September) is 15–16 °C. The warmest and coldest months are July and January with mean temperatures of 19–20 °C and –1 to –2 °C, respectively. All these values fall by about 1 °C at higher altitudes on the ridge of the Pavlov Hills. The area around the Pavlov Hills is one of the driest in the Czech Republic due to its location in the lee of the Bohemian-Moravian Highlands. The annual precipitation sums are 500–550 mm, of which 300–325 mm falls in the growing season. The temporal variation in precipitation is considerable and long periods of drought are common. Such a climate supports the development of forest-steppe vegetation.

History of botanical research

The Pavlov Hills have attracted naturalists and botanists since the early times of botanical research. The earliest plant records date back to the 1820s when the German botanist Christian F. Hochstetter explored the flora of Moravia during his stay in Brno, where he served as a Lutheran minister and school director (Hrabětová-Uhrová 1970; Danihelka 2008). He visited the area at least once, as is documented by herbarium specimens found in some European herbaria, including PRC, BRNM and STU. He also published an account of interesting plants from the area (Hochstetter 1825). His plant records, supplemented by additional finds by his contemporaries, were later included in the first flora of Moravia (Rohrer & Mayer 1835).

In the second half of the 19th century, the Pavlov Hills were frequently visited by botanists from Brno, particularly A. Makowsky, J. Wiesner, F. Haslinger and I. Czižek, all members of the Natural History Society in Brno (*Naturforschender Verein in Brünn*). Alexander Makowsky and Adolf Oborny summarized their finds in the local floras of the Brno province (Makowsky 1863) and Znojmo province (Oborny 1879). These two booklets and the two-volume Flora of Moravia by Oborny (1886) provide reliable information on the flora of the area in the past.

In the early 20th century, Josef Podpěra discovered a population of *Helictotrichon desertorum*, a continental relict species, on Šibeničník Hill south of the town of Mikulov (Podpěra 1912). As the first Professor of Botany at the newly established Masaryk University, he repeatedly visited the area during the 1920s and produced a combined description of its flora and vegetation (Podpěra 1928). At the same time, followers of the emerging Braun-Blanquet approach (Zlatník 1928; Klika 1931) described some plant associations and alliances of the attractive dry limestone grasslands of the Pavlov Hills. In parallel, the flora of Mikulov and its vicinity was documented by Anton Fröhlich, a secondary school teacher in Mikulov whose botanical activities continued until the mid 1960s. A brief flora of the Mikulov district, based on earlier records and his own observations, was compiled by Vratislav Šuk (Šuk 1956) who worked as a pharmacist in Mikulov for a couple of years in the early 1950s.

In the 1950s, Jaroslav Horák surveyed the vegetation of the Pavlov Hills and adjacent Milovice Wood using the classification system of forest site types developed by Alois Zlatník (Horák 1969). His vegetation plots are well documented and recorded on the map, and may therefore be considered permanent plots. Repeated survey of his plots made it possible to assess the changes of forest vegetation in this area over the last half century (Müllerová et al. 2015).

Research into the Pavlov Hills flora was resumed in the early 1980s, when Vít Grulich was appointed botanist of the District Museum in Mikulov. His research activities are documented by numerous specimens in the museum’s herbarium (MMI), now including about 50,000 sheets. In 1992–2004, Jiří Danihelka worked as botanist for the administrative authority of the *Pálava* Protected Landscape Area. He initiated a grid mapping of vascular plants of the Pavlov Hills and the Lower Dyje floodplain. This survey from 1992–2004 yielded about 140,000 records (Danihelka 2003; Danihelka & Šumberová 2004).

More recent surveys of the dry grassland vegetation of the Pavlov were been published by Šmarda (1975), Toman (1976) and Unar (2004).

Landscape history

The Pavlov Hills and their surroundings are world-famous for a series of Upper Palaeolithic archaeological sites on their foothills, most notably between the villages of Dolní Věstonice and Pavlov (Trinkaus & Svoboda 2006). These sites have provided a rich source of prehistoric artefacts (especially art) from the settlements of mammoth hunters from the Gravettian period (ca. 29–22 cal. ka BP). The artefacts include carved representations of animals, humans and enigmatic engravings, a figure of a young man carved in mammoth ivory that may represent the first example of portraiture (i.e. representation of an actual person), the earliest examples of ceramic (burned clay) figurines, including the famous Venus of Dolní Věstonice. One of the burials revealed a female skeleton placed beneath a pair of mammoth scapulae, which is believed to be the first proof of a female shaman.

In the 1980s, Czech palaeoecologists Eliška Rybníčková and Kamil Rybníček (Rybníčková & Rybníček 1991, 2014) analyzed pollen from a peat sediment from the nearby village of Bulhary, dated to the Gravettian period. In addition to indicators of steppe (*Artemisia*, *Chenopodiaceae*, *Ephedra* and *Plantago* cf. *media*) and tundra (*Betula nana*) they found surprisingly abundant tree pollen, including drought- and cold-adapted species such as *Pinus cembra*, *P. sylvestris*, *Larix* and *Betula pendula*, and also moisture-demanding species such as *Picea*, *Alnus* and rarely also some broad-leaved deciduous trees. This was one of the first pieces of evidence of the full-glacial forests in eastern-central Europe, which was later confirmed by new data from the Carpathians and their foothills (Willis & van Andel 2004). Based on the analogy with contemporary landscapes of continental southern Siberia, we can imagine the landscape of the Gravettian mammoth hunters as a forest-steppe with steppic grasslands on the loess plains and southern slopes, *Picea-Alnus* woodland in the river floodplains, *Pinus cembra-P. sylvestris-Larix-Betula* woodland on north-facing slopes and patches of *Betula nana* tundra in colder and wetter places. This interpretation is supported by the fossil mollusc faunas found in the Quaternary sediments on the foothills of the Pavlov Hills (Vašátko & Ložek 1973).

In view of the lack of peat deposits in the dry lowland area of southern Moravia, the Holocene history of the Pavlov Hills can be reconstructed mainly on the basis of malacozoological evidence (Vašátko & Ložek 1973). This indicates that loess sedimentation was followed by the spread of some warm-demanding continental species in the Late Glacial. The area was covered by forest-steppe in the early Holocene. There was an increase in precipitation at the beginning of the Atlanticum (8 cal. ka BP), which supported the spreading of mesic forests. However, Neolithic farmers colonized the area at approximately 7.5 cal. ka BP and began large-scale deforestation. The area has been permanently settled by humans ever since, with a remarkable peak in the Bronze Age when settlements were also built on the hilltops. Although patches of mesic deciduous forest were always present on the hills, particularly on the north-facing slope of Děvín Hill, several species of molluscs and plants typical of such forests are missing here, most probably because they failed to immigrate through the surrounding deforested landscape. The steppes in the Pavlov Hills are primary in the sense that they represent a direct continuation of the Pleistocene continental steppes. At the same time, they are secondary in many places as they spread to the areas deforested by humans since the Neolithic.

Vegetation

The Pavlov Hills are situated in the Pannonian phytogeographical province, which reaches its north-western limit in Lower Austria and southern Moravia. This region represents the westernmost extremity of the continuous zone of the Euro-Siberian forest-steppe, which extends through the Danube Valley and the Pannonian (Carpathian) Basin up to the southern fringes of the Western Carpathians, the eastern fringes of the Eastern Alps and the south-eastern edge of the Bohemian Massif. The following description of vegetation mainly concerns Děvín Hill (National Nature Reserve *Děvín-Kotel-Soutěska*), the highest and largest of the Pavlov Hills, which harbours most of the natural and semi-natural vegetation types found in the area.

Forests

The natural vegetation of the lower hillsides of the Pavlov Hills is Pannonian oak-hornbeam forest (association *Primulo veris-Carpinetum betuli*, alliance *Carpinion betuli*). The main tree species are *Quercus petraea* and *Carpinus betulus*, accompanied by *Acer campestre*, *Tilia cordata* and *T. platyphyllos*. The shrub layer is well developed and rich in species, including *Cornus mas*, *Euonymus verrucosus*, *Ligustrum vulgare* and *Staphylea pinnata*. The herb layer includes *Campanula persicifolia*, *C. rapunculoides*, *Festuca heterophylla*, *Melittis melissophyllum*, *Primula veris* and *Viola mirabilis*.

Moving upwards, on sites with soils still deep and moist enough to support a more or less closed canopy, oak-hornbeam forests are replaced by thermophilous oak forests of the association *Euphorbio-Quercetum* (alliance *Quercion pubescenti-petraeae*). The dominant trees are the Central European *Quercus petraea* and the sub-Mediterranean *Q. pubescens*. The shrub layer is usually luxuriant, consisting of thermophilous shrubs such as *Cornus mas*, *Ligustrum vulgare* and *Viburnum lantana*. The herb layer contains the thermophilous species *Buglossoides purpurocaerulea*, *Tanacetum corymbosum* and *Teucrium chamaedrys*, along with nutrient-demanding species of mesic forests, such as *Alliaria petiolata* and *Geum urbanum*.

The steep upper slopes with limestone outcrops support open stands of thermophilous oak forests classified as the association *Lithospermo purpurocaerulei-Quercetum pubescentis* (alliance *Quercion pubescenti-petraeae*). Their tree and shrub layers can hardly be separated, as *Quercus pubescens* trees are usually low and bushy, while shrubs, again mainly *Cornus mas*, *Ligustrum vulgare* and *Viburnum lantana*, are numerous and grow vigorously. Many species of thermophilous herbaceous forest fringes are present in the herb layer, such as *Dictamnus albus*, *Geranium sanguineum* and *Vincetoxicum hirundinaria*, as well as dry grassland species such as *Aster amellus*, *Carex humilis*, *Festuca rupicola*, *Inula ensifolia* and *Stachys recta*. On a finer scale, the shrub association *Violo hirtae-Cornetum maris* (alliance *Berberidion vulgaris*) and herbaceous forest-fringe communities of the alliance *Geranion sanguinei* can be distinguished here, along with various types of dry grasslands.

Two associations of broad-leaved ravine forest (alliance *Tilio platyphylli-Acerion*) occur on the north-facing slopes of Děvín Hill. The first, *Aceri-Tilietum*, is more widespread and includes stands with *Tilia platyphyllos*, *Carpinus betulus* and *Acer pseudoplatanus*. It is confined to sites with well-developed, moderately humid soils. The shrub layer is scarce due to the closed canopy and high densities of mouflon. The herb layer contains *Alliaria petiolata*, *Asarum europaeum*, *Campanula trachelium*, *Lathyrus vernus* and *Pulmonaria officinalis*; in early summer, it is dominated by the tall herb *Aconitum lycoctonum*. Upwards, at the foot and ledges of limestone cliffs, this type of ravine forest is replaced by patches of *Seslerio albicantis-Tilietum cordatae*. This relict community, with *Tilia platyphyllos* as the dominant tree here, harbours several species of *Sesleria* grasslands such as *Anthericum ramosum*, *Bupleurum falcatum*, *Erysimum odoratum*, *Hylotelephium maximum*, *Sesleria caerulea* and *Vincetoxicum hirundinaria*.

Grasslands

The dry grasslands of the Pavlov Hills have always attracted botanists, and formal phytosociological descriptions of their most important types were performed by Zlatník (1928) and, most notably, by Klika (1931). In phytosociological terms, they belong to the class of Euro-Siberian steppes *Festuco-Brometea.* The stands of the association *Festuco valesiacae-Stipetum capillatae* (alliance *Festucion valesiacae*) represent a type of continental steppe. They are associated with very dry places with moderately developed soil. In addition to the name-giving species, they also contain *Bothriochloa ischaemum*, *Centaurea stoebe*, *Festuca rupicola* and *Stipa pulcherrima*. The association *Poo badensis-Festucetum pallentis* (alliance *Bromo pannonici-Festucion pallentis*) is related to the sub-Mediterranean grasslands of southern Europe and the limestone and dolomite grasslands of the fringes of the Alps and Carpathians, although it also contains several species of the continental steppe. It occupies more extreme habitats with shallow soils of limestone outcrops. Several species of succulent *Crassulaceae*, such as *Jovibarba globifera*, *Sedum acre* and *S. album*, are confined to these places, along with *Allium flavum*, *Campanula sibirica*, *Festuca pallens*, *Iris pumila*, *Poa badensis* and *Teucrium montanum*. Short-living spring therophytes, such as *Arabis auriculata*, *Cerastium pumilum*, *Erophila spathulata* and *Holosteum umbellatum*, are typical of both types of dry grassland.

The north- and west-facing rocky slopes support *Sesleria caerulea* grasslands (association *Minuartio setaceae-Seslerietum caeruleae*, alliance *Diantho lumnitzeri-Seslerion*). These are related to the *Sesleria* grasslands that occur on limestone outcrops of the montane and subalpine belt of the Alps and the Carpathians. These grasslands are believed to have occupied lowland mesic sites on base-rich soils in the Pleistocene full-glacial periods, but retreated due to the spread of other vegetation types in the Holocene. They are currently restricted to high-altitudinal limestone areas in the Alps and Carpathians and to a few lowland sites such as the Pavlov Hills. They harbour several relict species with subalpine affinities, e.g. *Arenaria grandiflora*, *Biscutella laevigata* subsp. *varia*, *Dianthus lumnitzeri*, *Saxifraga paniculata* and *Tephroseris integrifolia*.

The dry grassland types described above are natural in many places, but have also developed at other sites due to deforestation and grazing. Some grassland types of secondary origin in the Pavlov Hills are of great interest in biodiversity conservation. For example, deep soils on loess and other soft sediments in the foothills support semi-dry grasslands with *Bromus erectus* and *Brachypodium pinnatum* (association *Polygalo majoris-Brachypodietum pinnati*, alliance *Cirsio-Brachypodion pinnati*). Some of these grasslands developed on abandoned fields and became rich in species over a few decades to attain a high conservation value (Sojneková & Chytrý 2015).

Other examples of remarkable plant communities in the Pavlov Hills include xeric shrub communities (alliances *Berberidion vulgaris* and *Prunion fruticosae*), weed communities of calcareous soils (alliance *Caucalidion*) and communities of fallow land (alliance *Dauco carotae-Melilotion*).

Flora

The flora of the Pavlov Hills is extremely remarkable due to the geographic location of the area on the north-western edge of the Pannonian Basin. Steppe and rock habitats harbour two major plant groups with contrasting distribution ranges: (1) 'eastern' species, i.e. those with Pannonian, Pontic-Pannonian or Continental distribution ranges, and (2) 'southern' species, i.e. mainly those with sub-Mediterranean distribution ranges, some of them broadly distributed on the limestone fringes of the Alps and the Carpathians. Several species of the former group reach their western distribution limit in southern Moravia, while those of the latter group grow here near their northern distribution limit. Eastern continental species are represented by, for example, *Adonis vernalis*, *Astragalus austriacus*, *Carex stenophylla*, *Helictotrichon desertorum*, *Peucedanum alsaticum*, *Phlomis tuberosa*, *Stipa pennata*, *Thalictrum foetidum* and *Viola ambigua*; they may be considered relicts of the late Pleistocene and early Holocene continental steppe. *Cytisus procumbens*, *Iris pumila*, *Jurinea mollis*, *Linum hirsutum* and *Medicago prostrata* are Pontic-Pannonian or Pannonian species. The group of southern species with sub-Mediterranean distribution includes *Buglossoides purpurocaerulea*, *Ficaria calthifolia*, *Fumana procumbens*, *Globularia bisnagarica*, *Linum tenuifolium*, *Minuartia rubra*, *M. setacea*, *Orlaya grandiflora*, *Parietaria officinalis*, *Quercus pubescens*, *Salvia aethiopis*, *Stipa pulcherrima*, *Teucrium montanum*, *Trinia glauca* and *Viola kitaibeliana*, the latter known in the Czech Republic only from the castle ruin *Děvičky* on Děvín Hill. *Stipa eriocaulis*, which in the Czech Republic grows only on the hill *Svatý kopeček* above the town of Mikulov, also belongs to this group. Central European taxa are represented by *Viola tricolor* subsp. *saxatilis* and species of broad-leaved deciduous forests such as *Aconitum lycoctonum*, *Corydalis pumila* and *Hepatica nobilis*. *Dianthus lumnitzeri*, protected under the EU Habitats Directive, is endemic to the western part of the Pannonian Basin. It occurs in southern Moravia (only in the Pavlov Hills), Lower Austria, south-western Slovakia and northern Hungary. The rocks of Děvín Hill harbour *Arenaria grandiflora* at the northernmost point of its distribution range.

Forest management

The earliest historical documents on forest management date back to the late 14th century (Hédl & Szabó 2009; Müllerová et al. 2014). At that time, the forests on Děvín Hill were managed as coppice with a rotation time of just seven years, producing mainly firewood and, along with the coppiced Milovice Wood, generating more than one quarter of all the income of the Liechtenstein Mikulov estate. Apparently, no standard trees were present. The coppice cycle increased to 11–12 years in the 17th century, and by that time the management system also included standard trees in some compartments. At that time, the right to underwood was leased to peasants for a fixed yearly sum, while the estate owners retained the right to standard trees in all forests. Consequently, the number of standard trees gradually increased. Modern forestry methods were introduced at the beginning of the 19th century starting with a detailed survey of standard trees; there were found to be more than 52,000 of them. In the 19th century and the first half of the 20th century, the coppicing cycle increased to 30–40 years. The last documented coppicing on Děvín Hill was in 1935–1938 (Altman et al. 2013). Coppicing was completely abandoned after WWII which resulted in a forest age structure completely different from that of the previous seven centuries. A game preserve for fallow deer (*Dama dama*) was established on Děvín Hill in 1885. Later on, a few dozen bezoar goat (*Capra aegagrus*) and mouflon (*Ovis musimon*) were kept there. The game preserve was closed in 1996, although a herd of mouflon, consisting of several dozen animals, can still be found there.

Repeated sampling of vegetation plots recorded by J. Horák in the 1950s revealed a substantial decrease in vegetation diversity by 2002–2003 (Hédl & Szabó 2009; Kopecký et al. 2013; Müllerová et al. 2014). Species richness per plot and per site declined and vegetation became more homogeneous. Light-demanding thermophilous species in particular, formerly fairly abundant in forest vegetation, have vanished or become extremely rare. This may be explained by changes in forest management (the transition from coppicing to high forest) and game pressure, and probably also by atmospheric nitrogen deposition. As a result, the forests have become darker, moister and richer in nutrients.

The nature conservation authorities currently aim to restore coppicing in some forest stands on Děvín Hill. After seven decades with almost no management, this would be another major change. The purpose of this move is conservation of vanishing plant and animal species and conservation of forest habitats protected under national and EU legislation. The management plan proposed for the period 2009–2019 by the *Pálava* Protected Landscape Area has been approved, though its implementation is encountering legislative and practical difficulties.

(8a) Děvín Hill

Děvín Hill (*Maidenberg* in German; 549 m) is a part of the National Nature Reserve *Děvín-Kotel-Soutěska*, situated in the northernmost part of the Pavlov Hills between the villages of Pavlov, Dolní Věstonice, Horní Věstonice, Perná and Klentnice. Besides Děvín Hill in the north-east the reserve includes also the hill *Obora* (also called *Kotel* or *Kotelná*; 483 m), separated by the deep gorge called *Soutěska.* The ruins of the medieval castle *Děvičky* (*Maidenstein*) can be found on the northernmost hilltop of Děvín. The hills are built mainly of hard and white *Ernstbrunn* limestone, forming spectacular cliffs above the *Soutěska* gorge, on the north-western slopes of Děvín and on the western slope of the hill *Obora*. The nature reserve, established in 1946, is 381 ha in size. A basic description of its vegetation can be found above in the characteristics of the Pavlov Hills as a whole. The flora of the reserve consists of more than 640 species.

The human impact on the ecosystems of Děvín Hill has an extremely long history. There were human settlements on the hills in the Upper Palaeolithic Gravettian Period. A fortified settlement was established on the north-east of the hilltop in the Upper Bronze Age. The castle Děvičky, built in the late-Romanesque and early-Gothic style, was first mentioned in written documents in the early 13th century. Another castle, known as *Neuhaus* or *Domus nova*, was established in the northern part of the hill *Obora* in the 14th century. Small limestone quarries existed in several places.

The sunny slopes of Děvín Hill are covered by a mosaic of steppic grasslands, dry oak woodlands and mesic forests in side valleys. Photo Z. Lososová.

Former coppice of Tilia platyphyllos on the north-facing slope of Děvín Hill. Photo M. Chytrý.

Děvín Hill in the northern part of the Pavlov Hills.

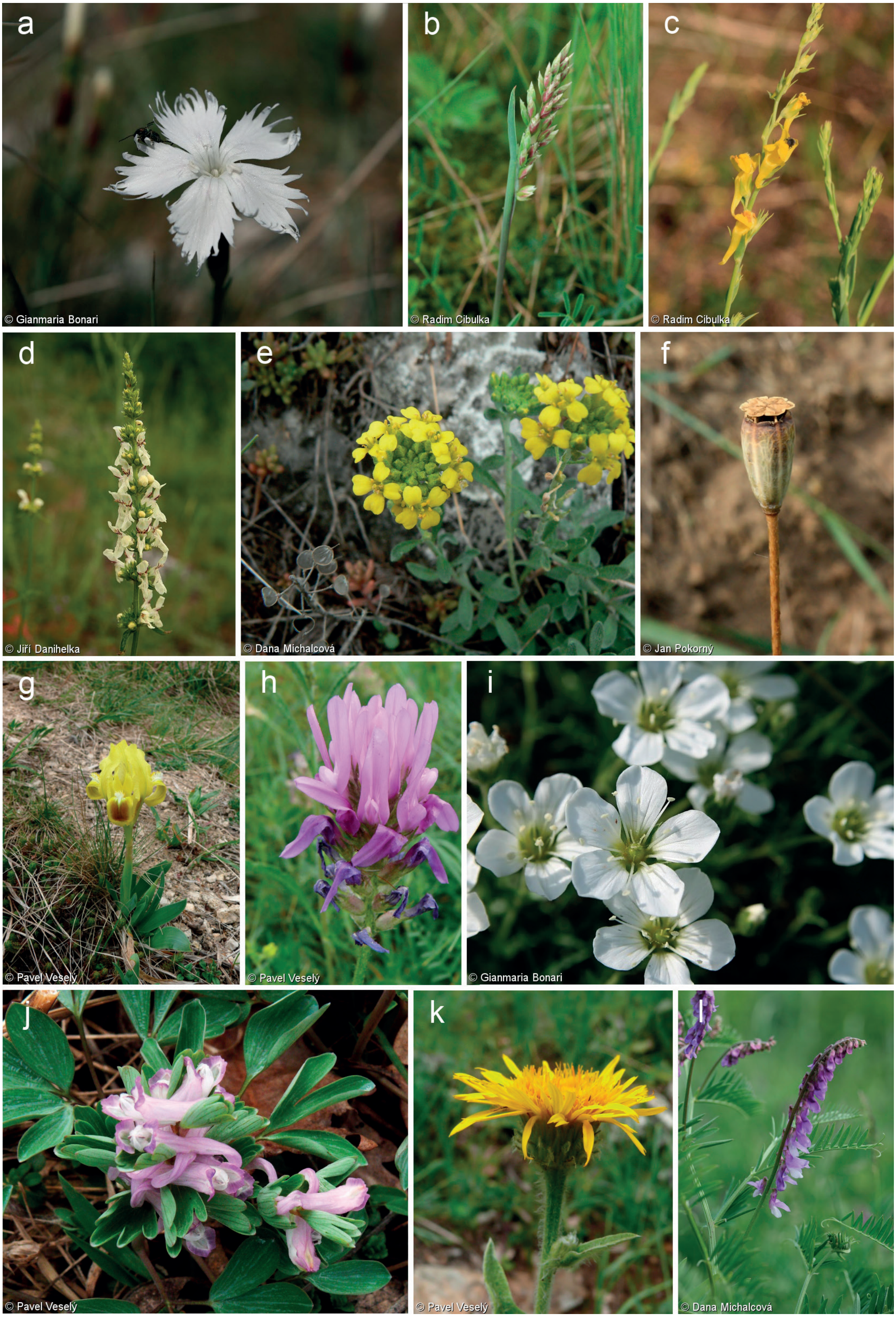
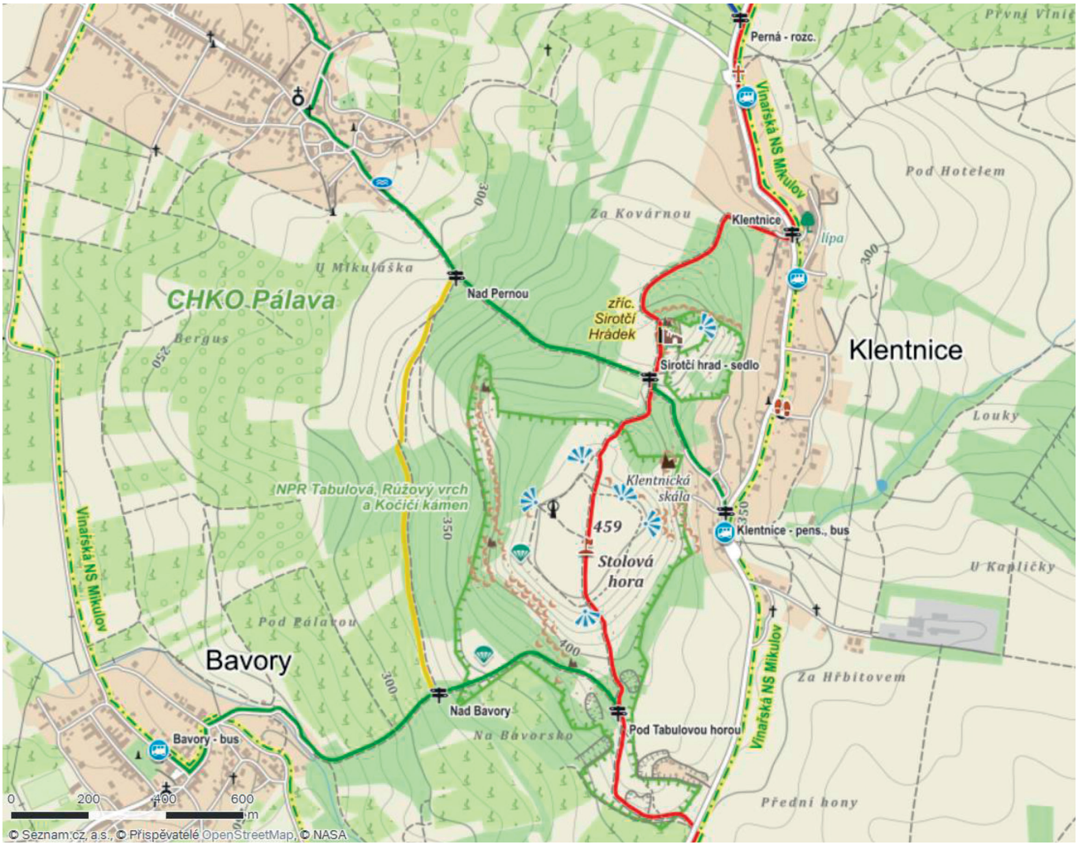


Plate 8a Plants of Děvín Hill in the Pavlov Hills: (a) *Dianthus lumnitzeri*, (b) *Poa badensis*, (c) *Linaria genistifolia*, (d) *Stachys recta*, (e) *Alyssum montanum*, (f) *Papaver confine*, (g) *Iris pumila*, (h) *Astragalus onobrychis*, (i) *Arenaria grandiflora*, (j) *Corydalis pumila*, (k) *Inula oculus-christi*, (l) *Vicia tenuifolia*.

(8b) *Tabulová* National Nature Reserve

This National Nature Reserve includes the hill *Růžový vrch* (ca 436 m), with a castle ruin on its top, and the hill *Stolová hora* (also *Tabulová*, *Tafelberg* in German, both meaning 'table mountain'; 459 m). They are situated in the middle part of the Pavlov Hills above the western edge of the village of Klentnice. The remarkable flat top of the hill *Stolová hora* has been interpreted as a landform shaped by Pliocene denudation processes. Picturesque limestone cliffs are found on the western and eastern slopes of both hills.



Tabulová National Nature Reserve in the central part of the Pavlov Hills

Dry grasslands, the most widespread vegetation formation on both hills, are represented by four types. Small patches of the association *Poo badensis-Festucetum pallentis* (alliance *Bromo pannonici-Festucion pallentis*) have developed mainly on the west- and east-facing slopes. The same slopes also harbour *Sesleria caerulea* grasslands of the association *Minuartio setaceae-Seslerietum caeruleae* (alliance *Diantho lumnitzeri-Seslerion*), containing *Dianthus lumnitzeri* and *Pulsatilla grandis*, both protected under the EU Habitats Directive. The south-facing slope of the hill *Stolová hora* is covered by dry grassland of the alliance *Festucion valesiacae* with *Carex humilis* and *Galatella linosyris* as local dominants. Species-rich semi-dry grasslands with *Bromus erectus* and *Brachypodium pinnatum* of the association *Polygalo majoris-Brachypodietum pinnati* (alliance *Cirsio-Brachypodion pinnati*) have developed on the lower slopes. Large patches of abandoned pastures are covered by scrub of the alliance *Berberidion vulgaris* with *Crataegus monogyna*, *Prunus mahaleb* and *P. spinosa.* Forests are mostly secondary, with *Fraxinus excelsior*, *Quercus robur* and non-native *Pinus nigra*. In some places, their species composition is similar to that of Pannonian oak-hornbeam forests of the association *Primulo veris-Carpinetum betuli* (alliance *Carpinion betuli*) or broad-leaved ravine forests of the association *Aceri-Tilietum* (alliance *Tilio platyphylli-Acerion*). Thermophilous oak forests of the association *Euphorbio-Quercetum* (alliance *Quercion pubescenti-petraeae*) have been preserved only at the southern foot of the hill *Stolová hora*.

Růžový vrch with ruins of the castle Sirotčí hrádek in the 1920s and 2014. Photo archive of the Department of Botany and Zoology, Masaryk University, and J. Chytrý.

The flora is similar to that of the National Nature Reserve *Děvín-Kotel-Soutěska*. There is a small population of *Salvia aethiopis*, considered the only native occurrence of this species in the Czech Republic, above the southern slope of *Stolová hora*.

Stolová hora was already deforested in the Bronze Age when a fortified settlement was built on its flat summit. The castle on the cliffs of the hill *Růžový vrch* was built in the 13th century and destroyed by the Swedish army in 1645. Several small limestone quarries existed here in the past. Both hills were used as pastures by the inhabitants of the nearby villages until the 1950s. The area has been protected since 1951.

Dry grasslands, the most widespread vegetation formation on both hills, are represented by four types. Small patches of the association *Poo badensis-Festucetum pallentis* (alliance *Bromo pannonici-Festucion pallentis*) have developed mainly on the west- and east-facing slopes. The same slopes also harbour *Sesleria caerulea* grasslands of the association *Minuartio setaceae-Seslerietum caeruleae* (alliance *Diantho lumnitzeri-Seslerion*), containing *Dianthus lumnitzeri* and *Pulsatilla grandis*, both protected under the EU Habitats Directive. The south-facing slope of the hill *Stolová hora* is covered by dry grassland of the alliance *Festucion valesiacae* with *Carex humilis* and *Galatella linosyris* as local dominants. Species-rich semi-dry grasslands with *Bromus erectus* and *Brachypodium pinnatum* of the association *Polygalo majoris-Brachypodietum pinnati* (alliance *Cirsio-Brachypodion pinnati*) have developed on the lower slopes. Large patches of abandoned pastures are covered by scrub of the alliance *Berberidion vulgaris* with *Crataegus monogyna*, *Prunus mahaleb* and *P. spinosa.* Forests are mostly secondary, with *Fraxinus excelsior*, *Quercus robur* and non-native *Pinus nigra*. In some places, their species composition is similar to that of Pannonian oak-hornbeam forests of the association *Primulo veris-Carpinetum betuli* (alliance *Carpinion betuli*) or broad-leaved ravine forests of the association *Aceri-Tilietum* (alliance *Tilio platyphylli-Acerion*). Thermophilous oak forests of the association *Euphorbio-Quercetum* (alliance *Quercion pubescenti-petraeae*) have been preserved only at the southern foot of the hill *Stolová hora*.

The flora is similar to that of the National Nature Reserve *Děvín-Kotel-Soutěska*. There is a small population of *Salvia aethiopis*, considered the only native occurrence of this species in the Czech Republic, above the southern slope of *Stolová hora*.

Stolová hora was already deforested in the Bronze Age when a fortified settlement was built on its flat summit. The castle on the cliffs of the hill *Růžový vrch* was built in the 13th century and destroyed by the Swedish army in 1645. Several small limestone quarries existed here in the past. Both hills were used as pastures by the inhabitants of the nearby villages until the 1950s. The area has been protected since 1951.

(8c) *Svatý kopeček* Nature Reserve

The hill *Svatý kopeček* (*Heiliger Berg* in German, both names meaning *Holy Hill*; 363 m) flanks the town of Mikulov from the east. It is elongated roughly from the north-east to the south-west and formed of white and hard Jurassic limestone. Its north-western part was destroyed by the quarrying of limestone from 1816 to the early 1970s.

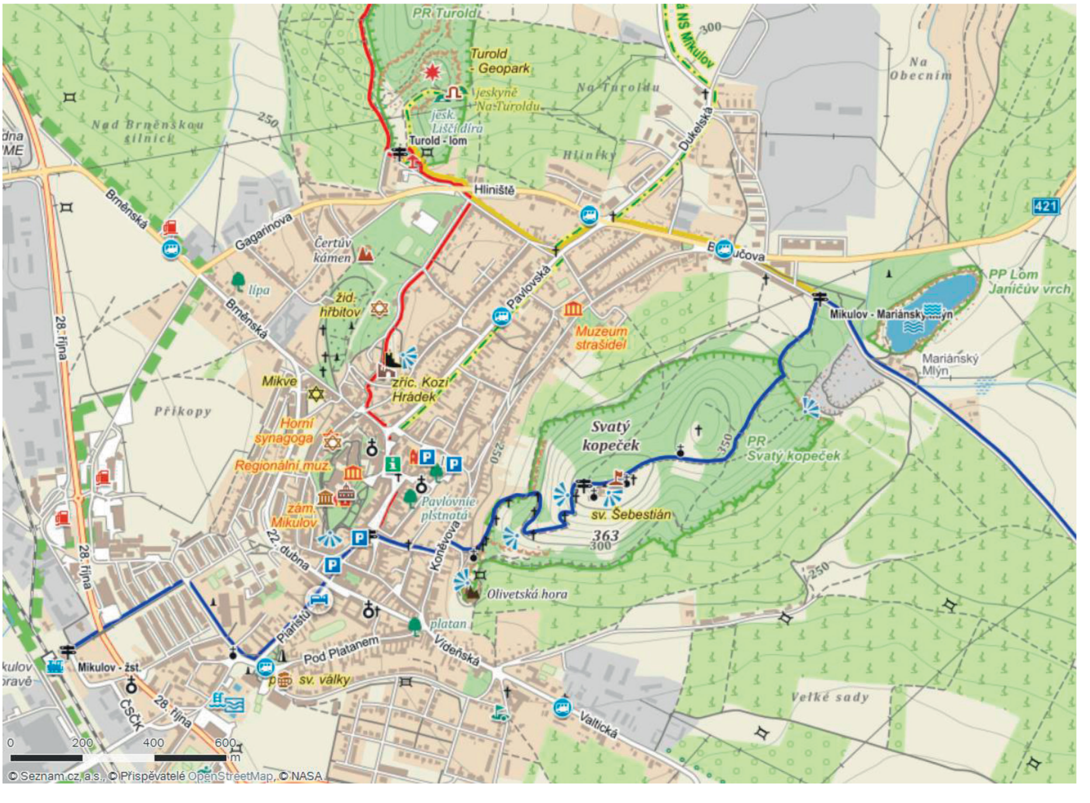
Fragments of rock-outcrop vegetation with *Aurinia saxatilis* and *Thalictrum foetidum* are developed on the north-western slopes of the hill. The steep west-facing slope above the town of Mikulov is covered by *Sesleria caerulea* grasslands of the association *Minuartio setaceae-Seslerietum caeruleae* (alliance *Diantho lumnitzeri-Seslerion*) harbouring a small population of *Pulsatilla grandis*. The south- and south-east-facing slopes of *Svatý kopeček* support a patchy mosaic of dry grasslands of the associations *Poo badensis-Festucetum pallentis* (alliance *Bromo pannonici-Festucion pallentis*) and *Koelerio macranthae-Stipetum joannis* (alliance *Festucion valesiacae*), the latter containing large stands of *Stipa eriocaulis* and *S. pulcherrima*. In mid-April, stands of flowering *Iris pumila* may be observed along the tourist trail, followed by *I. arenaria* two weeks later. *Crataegus monogyna* and *Prunus mahaleb* are dominant species of dense shrubberies on the south-east-facing slope.

The forests on the hill are mainly secondary, with *Acer platanoides*, *Fraxinus excelsior* and *Quercus robur* as dominant species. Non-native *Pinus nigra* was also planted here at the turn of the 19th century or somewhat later, as was *Syringa vulgaris*, introduced here by the local Scenic Improvement Society (*Verschönerungsverein*) and now encroaching on large patches on the west-facing slope. *Ailanthus altissima* and *Robinia pseudoacacia* are additional invasive alien trees, both spreading mainly on the east-facing slope. The thermophilous oak forests of the association *Euphorbio-Quercetum* (alliance *Quercion pubescenti-petraeae*) have survived only as a small stand in the north-eastern part of the reserve.

The flora of the reserve includes about 407 species and hybrids of vascular plants, recorded here in 1992–2004. *Svatý kopeček* is one of the most species-rich sites for the genera *Orobanche* (s.l.) and *Viola* in the Czech Republic, supporting seven species of the former, and eleven species and five hybrids of the latter. The most remarkable species of these genera are *Orobanche artemisiae-campestris*, *Phelipanche arenaria* and *Viola ambigua*. The proportion of alien species is large due to the proximity of the town of Mikulov and strong human influence.

Plate 8b Plants of the *Tabulová* National Nature Reserve in the Pavlov Hills: (a) *Arum cylindraceum*, (b) *Allium senescens* subsp. *montanum*, (c) *Vicia villosa* subsp. *villosa*, (d) *Globularia bisnagarica*, (e) *Orlaya grandiflora*, (f) *Melica ciliata*, (g) *Rapistrum perenne*, (h) *Bromus japonicus*, (i) *Viola tricolor* subsp. *saxatilis*, (j) *Salvia aethiopis*, (k) *Cytisus procumbens*, (l) *Ranunculus illyricus*.

The hill Svatý kopeček above the town of Mikulov with the Baroque Chapel of St. Sebastian and Stations of the Cross. Its west-facing slope with limestone outcrops is covered by Sesleria caerulea grasslands. Photo M. Chytrý.



The town of Mikulov in the southern part of the Pavlov Hills with the hill Svatý kopeček above its eastern edge.

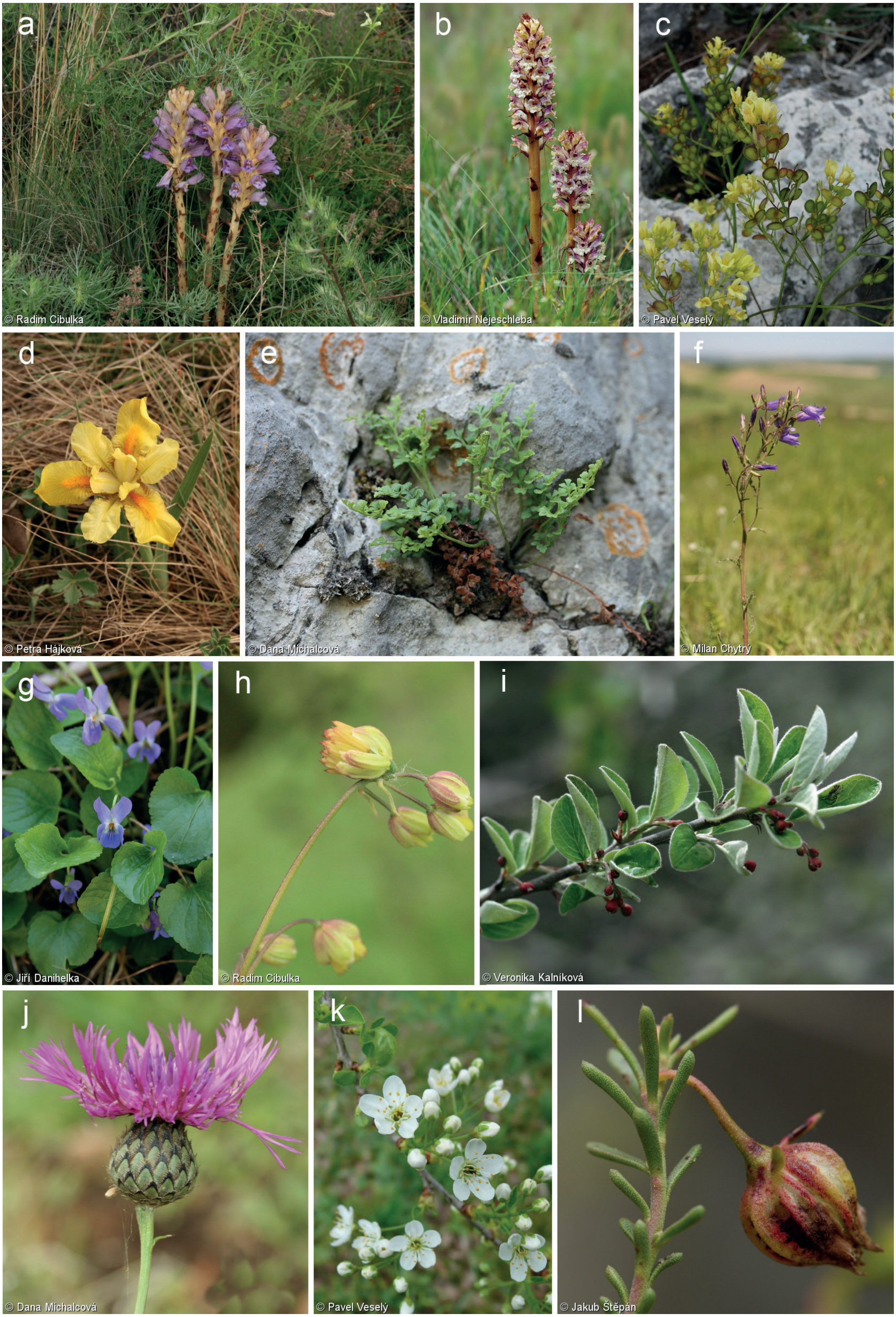


Plate 8c Plants of the *Svatý kopeček* Nature Reserve in the Pavlov Hills: (a) *Phelipanche arenaria*, (b) *Orobanche artemisiae-campestris*, (c) *Biscutella laevigata* subsp. *varia*, (d) *Iris arenaria*, (e) *Asplenium ruta-muraria*, (f) *Campanula sibirica*, (g) *Viola suavis*, (h) *Thalictrum foetidum*, (i) *Cotoneaster integerrimus*, (j) *Centaurea scabiosa*, (k) *Prunus mahaleb*, (l) *Fumana procumbens*.

The fifteen Stations of the Cross along the path to the hilltop were established in 1626–1723. The white Baroque pilgrimage Chapel of St. Sebastian and the neighbouring campanile on the flat top were built in the 17th century. By constructing these buildings the Catholic Church was attempting to support the Counter-Reformation and supress the old pagan belief that the hill summit was a meeting place of witches, as documented by the original German name of the hill *Tanzberg* (*Hill of Dances*). The top of *Svatý kopeček* provides an excellent view of the historical town of Mikulov, dominated by the chateau built by Cardinal Franz von Dietrichstein, Bishop of Olomouc and Governor of Moravia, in the 17th century on the foundations of the original Gothic castle. Since 1946, *Svatý kopeček* has been protected as a nature reserve.

Appendix 8 Selected species of vascular plants of the Pavlov Hills recorded on the Děvín Hill, in the *Tabulová* National Nature Reserve and in the *Svatý kopeček* Nature Reserve by J. Danihelka in 1992–2007. See also Danihelka & Řepka (1995) and Danihelka & Grulich (1996).

Acer campestre
Acer negundo (neo)
Acer platanoides
Acer pseudoplatanus
Achillea collina
Achillea pannonica
Acinos arvensis
Aconitum lycoctonum
Adonis aestivalis
Adonis vernalis
Adoxa moschatellina
Aegopodium podagraria
Aesculus hippocastanum (neo)
Aethusa cynapium
Agrimonia eupatoria
Agrostis gigantea (neo)
Ailanthus altissima (neo)
Ajuga chamaepitys
Ajuga genevensis
Ajuga reptans
Alliaria petiolata
Allium angulosum
Allium flavum
Allium oleraceum
Allium rotundum
Allium scorodoprasum
Allium senescens subsp. *montanum*
Alopecurus pratensis
Alyssum alyssoides
Alyssum montanum
Androsace elongata
Anemone nemorosa
Anemone ranunculoides
Anemone sylvestris
Anthericum ramosum
Anthriscus caucalis
Anthriscus cerefolium
Anthriscus sylvestris
Anthyllis vulneraria
Arabidopsis thaliana
Arabis auriculata
Arabis hirsuta
Arabis sagittata
Arctium lappa
Arctium minus
Arctium tomentosum
Arenaria grandiflora
Arenaria serpyllifolia agg.
Arrhenatherum elatius
Artemisia absinthium
Artemisia campestris
Artemisia pontica
Artemisia vulgaris
Arum cylindraceum
Asarum europaeum
Asparagus officinalis
Asperula cynanchica
Asplenium ruta-muraria
Asplenium trichomanes
Aster amellus
Astragalus austriacus
Astragalus cicer
Astragalus glycyphyllos
Astragalus onobrychis
Atriplex oblongifolia
Atriplex patula
Atriplex sagittata
Aurinia saxatilis
Avenula pubescens
Ballota nigra
Barbarea stricta
Barbarea vulgaris
Berberis vulgaris
Berteroa incana
Betonica officinalis
Betula pendula
Biscutella laevigata subsp. *varia*
Bothriochloa ischaemum
Botrychium lunaria
Brachypodium pinnatum
Brachypodium sylvaticum
Briza media
Bromus benekenii
Bromus erectus
Bromus hordeaceus
Bromus inermis
Bromus japonicus
Bromus sterilis
Bromus tectorum
Bryonia alba
Buglossoides incrassata subsp. *splitgerberi*
Buglossoides purpurocaerulea
Bunias orientalis (neo)
Bupleurum falcatum
Calamagrostis epigejos
Camelina microcarpa
Campanula bononiensis
Campanula glomerata
Campanula persicifolia
Campanula rapunculoides
Campanula sibirica
Campanula trachelium
Capsella bursa-pastoris
Cardamine impatiens
Carduus acanthoides
Carduus crispus
Carduus nutans
Carex caryophyllea
Carex digitata
Carex humilis
Carex michelii
Carex montana
Carex muricata
Carex pilosa
Carex praecox
Carex spicata
Carex stenophylla
Carex supina
Carex sylvatica
Carex tomentosa
Carlina acaulis
Carlina biebersteinii subsp. *brevibracteata*
Carpinus betulus
Carum carvi
Caucalis platycarpos
Centaurea jacea subsp. *angustifolia*
Centaurea scabiosa
Centaurea stoebe
Centaurea triumfetti
Cephalanthera damasonium
Cephalanthera rubra
Cerastium arvense
Cerastium brachypetalum

Cerastium glutinosum
Cerastium holosteoides
Cerastium pumilum
Cerastium semidecandrum
Cerastium tenoreanum
Cerastium tomentosum (neo)
Cerinthe minor
Chaerophyllum bulbosum
Chaerophyllum temulum
Chamaecytisus austriacus
Chamaecytisus ratisbonensis
Chamaecytisus virescens
Chelidonium majus
Chenopodium album
Chenopodium hybridum
Chondrilla juncea
Cichorium intybus
Cirsium arvense
Cirsium canum
Cirsium vulgare
Clematis recta
Clematis vitalba
Clinopodium vulgare
Colchicum autumnale
Conium maculatum
Consolida regalis
Convallaria majalis
Convolvulus arvensis
Cornus mas
Cornus sanguinea
Corydalis cava
Corydalis intermedia
Corydalis pumila
Corylus avellana
Cota austriaca
Cotoneaster integerrimus
Crataegus ×fallacina
Crataegus laevigata
Crataegus ×media
Crataegus monogyna
Crepis biennis
Crepis foetida subsp. *rhoeadifolia*
Crepis praemorsa
Cuscuta epithymum
Cuscuta europaea
Cymbalaria muralis
Cynoglossum officinale
Cytisus nigricans
Cytisus procumbens
Dactylis glomerata
Dactylis polygama
Datura stramonium (neo)
Daucus carota
Dentaria bulbifera
Dentaria enneaphyllos
Descurainia sophia
Dianthus lumnitzeri
Dianthus pontederae
Dictamnus albus
Digitalis grandiflora
Diplotaxis tenuifolia
Dipsacus laciniatus
Dorycnium germanicum
Dryopteris filix-mas
Echinops sphaerocephalus
Echium vulgare
Elymus caninus
Elymus hispidus
Elymus repens
Epilobium montanum
Epipactis helleborine
Epipactis microphylla
Equisetum arvense
Erigeron acris
Erigeron annuus (neo)
Erigeron muralis
Erigeron podolicus
Erodium cicutarium
Erophila spathulata
Eryngium campestre
Erysimum cheiranthoides
Erysimum diffusum
Erysimum durum
Erysimum odoratum
Euonymus europaeus
Euonymus verrucosus
Eupatorium cannabinum
Euphorbia amygdaloides
Euphorbia cyparissias
Euphorbia epithymoides
Euphorbia helioscopia
Euphorbia virgata
Euphrasia stricta
Falcaria vulgaris
Fallopia convolvulus
Fallopia dumetorum
Festuca arundinacea
Festuca gigantea
Festuca heterophylla
Festuca pallens
Festuca pratensis
Festuca pulchra
Festuca rubra
Festuca rupicola
Festuca valesiaca
Ficaria calthifolia
Ficaria verna subsp. *verna*
Filipendula vulgaris
Fragaria moschata
Fragaria vesca
Fragaria viridis
Fraxinus excelsior
Fumana procumbens
Fumaria schleicheri
Fumaria vaillantii
Gagea lutea
Gagea minima
Gagea pratensis
Gagea pusilla
Gagea transversalis
Gagea villosa
Galanthus nivalis
Galatella linosyris
Galeobdolon montanum
Galeopsis angustifolia
Galeopsis pubescens
Galinsoga parviflora (neo)
Galium album subsp. *album*
Galium album subsp. *pycnotrichum*
Galium aparine
Galium austriacum
Galium boreale
Galium glaucum
Galium odoratum
Galium spurium
Galium sylvaticum
Galium verum
Genista tinctoria
Gentiana cruciata
Geranium columbinum
Geranium divaricatum
Geranium pratense
Geranium pusillum
Geranium pyrenaicum (neo)
Geranium robertianum
Geranium sanguineum
Geum urbanum
Glechoma hederacea
Glechoma hirsuta
Globularia bisnagarica
Hedera helix
Helianthemum grandiflorum subsp. *obscurum*
Helictochloa pratensis subsp. *hirtifolia*
Hepatica nobilis
Heracleum sphondylium
Hesperis sylvestris
Hesperis tristis
Hieracium bifidum
Hieracium lachenalii
Hieracium murorum
Hieracium racemosum
Hieracium sabaudum
Hieracium umbellatum
Holosteum umbellatum
Hordelymus europaeus
Hordeum murinum
Humulus lupulus
Hylotelephium maximum
Hyoscyamus niger
Hypericum hirsutum
Hypericum montanum
Hypericum perforatum
Impatiens parviflora (neo)
Inula britannica
Inula conyzae
Inula ensifolia
Inula hirta

Inula oculus-christi
Inula salicina
Inula ×stricta
(*I. ensifolia × I. salicina*)
Iris arenaria
Iris graminea
Iris pumila
Iris variegata
Isatis tinctoria
Isopyrum thalictroides
Jovibarba globifera
Juglans nigra (neo)
Juglans regia
Jurinea mollis
Knautia arvensis
Knautia ×posoniensis
Koeleria macrantha
Laburnum anagyroides (neo)
Lactuca quercina
Lactuca serriola
Lactuca viminea
Lamium album
Lamium amplexicaule
Lamium maculatum
Lamium purpureum
Lappula squarrosa
Lapsana communis
Larix decidua (planted)
Lathraea squamaria
Lathyrus hirsutus (neo)
Lathyrus latifolius
Lathyrus niger
Lathyrus pratensis
Lathyrus tuberosus
Lathyrus vernus
Lavatera thuringiaca
Leontodon hispidus
Leonurus cardiaca
Leonurus marrubiastrum
Lepidium campestre
Lepidium draba
Leucanthemum vulgare
Libanotis pyrenaica
Ligustrum vulgare
Lilium martagon
Limodorum abortivum
Linaria genistifolia
Linaria vulgaris
Linum catharticum
Linum hirsutum
Linum tenuifolium
Lithospermum officinale
Lolium perenne
Lonicera caprifolium (neo)
Lonicera xylosteum
Loranthus europaeus
Lotus borbasii
Lotus corniculatus
Lotus maritimus
Lycium barbarum (neo)
Lycopus europaeus
Lysimachia nummularia
Mahonia aquifolium (neo)
Malus domestica
Malus sylvestris
Malva alcea
Malva sylvestris
Medicago falcata
Medicago lupulina
Medicago minima
Medicago prostrata
Medicago sativa (neo)
Melampyrum arvense
Melampyrum cristatum
Melampyrum nemorosum
Melampyrum pratense
Melica altissima (neo)
Melica ciliata
Melica nutans
Melica picta
Melica transsilvanica
Melica uniflora
Melilotus albus
Melilotus officinalis
Melittis melissophyllum
Mentha longifolia
Mercurialis annua
Mercurialis perennis
Microthlaspi perfoliatum
Milium effusum
Minuartia rubra
Minuartia setacea
Moehringia trinervia
Muscari comosum
Muscari neglectum
Muscari tenuiflorum
Mycelis muralis
Myosotis arvensis
Myosotis ramosissima
Myosotis stricta
Myosoton aquaticum
Neottia nidus-avis
Nepeta cataria
Nepeta nuda
Nigella arvensis
Nonea pulla
Odontites luteus
Odontites vernus subsp. *serotinus*
Omphalodes scorpioides
Onobrychis arenaria
Ononis spinosa
Onopordum acanthium
Orchis militaris
Orchis purpurea
Origanum vulgare
Orlaya grandiflora
Ornithogalum kochii
Orobanche alba subsp. *alba*
Orobanche alba subsp. *major*
Orobanche alsatica
Orobanche artemisiae-campestris
Orobanche caryophyllacea
Orobanche kochii
Orobanche lutea
Orobanche picridis
Oxytropis pilosa
Papaver confine
Papaver maculosum
Papaver rhoeas
Parietaria officinalis
Parthenocissus inserta (neo)
Pastinaca sativa
Petrorhagia prolifera
Peucedanum alsaticum
Peucedanum cervaria
Phalaris arundinacea
Phelipanche arenaria
Phelipanche purpurea
Phleum phleoides
Phleum pratense
Phlomis tuberosa
Picris hieracioides
Pilosella bauhini
Pilosella brachiata
Pilosella cymosa
Pilosella densiflora
Pilosella officinarum
Pilosella pilosellina
Pilosella rothiana
Pimpinella major
Pimpinella saxifraga
Pinus nigra (neo)
Pinus sylvestris
Plantago lanceolata
Plantago major
Plantago media
Plantago uliginosa
Poa angustifolia
Poa annua
Poa badensis
Poa bulbosa
Poa compressa
Poa nemoralis
Poa pratensis
Poa trivialis
Polygala major
Polygonatum multiflorum
Polygonatum odoratum
Polygonum aviculare agg.
Polypodium vulgare
Populus alba
Populus tremula
Potentilla anserina
Potentilla argentea
Potentilla heptaphylla
Potentilla incana
Potentilla inclinata
Potentilla recta
Potentilla reptans
Primula veris

Prunella grandiflora
Prunella vulgaris
Prunus avium
Prunus cerasifera
Prunus domestica
Prunus ×eminens
Prunus fruticosa
Prunus mahaleb
Prunus spinosa
Pseudoturritis turrita
Pulmonaria officinalis
Pulsatilla grandis
Pyrus communis
Pyrus pyraster
Quercus cerris
Quercus petraea
Quercus pubescens
Quercus robur
Ranunculus auricomus agg.
Ranunculus bulbosus
Ranunculus illyricus
Ranunculus polyanthemos
Ranunculus repens
Raphanus raphanistrum
Rapistrum perenne
Reseda lutea
Reseda luteola
Rhamnus cathartica
Rhinanthus major
Ribes uva-crispa
Robinia pseudoacacia (neo)
Rosa agrestis
Rosa canina
Rosa dumalis
Rosa gallica
Rosa rubiginosa
Rosa spinosissima
Rubus caesius
Rumex acetosa
Rumex crispus
Rumex obtusifolius
Rumex patientia
Rumex thyrsiflorus (neo)
Salix alba
Salix caprea
Salvia aethiopis
Salvia nemorosa
Salvia pratensis
Salvia verticillata
Sambucus ebulus
Sambucus nigra
Sanguisorba minor
Saponaria officinalis
Saxifraga paniculata
Saxifraga tridactylites
Scabiosa canescens
Scabiosa ochroleuca
Scorzonera austriaca
Scorzonera cana
Scorzonera hispanica
Scrophularia nodosa
Securigera varia
Sedum acre
Sedum album
Sedum spurium (neo)
Senecio jacobaea
Senecio viscosus
Senecio vulgaris
Serratula tinctoria
Seseli annuum
Seseli hippomarathrum
Seseli osseum
Sesleria caerulea
Setaria pumila
Setaria viridis
Sherardia arvensis
Silene latifolia subsp. *alba*
Silene nutans
Silene otites
Silene vulgaris
Sinapis arvensis
Sisymbrium orientale
Sisymbrium strictissimum (neo)
Solanum nigrum
Solidago canadensis (neo)
Solidago gigantea (neo)
Solidago virgaurea
Sonchus asper
Sonchus oleraceus
Sorbus danubialis
Sorbus domestica
Sorbus torminalis
Stachys annua
Stachys germanica
Stachys palustris
Stachys recta
Stachys sylvatica
Staphylea pinnata
Stipa capillata
Stipa eriocaulis
Stipa pennata
Stipa pulcherrima
Symphyotrichum lanceolatum (neo)
Symphytum officinale
Syringa vulgaris (neo)
Tanacetum corymbosum
Tanacetum vulgare
Taraxacum erythrospermum
Taraxacum parnassicum
Taraxacum sect. *Taraxacum*
Taraxacum serotinum
Taxus baccata
Tephroseris integrifolia
Teucrium chamaedrys
Teucrium montanum
Thalictrum flavum
Thalictrum foetidum
Thalictrum minus
Thesium dollineri
Thesium linophyllon
Thymelaea passerina
Thymus glabrescens
Thymus pannonicus
Thymus praecox
Tilia cordata
Tilia platyphyllos
Torilis arvensis
Torilis japonica
Tragopogon dubius
Tragopogon orientalis
Trifolium alpestre
Trifolium arvense
Trifolium campestre
Trifolium dubium
Trifolium medium
Trifolium montanum
Trifolium pratense
Trifolium repens
Trifolium rubens
Trisetum flavescens
Turritis glabra
Tussilago farfara
Ulmus glabra
Ulmus laevis
Ulmus minor
Urtica dioica
Valeriana stolonifera subsp. *angustifolia*
Valerianella carinata
Valerianella locusta
Verbascum chaixii subsp. *austriacum*
Verbascum lychnitis
Verbascum phlomoides
Verbascum phoeniceum
Veronica arvensis
Veronica chamaedrys
Veronica hederifolia
Veronica orchidea
Veronica persica (neo)
Veronica polita
Veronica praecox
Veronica prostrata
Veronica spicata
Veronica sublobata
Veronica teucrium
Veronica triloba
Veronica verna
Veronica vindobonensis
Viburnum lantana
Viburnum opulus
Vicia angustifolia
Vicia cracca
Vicia dumetorum
Vicia hirsuta
Vicia pannonica subsp. *striata*
Vicia pisiformis
Vicia sepium
Vicia tenuifolia

Vicia tetrasperma
Vicia villosa subsp. *villosa*
Vinca minor
Vincetoxicum hirundinaria
Viola ambigua
Viola arvensis
Viola collina
Viola hirta
Viola kitaibeliana
Viola mirabilis
Viola odorata
Viola reichenbachiana
Viola riviniana
Viola rupestris
Viola suavis (neo)
Viola tricolor subsp. *saxatilis*
Viscum album

The hilly landscape with chernozem soils on the foot of the Pavlov Hills is an important wine-growing area of the Czech Republic. Photo M. Chytrý.

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9 *Milovická stráň* Nature Reserve

Jiří Danihelka

Introduction

The site is located near the southern edge of the village of Milovice about 40 km south of Brno and 6 km NE of the town of Mikulov. It is one of 14 small-scale protected areas (nature reserves and nature monuments) in the *Pálava* Protected Landscape Area. This nature reserve was established in 1994 and takes in an area of over 88 ha of mainly forests and, to a lesser extent, dry grasslands (Čtyroký et al. 2007). It is part of the Site of Community Importance *Milovický les*, established to protect mainly Pannonian oak-hornbeam and oak forests.

The reserve is situated on the plateau and north- and west-facing slopes of the hill *Špičák* (297 m) in the gently undulating landscape of Milovice Wood. The bedrock of Milovice Wood consists mainly of Lower Tertiary flysch sandstone with insertions of conglomerates containing calcareous cement. They are covered by loess on the plateaus, while deposits from surface runoff are found in the valleys (Čtyroký et al. 1995). Cambisols and luvisols developed on loess under forest stands, alternating with chernozems under steppic grasslands. Leptosols are found in a couple of places around flysch outcrops on steep west-facing slopes.

Canopy openings in a Quercus pubescens thermophilous woodland with Dictamnus albus on the upper slope of Milovická stráň. Photo M. Chytrý.

The climate is very similar to that of the Pavlov Hills, being subcontinental, summer-warm and dry. The mean annual temperature is 9–10 °C and the mean temperature in the growing season (April–September) is 15–16 °C. The warmest and coldest months are July and January with mean temperatures of 19–20 °C and –1 to –2 °C, respectively. The annual precipitation sums are 500–550 mm, of which 300–325 mm falls in the growing season. Monthly precipitation varies considerably and long periods of drought are common.

Steppic grasslands with Stipa pulcherrima on slopes of Milovická stráň affected by landslide. Photo M. Chytrý.

Mammoth bones and remnants of a prehistoric settlement were discovered on the opposite side of the valley west of the road Milovice – Mikulov in the 1980s. Numerous fossil mollusc shells found in a Neolithic pit made it possible to draw some conclusions about the mid-Holocene climate and vegetation (Ložek 1999): the adjacent forests consisted of mesophilous trees, such as *Fraxinus excelsior*, *Tilia* sp. and *Ulmus* sp., and their malacofauna was richer in species than it is today.

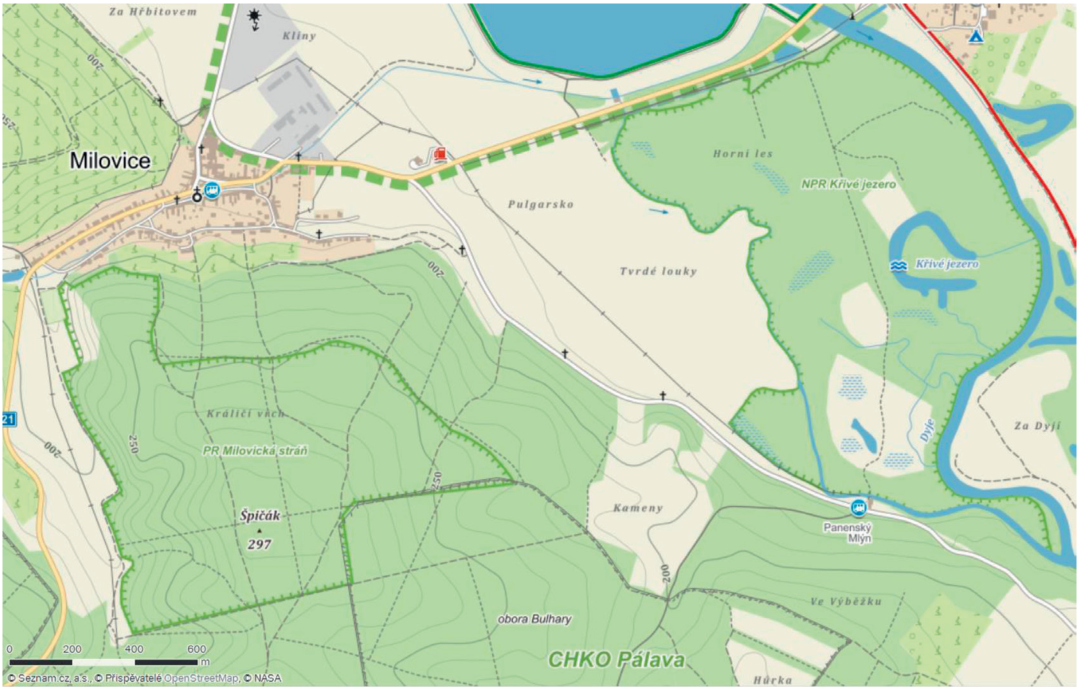
Vegetation

The steep west-facing slopes of *Milovická stráň* are covered by dry grasslands of the alliance *Festucion valesiacae*. These are replaced by broad-leaved semi-dry grasslands of the alliance *Cirsio-Brachypodion pinnati* on lower parts of the slopes and by forest-fringe vegetation of the association *Geranio sanguinei-Dictamnetum albi* (alliance *Geranion sanguinei*) along forest margins and in small canopy openings. Large forest openings on steep west-facing slopes support vegetation dominated by *Stipa pulcherrima* (alliance *Festucion valesiacae*). Given the topographic situation, i.e. a steep, west-facing slope and shallow erosion-prone soils, most of the treeless patches at *Milovická stráň* may be considered natural. The influence of the mesoclimate is reinforced by grazing ungulates that concentrate in sun-exposed places, particularly in winter and early spring. The slopes have probably been grazed by livestock since the Neolithic, which also helped keep open even slightly more mesic habitats that would otherwise have been overgrown by forest.

Three types of forest vegetation may be found in the reserve. The perialpidic thermophilous oak forests of the association *Euphorbio-Quercetum* (alliance *Quercion pubescenti-petraeae*) form small patches on exposed ridges and in a narrow strip along the plateau margin above its west-facing slopes. The dominant tree is *Quercus pubescens*, while the shrub layer consists chiefly of *Cornus mas* and *Ligustrum vulgare*. The herb layer is very rich in species and supports thermophilous graminoids such as *Brachypodium pinnatum*, *Carex humilis* and *C. michelii*, as well as dicots such as *Aster amellus*, *Buglossoides purpurocaerulea*, *Dictamnus albus*, *Inula hirta*, *Stachys recta*, *Teucrium chamaedrys* and *Viola hirta*.

The dominant forest community, covering large parts of the plateau, is subcontinental oak forest of the association *Quercetum pubescenti-roboris* (alliance *Aceri tatarici-Quercion*). Similar forests of the same alliance are typical of the eastern-central and eastern European forest-steppe biome, being more common in Hungary and further to the east. Their tree layer at *Milovická stráň* is formed mainly of *Quercus petraea* and *Q. pubescens*, accompanied by *Ligustrum vulgare* and *Acer campestre* in the shrub layer. The herb layer is poorer in species than in the association *Euphorbio-Quercetum*, usually being dominated by *Melica uniflora*, *Convallaria majalis*, *Poa nemoralis* or *Brachypodium pinnatum*. These species are accompanied by mesophilous species shared with oak-hornbeam forests, including *Asarum europaeum*, *Campanula rapunculoides*, *Dactylis polygama*, *Galium odoratum*, *G. sylvaticum*, *Polygonatum multiflorum* and *Pulmonaria officinalis*.

Pannonian oak-hornbeam forests with *Carpinus betulus* and *Quercus petraea* (association *Primulo veris-Carpinetum betuli*, alliance *Carpinion betuli*) occupy the valley bottoms and the north-facing slopes adjacent to the village.



The Milovická stráň Nature Reserve near the village of Milovice and the Křivé jezero National Nature Reserve in the Dyje floodplain.

Flora

The vascular flora of the nature reserve comprises more than 420 species and subspecies and is generally similar to that of the Pavlov Hills, although some differences may be identified. For example, *Pulsatilla grandis*, usually growing above hard bedrock and more or less abundant in the Pavlov Hills, is replaced here by *P. pratensis* subsp. *bohemica*, which is absent from the Pavlov Hills. *Lathyrus pannonicus* subsp. *collinus*, found in one of the forest gaps, also does not occur in the Pavlov Hills. Interestingly, *Allium sphaerocephalon* and *Melica ciliata*, usually growing on shallow soils around rock outcrops, are both found in the reserve's dry grasslands on deeper soils.

The remarkable and striking plants here include species typical of dry grasslands and open thermophilous oak forests, such as *Adonis vernalis* (locally very abundant), *Aster amellus*, *Astragalus onobrychis*, *Campanula sibirica*, *Carex humilis*, *Dictamnus albus*, *Iris graminea*, *I. pumila*, *I. variegata*, *Jurinea mollis*, *Melittis melissophyllum*, *Orchis militaris*, *O. purpurea*, *Stipa pulcherrima* (locally very abundant) and *Viola ambigua*.

In 1995, *Orobanche teucrii* was found in the reserve's largest steppic patch south of the western edge of the village of Milovice (Danihelka & Grulich 1996). This was the first ever record of this sub-Mediterranean species in the Czech flora and it has not been found anywhere else in the country since. This Milovice site is situated at the northern distribution limit of the species. The reserve is also one of the few sites of the myco-heterotrophic achlorophyllous orchid *Limodorum abortivum* in the Czech Republic and probably holds its largest population in the country (140 flowering specimens were observed in May 2007).

Forest management

Being a part of the Mikulov estate, the forests of Milovice Wood were managed in the same manner as those of the Pavlov Hills (see above). Coppicing is documented from the late 14th century (Müllerová et al. 2014). The rotation time has increased from about 7 years in the Middle Ages to 11–12 years in the 17th century and 30–40 years in the 19th and early 20th century when coppice with standards prevailed in most of the forest compartments. Coppicing was replaced by a high-forest management system after WWII. The state forest enterprise established two game preserves in Milovice Wood in the 1960s, one for fallow deer (*Dama dama*) and mouflon (*Ovis musimon*), the other for red deer (*Cervus elaphus*) and fallow deer. The area covered by the present nature reserve was not part of the game preserves, as it included military facilities and an ammunition store house, and was therefore spared from strong grazing pressure by ungulates and ruderalization. Two studies based on repeated surveys of vegetation plots established by the forester Jaroslav Horák in the 1950s (Chytrý & Danihelka 1993; Hédl et al. 2010) have demonstrated a decrease in the diversity of plant species, a decline of species once typical of open coppiced woods and the spread of alien species. The causes are complex and include both changes in management and the influence of grazing ungulates.

Appendix 9 Selected species of vascular plants of the *Milovická stráň* Nature Reserve based mainly on the field records by J. Danihelka from 1992–2006. See also Šuk (1956), Danihelka et al. (1995) and Danihelka & Grulich (1996).

Acer campestre
Acer platanoides
Acinos arvensis
Adonis vernalis
Agrimonia eupatoria
Agrostis gigantea (neo)
Achillea collina
Achillea pannonica
Ailanthus altissima (neo)
Ajuga genevensis
Alliaria petiolata
Allium flavum
Allium oleraceum
Allium rotundum
Allium scorodoprasum
Allium sphaerocephalon
Alyssum alyssoides
Anemone ranunculoides
Anthericum ramosum
Arabis auriculata
Arabis hirsuta agg.
Arctium minus
Arctium nemorosum
Arctium tomentosum
Arenaria serpyllifolia agg.
Artemisia absinthium
Artemisia campestris
Artemisia pontica
Artemisia vulgaris
Asarum europaeum
Asperula tinctoria
Aster amellus
Astragalus cicer
Astragalus glycyphyllos
Astragalus onobrychis
Avenula pubescens
Ballota nigra
Barbarea vulgaris
Betonica officinalis
Bothriochloa ischaemum
Brachypodium pinnatum
Brachypodium sylvaticum
Briza media
Bromus benekenii
Bromus inermis
Buglossoides purpurocaerulea
Bupleurum falcatum
Calamagrostis arundinacea
Calamagrostis epigejos
Campanula glomerata
Campanula persicifolia
Campanula rapunculoides
Campanula sibirica
Campanula trachelium
Cardamine impatiens
Carex humilis
Carex michelii
Carex montana
Carex spicata
Carlina biebersteinii subsp. *brevibracteata*
Carpinus betulus
Centaurea jacea subsp. *angustifolia*
Centaurea stoebe
Cerastium pumilum
Cirsium arvense
Chaerophyllum temulum
Chamaecytisus ratisbonensis
Chamaecytisus virescens
Clematis recta
Clematis vitalba
Clinopodium vulgare
Convallaria majalis
Cornus mas
Cornus sanguinea
Corydalis cava
Corydalis pumila
Corylus avellana
Crataegus monogyna
Cuscuta epithymum
Cytisus procumbens
Dactylis glomerata
Dactylis polygama
Dianthus armeria
Dictamnus albus
Dorycnium germanicum
Echinops sphaerocephalus
Elymus caninus
Elymus hispidus
Elymus repens
Eryngium campestre
Euonymus europaeus
Euonymus verrucosus
Euphorbia cyparissias
Euphorbia epithymoides

Plate 9 Plants of the *Milovická stráň* Nature Reserve: (a) *Scorzonera hispanica*, (b) *Campanula sibirica*, (c) *Galatella linosyris*, (d) *Limodorum abortivum*, (e) *Iris graminea*, (f) *Dictamnus albus*, (g) *Melittis melissophyllum*, (h) *Quercus pubescens*, (i) *Adonis vernalis*, (j) *Aster amellus*, (k) *Jurinea mollis*, (l) *Trifolium rubens*.

Falcaria vulgaris
Fallopia dumetorum
Festuca heterophylla
Festuca rupicola
Festuca valesiaca
Ficaria verna subsp. *verna*
Filipendula vulgaris
Fragaria moschata
Fragaria viridis
Fraxinus angustifolia subsp. *danubialis*
Fraxinus excelsior
Gagea lutea
Galatella linosyris
Galium album subsp. *pycnotrichum*
Galium aparine
Galium glaucum
Galium odoratum
Galium sylvaticum
Galium verum
Genista tinctoria
Geranium sanguineum
Geum urbanum
Glechoma hederacea
Helianthemum grandiflorum subsp. *obscurum*
Helictochloa pratensis subsp. *hirtifolia*
Heracleum sphondylium
Hesperis sylvestris
Hieracium lachenalii
Hieracium maculatum
Hieracium murorum
Hieracium sabaudum
Hylotelephium maximum
Hypericum hirsutum
Hypericum montanum
Hypericum perforatum
Impatiens parviflora (neo)
Inula conyzae
Inula ensifolia
Inula hirta
Inula oculus-christi
Inula salicina
Inula ×stricta (*I. ensifolia* × *I. salicina*)
Iris graminea
Iris pumila
Iris variegata
Isopyrum thalictroides
Jurinea mollis
Koeleria macrantha
Lactuca quercina
Lamium maculatum
Lamium purpureum
Lapsana communis
Lathyrus niger
Lathyrus pannonicus subsp. *collinus*
Lathyrus vernus
Lavatera thuringiaca
Leontodon hispidus
Leonurus cardiaca
Leonurus marrubiastrum
Lepidium campestre
Leucanthemum vulgare
Ligustrum vulgare
Lilium martagon
Limodorum abortivum
Linaria vulgaris
Linum tenuifolium
Lithospermum officinale
Lonicera caprifolium (neo)
Lonicera xylosteum
Loranthus europaeus
Lotus borbasii
Malus sylvestris
Medicago falcata
Melampyrum cristatum
Melampyrum pratense
Melica ciliata
Melica nutans
Melica picta
Melica transsilvanica
Melica uniflora
Melilotus officinalis
Melittis melissophyllum
Microthlaspi perfoliatum
Milium effusum
Moehringia trinervia
Morus alba (neo)
Muscari tenuiflorum
Nonea pulla
Odontites luteus
Odontites vernus subsp. *serotinus*
Omphalodes scorpioides
Ononis spinosa
Orchis militaris
Origanum vulgare
Orobanche caryophyllacea
Orobanche teucrii
Peucedanum alsaticum
Peucedanum cervaria
Phleum phleoides
Pilosella cf. *densiflora*
Pilosella officinarum
Pimpinella major
Pimpinella saxifraga
Plantago lanceolata
Plantago major
Plantago media
Poa nemoralis
Poa pratensis agg.
Polygala comosa
Polygonatum multiflorum
Polygonatum odoratum
Potentilla alba
Potentilla anserina
Potentilla heptaphylla
Potentilla incana
Potentilla inclinata
Primula veris
Prunella vulgaris
Prunus avium
Prunus cerasus
Prunus spinosa
Pulmonaria officinalis
Pulsatilla pratensis subsp. *bohemica*
Pyrus pyraster
Quercus cerris
Quercus petraea
Quercus pubescens
Quercus robur
Ranunculus auricomus agg.
Ranunculus polyanthemos
Reseda lutea
Rhamnus cathartica
Robinia pseudoacacia (neo)
Rosa canina
Rosa gallica
Rosa rubiginosa
Rosa spinosissima
Salvia nemorosa
Salvia pratensis
Sambucus nigra
Scabiosa canescens
Scabiosa ochroleuca
Scorzonera austriaca
Scorzonera cana
Scorzonera hispanica
Scrophularia nodosa
Securigera varia
Senecio jacobaea
Serratula tinctoria
Seseli annuum
Seseli hippomarathrum
Seseli pallasii
Silene latifolia subsp. *alba*
Silene nutans
Silene vulgaris
Solidago virgaurea
Sorbus domestica
Sorbus torminalis
Stachys germanica
Stachys recta
Stellaria graminea
Stellaria holostea
Stipa capillata
Stipa pennata
Stipa pulcherrima
Symphyotrichum lanceolatum (neo)
Tanacetum corymbosum
Taraxacum sect. *Erythrosperma*
Taraxacum sect. *Taraxacum*
Teucrium chamaedrys
Thalictrum minus
Thesium linophyllon

Continental oak forest with Quercus pubescens in the Milovická stráň Nature Reserve. Photo M. Chytrý.

Thymus pannonicus
Thymus praecox
Tilia cordata
Tilia platyphyllos
Torilis japonica
Tragopogon orientalis
Trifolium alpestre
Trifolium arvense
Trifolium aureum
Trifolium campestre
Trifolium montanum
Trifolium pratense
Trifolium rubens
Turritis glabra
Ulmus minor
Urtica dioica
Valeriana stolonifera subsp. *angustifolia*
Verbascum chaixii subsp. *austriacum*
Verbascum phlomoides
Verbascum phoeniceum
Veronica arvensis
Veronica officinalis
Veronica praecox
Veronica prostrata
Veronica spicata
Veronica sublobata
Veronica teucrium
Veronica vindobonensis
Viburnum lantana
Vicia cracca
Vicia dumetorum
Vicia pisiformis
Vicia sepium
Vicia tenuifolia
Vicia tetrasperma
Vincetoxicum hirundinaria
Viola ambigua
Viola hirta
Viola mirabilis
Viola reichenbachiana
Viola rupestris

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10 Dyje floodplain near Lednice (Lednice-Valtice Cultural Landscape)

Jiří Danihelka

Introduction

The town of Lednice, about 45 km SSE of Brno, is situated above the floodplain of the Dyje River approximately half way between the Nové Mlýny reservoirs to the north-west and the northern edge of the town of Břeclav to the south-east.

Geomorphology, soils and hydrology

The altitude of the Dyje floodplain is about 163 m in the north below the dam of the Nové Mlýny reservoirs and drops gradually to 158 m on the northern edge of Břeclav. It is formed of Quaternary fluvial deposits including loam, sand and gravel. Former river beds and river arms are filled with fen accumulations and organic muddy deposits (gyttja). The floodplain surface is generally flat, although some small elevations, mostly remnants of old sand dunes, are found throughout the area. Gleyic fluvisols are the prevailing soil type, being replaced by arenosols or cambisols on sandy elevations. Until a cascade of three shallow artificial lakes was built on the Dyje River upstream of the village of Nové Mlýny in the 1970s–1980s, the whole floodplain used to be regularly inundated in spring from snow melting in the highlands, though floods also occurred throughout the year after heavy rains.

Climate

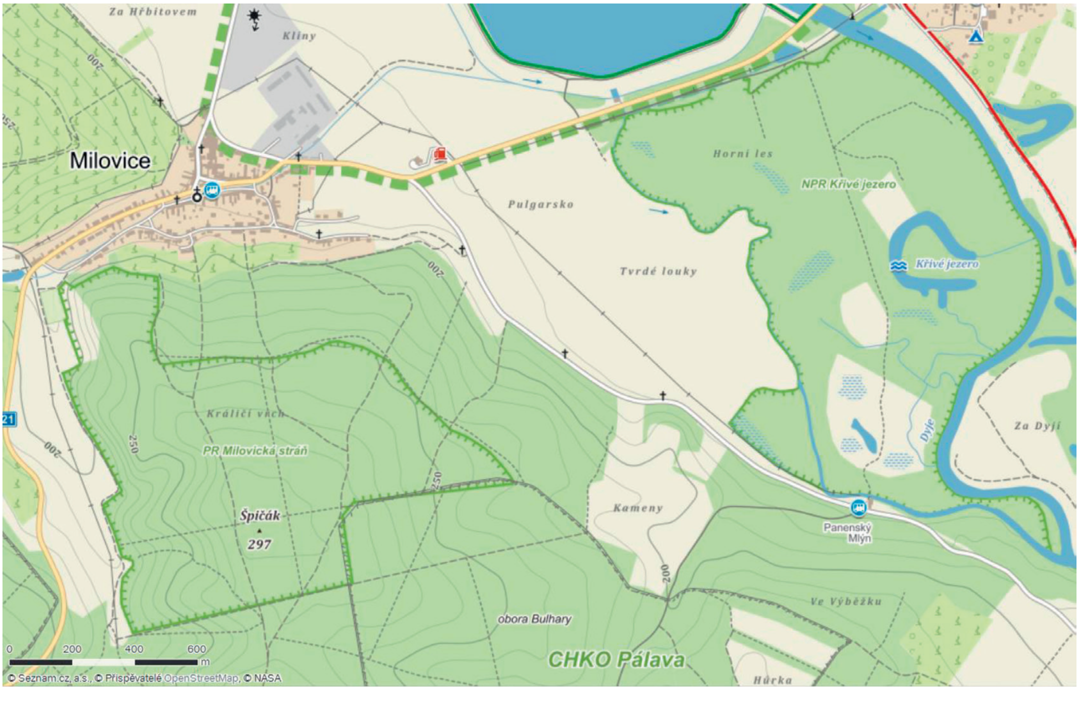
The climate in the area is warm and dry. A Czech Hydrometeorological Institute climate station is situated in the town of Lednice. The mean annual temperature here for the period 1961–1990 was 9.2 °C. The lowest and highest temperatures usually occur in January (the mean January temperature is –1.9 °C) and July (the mean July temperature is 19.1 °C), respectively. The annual precipitation sum in the same period was 480 mm, of which 306 mm fell during the growing season from April to September. The distribution of rainfall over the growing season is rather unbalanced, and periods of drought occur.

Vegetation

The natural vegetation of the Dyje floodplain is hardwood Pannonian floodplain forest of the association *Fraxino pannonicae-Ulmetum* (alliance *Alnion incanae*). It is replaced in slightly elevated places by Pannonian oak-hornbeam forests of the association *Primulo veris-Carpinetum betuli* (alliance *Carpinion betuli*). Softwood floodplain forests of *Salix alba* and *Populus alba* (association *Salicetum albae*, alliance *Salicion albae*) are confined to wetter places in and around old river arms or immediately flanking the active river channel. In many places, natural forests have been removed and replaced by floodplain meadows, mostly of the alliance *Deschampsion cespitosae*. Patches of various types of wetland vegetation, mainly tall-sedge beds, are also common in the floodplain. Although there is no comprehensive vegetation survey study of the Dyje floodplain section described in this chapter, detailed inventories of vegetation type have been done for the adjacent area upstream (now flooded by the Nové Mlýny reservoirs; Vicherek 1962) and the adjacent area downstream near the confluence of the Dyje and Morava Rivers (Vicherek et al. 2000; see the excursion site 11 Dyje-Morava floodplain near Lanžhot).

The Lednice-Valtice Cultural Landscape – a UNESCO World Heritage Site

A large part of the Dyje floodplain and the adjacent gently undulating landscape between the towns of Lednice (in German *Eisgrub*), Břeclav (*Lundenburg*) and Valtice (*Feldsberg*), all centres of former Liechtenstein estates in South Moravia and Lower Austria, is now included in the Lednice-Valtice Cultural Landscape, a UNESCO World Heritage Site since 1996. The transformation of the estates into a designed landscape began during the 17th century when Karl I of Liechtenstein was given the title of duke and made Valtice Chateau his main residence and the smaller Lednice Chateau, situated about 7 km north-east, his summer residence. The Duke's residential town was gradually connected by avenues and paths with other parts of the estates, 'providing vistas and rides, imposing order on nature in the manner of the Renaissance artists and architects' (UNESCO 2015). The English concept of the designed landscape park was introduced in the early 19th century under Duke Johann Josef I. The large-scale landscaping project, supervised by the estate manager Bernhard Petri, included raising the terrain level of the Lednice park and digging a new channel for the Dyje River. At the same time, the surroundings of the three smaller Lednice fishponds were turned into an English-style park. Manors, chapels and other structures were built on higher spots in the landscape, on the crossroads of major routes and in other remarkable places, surrounded in most cases by small English-style parks. These landscaping activities, bringing together natural landscape elements with pieces of architecture and stretching over an area of more than 200 km^2, together with the architecture of the Baroque Valtice Chateau and neo-Gothic Lednice Chateau, formed one of the largest artificial landscapes in Europe (UNESCO 2015). A comprehensive description of this World Heritage Site is provided by Zatloukal et al. (2012). The three sites described below are situated within the Site of Community Importance *Niva Dyje* of the Natura 2000 network.



The Milovická stráň Nature Reserve near the village of Milovice and the Křivé jezero National Nature Reserve in the Dyje floodplain.

(10a) *Křivé jezero* National Nature Reserve

Introduction

The *Křivé jezero* National Nature Reserve is situated on the right-bank side of the Dyje floodplain downstream of the village of Nové Mlýny ca. 40 km SSE of Brno. It is not part of the Lednice-Valtice Cultural Landscape UNESCO World Heritage Site, but is protected under national law as a National Nature Reserve (established in 1973) and part of the *Pálava* Protected Landscape Area. It takes in an area of almost 124 ha. The name *Křivé jezero* (*Curved Lake*) refers to the shape of an oxbow lake of the Dyje River.

The altitude of the floodplain is about 163 m with a few elevations rising about 2 m above the main level. The reserve is surrounded by the Dyje River in the west and its artificial side arm, actually a former millrace, in the east. In contrast to the rest of its lower section, this part of the river has not yet been fully canalized. An old dead river arm, now partly filled in by organic muddy deposits, is found in the central part of the reserve, and a few smaller permanent and temporary pools are scattered throughout the reserve.

The most remarkable feature of this nature reserve are remnants of alluvial meadows, once typical of the Dyje floodplain, which were mown for hay two or three times a year. Pollarded willows, planted in a regular pattern across these meadows, provided local peasants firewood of poor quality. The resulting picturesque landscape became emblematic of the southern Moravian floodplains. This type of management was, however, discontinued after WWII, partly because of the expulsion of the German-speaking population from local villages, partly because it became unprofitable. Most of the stands were abandoned and later destroyed by the construction of the Nové Mlýny reservoirs.

The reserve is the first site in the Czech Republic where money donated by the WWF has been used for nature management. This support was used to make artificial ditches in the reserve in 1976 to prevent drying out of the area following river regulation. These ditches were cleaned and improved two decades later. This may have stopped the process of drying out, but the resulting situation is different from the previous flooding regime. Some parts of the reserve have become waterlogged since the 1990s due to the activities of spreading Eurasian beaver (*Castor fiber*) which makes conservation management rather difficult in places.

Since 1993, the reserve has been part of the Ramsar site *Mokřady dolního Podyjí*, which is protected under the Ramsar Convention (Hudec et al. 1995). It is also a nesting site for the white-tailed eagle (*Haliaeetus albicilla*).

A reed bed with Phalaris arundinacea and floodplain meadow with scattered pollarded willows in the Křivé jezero National Nature Reserve. Photo J. Danihelka.

Vegetation

Hardwood floodplain forests of the association *Fraxino pannonicae-Ulmetum* (alliance *Alnion incanae*) are preserved in some places. Their tree layer is composed mainly of *Fraxinus angustifolia* subsp. *danubialis* and *Quercus robur*, accompanied by *Populus alba* and a few remaining trees of *Ulmus laevis.* Small stands of the softwood floodplain forests of the association *Salicetum albae* are found on wetter sites, with *Populus alba* and *Salix alba* being the canopy dominants. These two natural forest community types have been replaced in many places by plantations of *Populus ×canadensis* (a hybrid of the native *P. nigra* and the North American *P. deltoides*), although native trees have been used more often in plantations recently.

Continental floodplain meadows of the association *Cnidio dubii-Deschampsietum cespitosae* (alliance *Deschampsion cespitosae*) used to be widespread in the reserve. However, most of them were abandoned in the 1980s and early 1990s and changed, under the canopy of overgrown willow pollards, into a mosaic of nitrophilous herbaceous vegetation and tall-sedge communities. They are now well preserved only in the largest meadow in the southern part of the reserve. There have been some efforts by the nature conservation authorities to restore the appropriate management.

Tall-sedge communities of the associations *Caricetum ripariae* and *Caricetum gracilis* and reed beds of the association *Phalaridetum arundinaceae* (all belonging to the alliance *Magno-Caricion gracilis*) are found in shallow depressions, around pools and in wetter unmanaged parts of the meadows and forest openings. Small stands of the association *Caricetum distichae* (alliance *Magno-Caricion gracilis*), with the dominant *Carex disticha*, accompanied by *C. acuta* and *C. riparia*, may be observed in the largest meadow tract next to the main entrance to the reserve. Submerged vegetation of the alliance *Potamion*, composed of *Ceratophyllum demersum*, *Potamogeton crispus* and *Batrachium baudotii*, develops in temporary pools in spring and summer. The remaining water bodies are usually covered by carpets of floating lemnoid plants (alliance *Lemnion minoris*) in the summer. Submerged stands of *Ceratophyllum demersum* occur in the *Křivé jezero* oxbow lake. The local population of *Nymphaea alba* vanished in the early 1990s, and only patches of *Persicaria amphibia* (association *Potamo natantis-Polygonetum natantis*, alliance *Nymphaeion albae*) can be found in the lake. Stands of *Glyceria maxima* (association *Glycerietum maximae*, alliance *Phragmition australis*), also harbouring *Butomus umbellatus*, occur around temporary pools and in shallow depressions in late spring and summer. Patches of *Eleocharis acicularis* and nitrophilous vegetation of the alliance *Eleocharito palustris-Sagittarion sagittifoliae*, the latter including *Oenanthe aquatica*, *Rorippa amphibia* and *Sagittaria sagittifolia*, develop on exposed mud of pool bottoms. In other places, stands of the association *Rumici maritimi-Ranunculetum scelerati* and stands of *Bidens frondosus* (alliance *Bidention tripartitae*) colonize exposed pool bottoms. Reed beds of the association *Phragmitetum australis* (alliance *Phragmition australis*) are rare in the reserve and occupy only small areas. Unmanaged river banks are covered by tall nitrophilous vegetation of the alliance *Senecionion fluviatilis*, harbouring noxious invasive species such as the North American *Symphyotrichum lanceolatum*, also found elsewhere in the reserve's forests, *Helianthus tuberosus* and *Impatiens glandulifera*. Unmanaged places and forests are invaded by the alien *Acer negundo* and *Fraxinus pennsylvanica*, originally planted in the reserve by foresters.

Flora

The flora of the reserve consists of more than 400 species of vascular plants (Danihelka 2004). Those protected under national legislation include *Allium angulosum*, *Euphorbia palustris*, *Iris sibirica*, *Lathyrus palustris*, *Senecio sarracenicus*, *Scutellaria hastifolia*, *Teucrium scordium*, *Thalictrum flavum* and *Viola stagnina*. Some of them have large continental distribution ranges and are concentrated in Central Europe in the floodplains of large lowland rivers. *Leucojum aestivum* is probably the most remarkable plant species in the reserve. Its largest population in the Czech Republic is found here, as more than 100,000 bulbs were transplanted to the reserve by volunteers in the 1980s from the Dyje floodplain a few kilometres upstream that was later flooded by the Nové Mlýny reservoirs. A population of *Scilla vindobonensis*, a central and south-eastern European diploid species related to *S. bifolia*, was established in the same manner. Two trees of the pure *Populus nigra*, a species that is now largely replaced by planted hybrid poplars, are found in the reserve. *Cuscuta lupuliformis*, a rare parasitic plant of the Czech flora, also occurs here.

Like other riparian ecosystems, the reserve is strongly affected by plant invasions. The botanical survey by Danihelka (2004) has shown that archaeophytes and neophytes constitute 17.2% and 8.2% of the vascular flora, respectively, which is much more than the average proportions of 4.1% and 2.0% for these two groups reported by Pyšek et al. (2002) in the Czech nature reserves. In addition to the general effects of floodplain dynamics, the plant invasions in this region are also supported by the abandonment of some grassland areas and by inappropriate forest management that includes soil disturbance by heavy machinery and, until recently, ploughing and other severe methods of soil cultivation.

Appendix 10a Selected species of vascular plants of the *Křivé jezero* National Nature Reserve based on the field records from 1992–2004 (Danihelka 2004). See Danihelka et al. (1995) and Danihelka & Šumberová (2004) for published records.

Acer campestre
Acer negundo (neo)
Acorus calamus (neo)
Aegopodium podagraria
Aethusa cynapium subsp. *elata*
Agrostis gigantea (neo)
Agrostis stolonifera
Achillea collina
Achillea pratensis
Ajuga genevensis
Ajuga reptans
Alisma lanceolatum
Alisma plantago-aquatica
Alliaria petiolata
Allium angulosum
Allium scorodoprasum
Alnus glutinosa
Alopecurus aequalis
Alopecurus pratensis
Althaea officinalis
Amaranthus powellii (neo)
Amaranthus retroflexus (neo)
Amorpha fruticosa (neo)
Anagallis arvensis
Anemone nemorosa
Anemone ranunculoides
Angelica sylvestris
Anthriscus sylvestris
Arabidopsis thaliana
Arctium lappa
Arctium minus
Arctium tomentosum
Aristolochia clematitis
Arrhenatherum elatius
Artemisia absinthium
Artemisia vulgaris
Astragalus cicer
Astragalus glycyphyllos
Atriplex oblongifolia
Atriplex patula
Atriplex prostrata
Atriplex sagittata
Ballota nigra
Barbarea stricta
Batrachium baudotii
Batrachium trichophyllum
Bidens frondosus (neo)
Bidens tripartitus
Brachypodium sylvaticum
Bromus benekenii
Bromus hordeaceus
Bromus inermis
Bromus japonicus
Bromus sterilis
Bromus tectorum
Butomus umbellatus
Calamagrostis epigejos
Callitriche cophocarpa
Caltha palustris
Calystegia sepium
Campanula trachelium
Capsella bursa-pastoris
Cardamine dentata
Cardamine impatiens
Cardamine matthioli
Cardamine pratensis
Carduus crispus
Carex acuta
Carex disticha
Carex hirta
Carex otrubae
Carex praecox
Carex riparia
Carex spicata
Carex sylvatica
Carex vesicaria
Carex vulpina
Carpinus betulus
Centaurea jacea
Cerastium dubium
Cerastium holosteoides
Ceratophyllum demersum
Chaerophyllum bulbosum
Chaerophyllum temulum
Chelidonium majus
Chenopodium album
Chenopodium ficifolium
Chenopodium hybridum
Chenopodium polyspermum
Chenopodium rubrum
Cichorium intybus
Circaea lutetiana
Cirsium arvense
Cirsium canum
Cirsium vulgare
Clematis vitalba
Cnidium dubium
Colchicum autumnale
Conium maculatum
Consolida regalis
Convallaria majalis
Convolvulus arvensis
Cornus sanguinea
Corydalis cava
Corylus avellana
Crataegus laevigata
Crataegus monogyna
Crepis biennis
Cuscuta europaea
Cuscuta lupuliformis
Cynosurus cristatus
Cyperus fuscus
Dactylis glomerata
Dactylis polygama
Datura stramonium (neo)
Daucus carota
Descurainia sophia
Deschampsia cespitosa
Dipsacus fullonum
Dipsacus laciniatus
Dipsacus pilosus
Dryopteris carthusiana
Dryopteris filix-mas
Echinochloa crus-galli
Eleocharis acicularis
Eleocharis palustris
Elymus caninus
Elymus repens
Epilobium adenocaulon (neo)
Epilobium hirsutum
Epilobium lamyi
Epilobium tetragonum
Epipactis helleborine
Equisetum arvense
Erophila verna
Erysimum cheiranthoides
Euonymus europaeus
Euphorbia palustris
Fallopia convolvulus
Fallopia dumetorum
Festuca gigantea
Festuca pratensis
Festuca rubra
Ficaria calthifolia

Ficaria verna subsp. *verna*
Filipendula ulmaria
Frangula alnus
Fraxinus angustifolia subsp. *danubialis*
Fraxinus excelsior
Fraxinus pennsylvanica (neo)
Gagea lutea
Galega officinalis
Galeopsis bifida
Galeopsis pubescens
Galinsoga parviflora (neo)
Galinsoga quadriradiata (neo)
Galium album subsp. *album*
Galium aparine
Galium boreale
Galium elongatum
Galium palustre
Galium rivale
Galium verum
Geranium pratense
Geranium pusillum
Geranium robertianum
Geum urbanum
Glechoma hederacea
Glyceria fluitans
Glyceria maxima
Gnaphalium uliginosum
Helianthus tuberosus (neo)
Hesperis sylvestris
Humulus lupulus
Hypericum hirsutum
Hypericum perforatum
Impatiens glandulifera (neo)
Impatiens parviflora (neo)
Inula britannica
Iris pseudacorus
Iris sibirica
Juncus articulatus
Juncus bufonius
Juncus compressus
Juncus effusus
Lactuca serriola
Lamium album
Lamium maculatum
Lamium purpureum
Lapsana communis
Lathyrus palustris
Lathyrus pratensis
Lavatera thuringiaca
Leersia oryzoides
Lemna gibba
Lemna minor
Lemna trisulca
Leonurus marrubiastrum
Lepidium draba
Leucojum aestivum
Linaria vulgaris
Lolium perenne
Lonicera xylosteum
Loranthus europaeus
Lotus tenuis
Lycopus europaeus
Lychnis flos-cuculi
Lysimachia nummularia
Lysimachia vulgaris
Lythrum salicaria
Lythrum virgatum
Maianthemum bifolium
Malus sylvestris
Matricaria discoidea (neo)
Matricaria chamomilla
Medicago lupulina
Melilotus albus
Melilotus officinalis
Mentha aquatica
Mentha arvensis
Mentha ×verticillata
Milium effusum
Moehringia trinervia
Myosotis arvensis
Myosotis caespitosa
Myosotis palustris
Myosotis ramosissima
Myosoton aquaticum
Nuphar lutea
Odontites vernus subsp. *serotinus*
Oenanthe aquatica
Oxalis stricta (neo)
Papaver rhoeas
Paris quadrifolia
Pastinaca sativa
Persicaria amphibia
Persicaria hydropiper
Persicaria lapathifolia
Persicaria minor
Persicaria mitis
Phalaris arundinacea
Phleum pratense
Phragmites australis
Picris hieracioides
Pimpinella major
Plantago lanceolata
Plantago major
Plantago uliginosa
Poa angustifolia
Poa annua
Poa compressa
Poa palustris
Poa pratensis
Poa trivialis
Polygonum aviculare agg.
Populus alba
Populus ×canadensis (neo)
Populus nigra
Populus tremula
Portulaca oleracea
Potamogeton berchtoldii
Potamogeton crispus
Potentilla anserina
Potentilla reptans
Potentilla supina
Prunella vulgaris
Prunus cerasifera
Prunus padus
Prunus spinosa
Pulmonaria officinalis
Quercus robur
Ranunculus acris
Ranunculus auricomus agg.
Ranunculus flammula
Ranunculus repens
Ranunculus sceleratus
Rhamnus cathartica
Ribes rubrum (neo)
Robinia pseudoacacia (neo)
Rorippa amphibia
Rorippa palustris
Rorippa sylvestris
Rosa canina
Rubus caesius
Rumex acetosa
Rumex conglomeratus
Rumex crispus
Rumex hydrolapathum
Rumex maritimus
Rumex obtusifolius
Rumex patientia
Rumex sanguineus
Rumex stenophyllus
Sagittaria sagittifolia
Salix alba
Salix caprea
Salix cinerea
Salix euxina (= *S. fragilis*)
Salix triandra
Salix viminalis
Sambucus ebulus
Sambucus nigra
Scilla vindobonensis
Scrophularia nodosa
Scrophularia umbrosa
Scutellaria galericulata
Scutellaria hastifolia
Securigera varia
Sedum album
Selinum carvifolia
Senecio erraticus
Senecio sarracenicus
Setaria pumila
Setaria viridis
Schoenoplectus lacustris
Silene baccifera
Silene latifolia subsp. *alba*
Sinapis arvensis
Sisymbrium officinale
Sium latifolium
Solanum dulcamara
Solanum nigrum
Solidago gigantea (neo)
Sonchus arvensis
Sonchus asper
Sonchus oleraceus

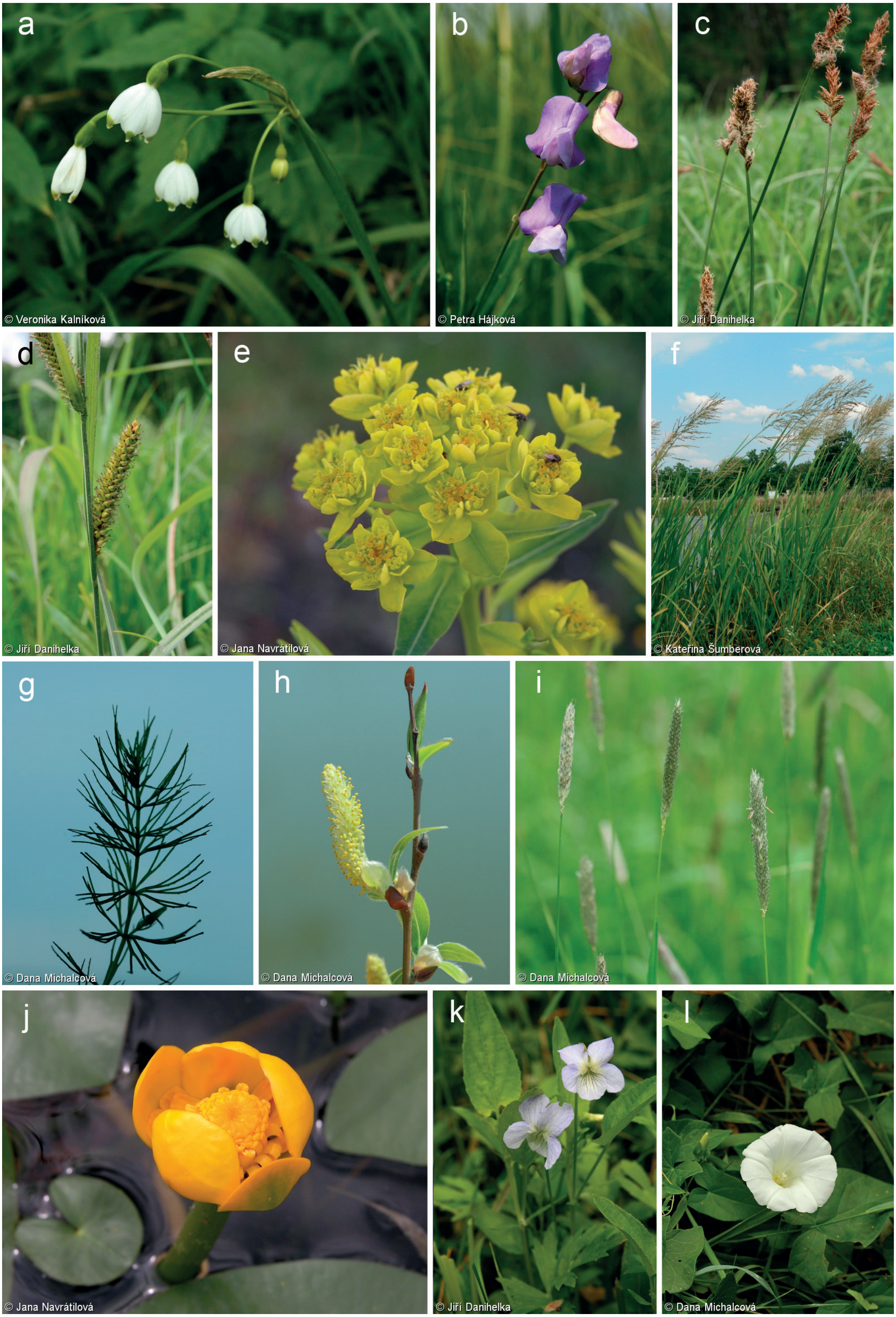


Plate 10a Plants of the *Křivé jezero* National Nature Reserve: (a) *Leucojum aestivum*, (b) *Lathyrus palustris*, (c) *Carex disticha*, (d) *Carex riparia*, (e) *Euphorbia palustris*, (f) *Glyceria maxima*, (g) *Ceratophyllum demersum*, (h) *Salix alba*, (i) *Alopecurus pratensis*, (j) *Nuphar lutea*, (k) *Viola stagnina*, (l) *Calystegia sepium*.

Sparganium erectum
Spirodela polyrhiza
Stachys palustris
Stachys sylvatica
Stellaria graminea
Stellaria media
Stellaria nemorum
Stellaria palustris
Stuckenia pectinata
Symphyotrichum lanceolatum (neo)
Symphytum officinale
Tanacetum vulgare
Taraxacum sect. *Taraxacum*
Teucrium scordium
Thalictrum flavum
Torilis japonica
Trifolium arvense
Trifolium campestre
Trifolium fragiferum
Trifolium hybridum
Trifolium pratense
Trifolium repens
Tussilago farfara
Typha angustifolia
Typha latifolia
Ulmus laevis
Ulmus minor
Urtica dioica
Valeriana officinalis
Verbascum blattaria
Verbascum thapsus
Veronica anagallis-aquatica
Veronica anagalloides
Veronica arvensis
Veronica catenata
Veronica chamaedrys
Veronica maritima
Veronica scutellata
Veronica serpyllifolia
Veronica sublobata
Viburnum opulus
Vicia angustifolia
Vicia cracca
Vicia hirsuta
Vicia sepium
Vicia tetrasperma
Viola arvensis
Viola odorata
Viola reichenbachiana
Viola stagnina
Viola suavis (neo)
Viscum album subsp. *album*
Xanthium albinum (neo)

(10b) Lednice Chateau Park

Introduction

The Liechtenstein family acquired the Lednice estate as early as about 1249 and became exclusive holders of the domain in 1371. Lednice Chateau is found at the edge of the river terrace about 10 m above the floodplain on the site of a former Gothic fortress. The latter was replaced in the late 16th century by a Renaissance villa which was converted into a Baroque chateau in the late 17th century and modified in the style of the early Classicism in the late 18th century and in the Empire style in the early 19th century. A large orangerie was built in 1843–1845. The last reconstruction, led by the Viennese architect Georg Wingelmüller, dates back to 1846–1858, at which time the chateau acquired its present neo-Gothic appearance.

The Renaissance villa was already surrounded by a garden situated on the terraces above the Dyje floodplain. At that time, the main riverbed was found about 150 m north of the chateau; it is now preserved as a side river arm referred to as *Zámecká Dyje* (*Chateau Dyje*). The garden was gradually developed into a Baroque-style park from the 1630s onwards, at which time the park did not yet include the Dyje floodplain. However, the park was extended towards the floodplain across the river after the chateau's renovation in the Classicist style, and the main composition axis of the future landscape park was created. The park still observed the principles of Baroque gardens and parks. Several Romantic structures were erected in the park at that time, including an artificial castle ruin, a Chinese pavilion and a minaret. In 1805–1811, the park was transformed into a landscape park applying the English concept of the designed park. This enormous landscaping project included raising the level of the terrain in the park, establishing an artificial lake with islands, and digging a new channel for the Dyje River which subsequently formed the northern border of the park. About 36,000 young trees and shrubs were imported from North America and planted in the park and its surroundings. The last major development of the park followed the neo-Gothic rebuild of the chateau in the 1850s (Kříž et al. 1978). Recently, the park harbours 614 woody species and their cultivars (Zatloukal et al. 2012).

The following description of the vegetation and flora of the park is concerned only with spontaneous species, and not with cultivated ornamental plants. Detailed descriptions of the park from the architectonical, dendrological and historical point of view are provided by Kříž et al. (1978), Hieke (1985) and Pejchal & Krejčiřík (2010, 2012).

Spontaneous vegetation

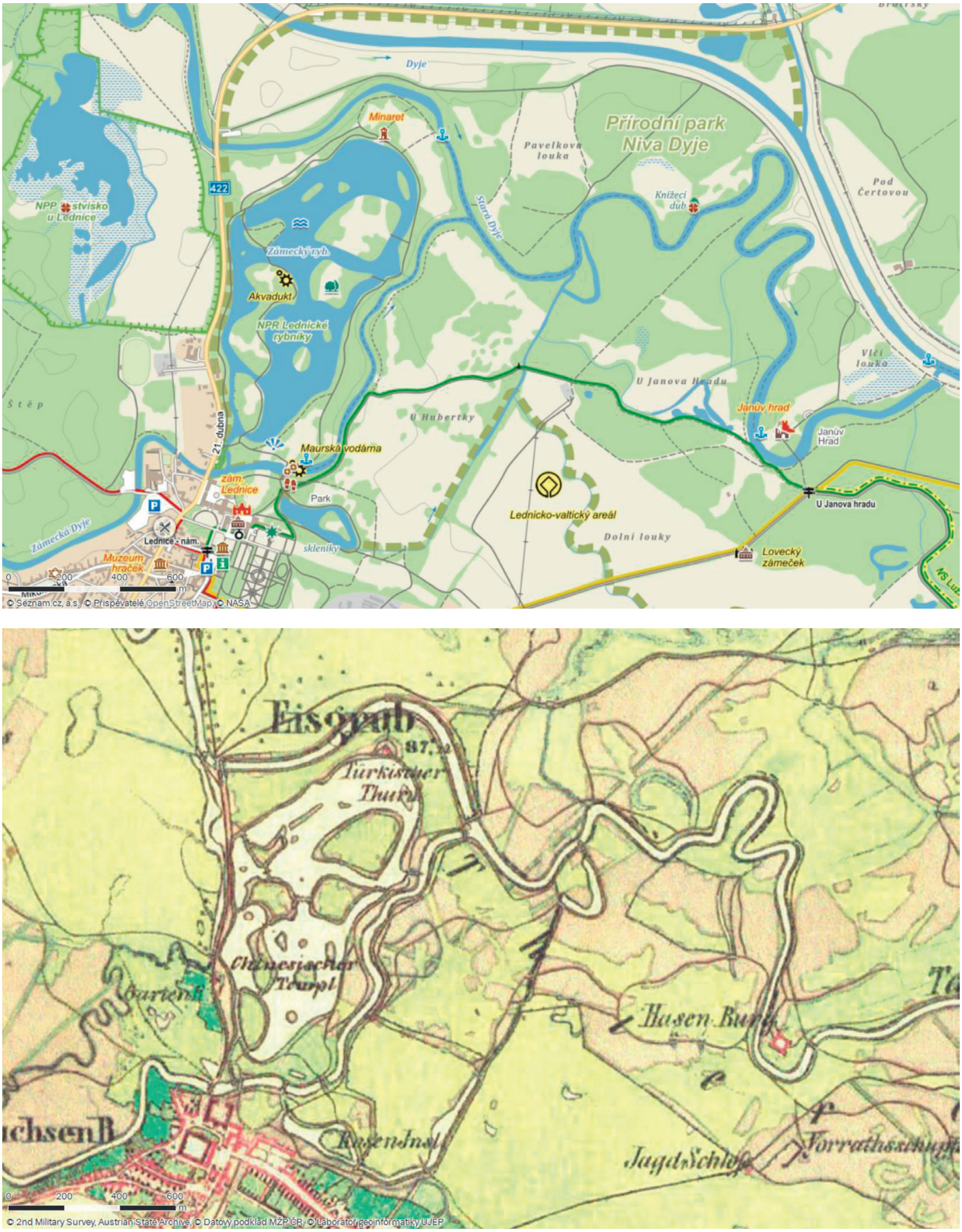
The spontaneous vegetation in the park includes aquatic and wetland vegetation and various types of grasslands. It is similar to the vegetation of other parts of the Dyje floodplain though some of the plant communities developed in the park are not found elsewhere in the surrounding landscape.

Lednice Chateau Park with its Romantic minaret is an example of a designed landscape in the Dyje floodplain. Photo Z. Losos.

Several types of aquatic plant communities have been recorded in the park. Stands of *Lemna minor* (association *Lemnetum minoris*, alliance *Lemnion minoris*) develop regularly in a small fishpond (*Růžový rybník*) north-east of the chateau. Submerged monodominant vegetation of *Ceratophyllum demersum* (association *Ceratophylletum demersi*) is found in the same fishpond and in the side river arm *Zámecká Dyje*. A small population of *Nuphar lutea* (association *Nymphaeo albae-Nupharetum luteae*, alliance *Nymphaeion albae*) occurs in the ditch connecting the *Zámecká Dyje* river arm with the Zámecký fishpond.

The wetland vegetation includes reed beds of *Phragmites australis* (association *Phragmitetum australis*, alliance *Phragmition australis*) developed in narrow strips in the littoral zone of the Zámecký fishpond and in other places. Stands of *Sparganium erectum* (association *Glycerio-Sparganietum neglecti*, alliance *Phragmition australis*) are restricted to a small section of the fishpond littoral zone along its western bank. It is found here together with very small patches of *Leersia oryzoides* marsh grassland (association *Leersietum oryzoidis*, alliance *Glycerio-Sparganion*). The association *Caricetum gracilis* (alliance *Magno-Caricion gracilis*), dominated by the tall sedge *Carex acuta* (syn. *C. gracilis*), occurs in the littoral zone of the Zámecký fishpond and on one of its islands. Small patches of another tall-sedge community, dominated by *Carex riparia* (association *Caricetum ripariae*, alliance *Magno-Caricion gracilis*), are found in a large meadow in the north-eastern part of the park.

The meadows in the park are particularly interesting. Mesophilous *Arrhenatherion elatioris* meadows occur on the artificially raised surface in the western part of the park around the fishpond and on the islands. Their species composition depends on the water supply: patches with mesophilous species such as *Arrhenatherum elatius*, *Campanula patula*, *Crepis biennis*, *Galium album* and *Geranium pratense* alternate with patches dominated by drought-tolerant species including *Bromus erectus*, *Festuca rupicola* and *Pimpinella saxifraga*. This drier variant of *Arrhenatherum* meadows, dominated by *Bromus erectus*, is widespread on slightly elevated landforms in the eastern part of the park, usually referred to as the Hubertka meadow. These mesophilous meadows are now spreading at the expense of meadow types adapted to flooding.



Lednice Chateau Park and the Pavelka Meadow in the Dyje floodplain and the same area before river regulation as shown on a map from the 2nd Military Survey (1836–1852; source: Austrian State Archive, Vienna; digitized by the Geoinformatics Laboratory, University of J.E. Purkyně, Ústí nad Labem).

The Hubertka meadow also harbours grassland communities once typical of the large floodplains in the continental climate of southern Moravia, i.e. the association *Cnidio dubii-Deschampsietum cespitosae* (alliance *Deschampsion cespitosae*). They contain graminoids such as *Alopecurus pratensis*, *Carex praecox*, *Festuca pratensis*, *Poa palustris* and *Phalaris arundinacea*, together with broad-leaved herbs such as *Cnidium dubium*, *Colchicum autumnale*, *Euphorbia lucida*, *Galium boreale*, *Iris sibirica*, *Serratula tinctoria* and *Viola pumila*. A patch of dry grassland may be found in the easternmost part of the meadow on the top of a buried acidic sand dune. It harbours *Achillea collina*, *Dianthus pontederae*, *Festuca pulchra*, *F. rupicola*, *Potentilla argentea* and *Rumex acetosella*, as well as some spring ephemerals (association *Potentillo heptaphyllae-Festucetum rupicolae*, alliance *Koelerio-Phleion phleoidis*). These meadows and dry grasslands are considered semi-natural replacement vegetation of the Pannonian hardwood forests of the association *Fraxino pannonicae-Ulmetum* and Pannonian oak-hornbeam forests of the association *Primulo veris-Carpinetum betuli*, respectively.

The meadows of the Lednice Chateau Park are the last remnants of once widespread plant communities of the Dyje floodplain. Most of them were ploughed after the Nové Mlýny reservoirs were built, while small patches were abandoned or destroyed in other ways. The best preserved meadow remnants upstream of the town of Břeclav are those situated in the buffer zones of water supply facilities and in the Lednice Chateau Park. They have been extensively managed for a long time, usually mown twice a year and not fertilized. They may also have been grazed by sheep in the past.

Spontaneous flora

The survey conducted in 1998 (Danihelka 1998; see also Danihelka & Šumberová 2004) reported 435 species, subspecies and hybrids of spontaneously occurring vascular plants in the Lednice Chateau Park. The chateau park is an important refuge for a number of rare and remarkable plant species. The main reasons for its floristic richness include the large area of natural and semi-natural habitats such as water bodies, wetlands, meadows, dry grasslands and woodlots of exotic and native trees, and the fact that the park has not been affected by intensive agriculture and most parts of it have been permanently and extensively managed for decades or even centuries.

In addition to the species listed in the vegetation description the following species are also worth mentioning: *Arum cylindraceum* (a nemoral species replacing *A. maculatum* in the eastern part of the Czech Republic), *Bidens cernuus* (locally rare), *Carex melanostachya* (a sedge with a large continental distribution range), *Cerastium dubium* (a rare species with native occurrences only in the south-east of the country), *Cruciata verna* (native to more eastern and southern areas, accidentally introduced probably with young trees or shrubs a century ago), *Cynodon dactylon* (typical of trampled sites on sandy soils), *Draba nemorosa* (a continental species with a large distribution range, in the Czech Republic confined to the very south-east), *Euphorbia palustris*, *Lactuca quercina*, *Listera ovata* (locally rare), *Lotus tenuis* (indicating slightly saline soils), *Lythrum virgatum* (typical of continental floodplain meadows), *Sagittaria sagittifolia* (locally rare), *Stellaria holostea* (locally very rare), *Veronica maritima* (a species of continental floodplain meadows with a large distribution range) and *Vicia lathyroides* (a species of dry grasslands, recently spreading in secondary habitats all over the country).

Appendix 10b Selected species of vascular plants of the Lednice Chateau Park based mainly on the field records from 1998 (Danihelka 1998). For published records see Danihelka & Šumberová (2004).

Acer campestre
Acer platanoides
Acer pseudoplatanus
Achillea collina
Acorus calamus (neo)
Aegopodium podagraria
Aesculus hippocastanum (neo)
Agrimonia eupatoria
Agrostis capillaris
Agrostis stolonifera
Ajuga reptans
Alisma plantago-aquatica
Alliaria petiolata
Allium angulosum
Allium oleraceum
Allium scorodoprasum
Allium ursinum
Allium vineale
Alnus glutinosa
Alopecurus pratensis
Amaranthus albus (neo)
Amaranthus powellii (neo)
Amaranthus retroflexus (neo)
Anemone nemorosa
Anemone ranunculoides
Angelica sylvestris
Anthoxanthum odoratum
Anthriscus sylvestris
Arabidopsis thaliana
Arabis hirsuta
Arctium lappa
Arctium tomentosum
Arenaria serpyllifolia agg.
Arrhenatherum elatius
Arum cylindraceum
Artemisia vulgaris
Asclepias syriaca (neo)
Asparagus officinalis
Asperugo procumbens
Astragalus glycyphyllos
Atriplex patula
Atriplex sagittata
Avenula pubescens
Ballota nigra
Barbarea stricta
Barbarea vulgaris
Bellis perennis
Berteroa incana
Betonica officinalis
Bidens cernuus
Bidens frondosus (neo)
Bothriochloa ischaemum
Brachypodium pinnatum
Brachypodium sylvaticum
Bromus benekenii
Bromus erectus
Bromus hordeaceus
Bromus sterilis
Bromus tectorum
Bryonia alba

Butomus umbellatus
Buxus sempervirens (neo)
Calamagrostis epigejos
Calystegia sepium
Campanula glomerata
Campanula patula
Campanula rapunculoides
Campanula trachelium
Capsella bursa-pastoris
Cardamine impatiens
Cardamine matthioli
Cardamine pratensis
Carduus crispus
Carex acuta
Carex acutiformis
Carex caryophyllea
Carex hirta
Carex melanostachya
Carex praecox
Carex remota
Carex riparia
Carex spicata
Carex sylvatica
Carex tomentosa
Carex vulpina
Carpinus betulus
Centaurea jacea
Cerastium arvense
Cerastium dubium
Cerastium glutinosum
Cerastium holosteoides
Cerastium semidecandrum
Ceratophyllum demersum
Chaerophyllum temulum
Chelidonium majus
Chenopodium album
Chenopodium hybridum
Chenopodium murale
Chenopodium polyspermum
Chenopodium strictum (neo)
Cichorium intybus
Circaea lutetiana
Cirsium arvense
Cirsium canum
Cirsium vulgare
Clematis vitalba
Clinopodium vulgare
Cnidium dubium
Colchicum autumnale
Convallaria majalis
Convolvulus arvensis
Conyza canadensis (neo)
Cornus sanguinea
Corydalis cava
Corylus avellana
Crataegus laevigata
Crataegus monogyna
Crepis biennis
Cruciata laevipes
Cruciata verna
Cuscuta epithymum
Cynodon dactylon
Dactylis glomerata
Dactylis polygama
Datura stramonium (neo)
Daucus carota
Descurainia sophia
Deschampsia cespitosa
Dianthus pontederae
Digitaria sanguinalis
Draba nemorosa
Echinochloa crus-galli
Eleocharis palustris agg.
Elymus caninus
Elymus repens
Epilobium hirsutum
Epilobium tetragonum
Equisetum arvense
Eragrostis minor
Erigeron annuus (neo)
Erodium cicutarium
Erophila verna
Erysimum cheiranthoides
Euonymus europaeus
Euphorbia cyparissias
Euphorbia esula
Euphorbia helioscopia
Euphorbia lucida
Euphorbia palustris
Euphorbia peplus
Euphorbia virgata
Falcaria vulgaris
Fallopia dumetorum
Festuca arundinacea
Festuca brevipila
Festuca gigantea
Festuca heterophylla
Festuca pratensis
Festuca pulchra
Festuca rubra
Festuca rupicola
Ficaria calthifolia
Ficaria verna subsp. *verna*
Filipendula ulmaria
Filipendula vulgaris
Fragaria moschata
Fragaria vesca
Fragaria viridis
Frangula alnus
Fraxinus angustifolia subsp. *danubialis*
Fraxinus excelsior
Fumaria schleicheri
Gagea lutea
Galeobdolon argentatum (neo)
Galeopsis bifida
Galeopsis pernhofferi
Galeopsis pubescens
Galinsoga parviflora (neo)
Galinsoga quadriradiata (neo)
Galium album
Galium aparine
Galium boreale
Galium elongatum
Galium palustre
Galium verum
Geranium pratense
Geranium pusillum
Geranium pyrenaicum (neo)
Geranium robertianum
Geum urbanum
Glechoma hederacea
Hedera helix
Helleborus foetidus (neo)
Heracleum sphondylium
Hieracium lachenalii
Hieracium murorum
Hieracium sabaudum
Holcus lanatus
Hordeum murinum
Humulus lupulus
Hypericum hirsutum
Hypericum perforatum
Impatiens parviflora (neo)
Inula salicina
Iris pseudacorus
Iris sibirica
Juglans nigra (neo)
Knautia arvensis
Lactuca quercina
Lactuca serriola
Lamium album
Lamium maculatum
Lamium purpureum
Lapsana communis
Lathyrus pratensis
Lathyrus tuberosus
Lathyrus vernus
Leersia oryzoides
Lemna minor
Leontodon hispidus
Leonurus marrubiastrum
Lepidium draba
Lepidium ruderale
Leucanthemum ircutianum
Leucanthemum vulgare
Ligustrum vulgare
Linum catharticum
Listera ovata
Lolium perenne
Lonicera caprifolium (neo)
Lonicera xylosteum
Loranthus europaeus
Lotus corniculatus
Lotus tenuis
Luzula campestris
Luzula luzuloides
Lycium barbarum (neo)
Lycopus europaeus
Lychnis flos-cuculi
Lysimachia nummularia
Lysimachia vulgaris
Lythrum salicaria

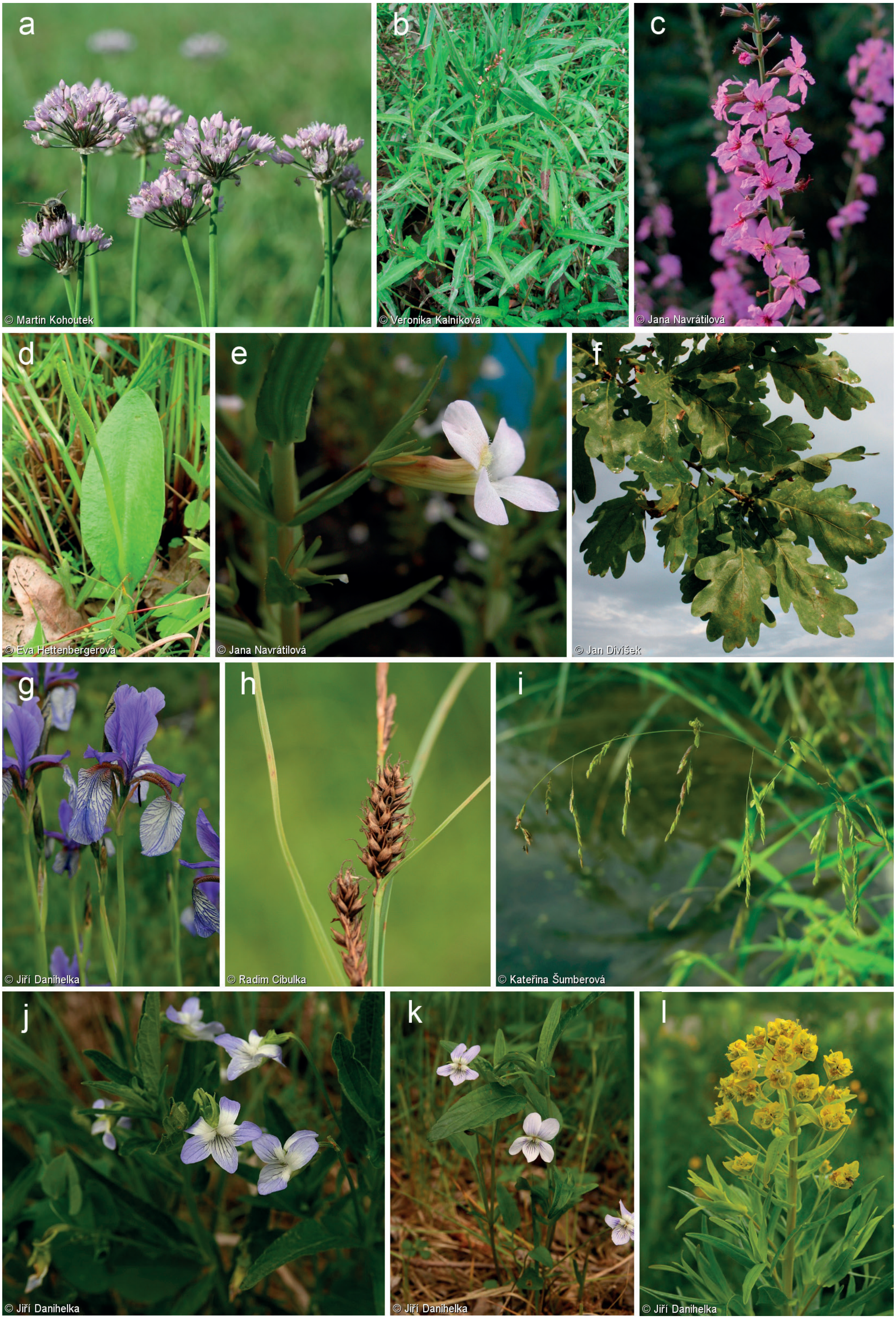


Plate 10b-c Plants of the Lednice Chateau Park and of the Pavelka Meadow: (a) *Allium angulosum*, (b) *Persicaria minor*, (c) *Lythrum virgatum*, (d) *Ophioglossum vulgatum*, (e) *Gratiola officinalis*, (f) *Quercus robur*, (g) *Iris sibirica*, (h) *Carex melanostachya*, (i) *Leersia oryzoides*, (j) *Viola elatior*, (k) *Viola pumila*, (l) *Euphorbia lucida*.

Lythrum virgatum
Mahonia aquifolium (neo)
Malus sylvestris
Malva neglecta
Matricaria chamomilla
Medicago lupulina
Medicago sativa (neo)
Mentha arvensis
Microthlaspi perfoliatum
Milium effusum
Moehringia trinervia
Muscari neglectum
Mycelis muralis
Myosotis arvensis
Myosotis palustris
Myosotis ramosissima
Myosotis sparsiflora
Myosoton aquaticum
Neottia nidus-avis
Nuphar lutea
Odontites vernus subsp. *serotinus*
Ononis spinosa
Ornithogalum cf. *boucheanum*
Ornithogalum kochii
Oxalis stricta (neo)
Parthenocissus quinquefolia (neo)
Pastinaca sativa
Persicaria amphibia
Persicaria hydropiper
Persicaria lapathifolia
Persicaria maculosa
Persicaria mitis
Petasites hybridus
Phalaris arundinacea
Phragmites australis
Phytolacca americana (neo)
Pilosella caespitosa
Pilosella officinarum
Pimpinella major
Pimpinella saxifraga
Plantago lanceolata
Plantago major
Plantago media
Poa angustifolia
Poa annua
Poa bulbosa
Poa nemoralis
Poa palustris
Poa trivialis
Polygonatum multiflorum
Polygonum aviculare agg.
Populus alba
Populus ×canadensis (neo)
Populus tremula
Portulaca oleracea
Potamogeton crispus
Potentilla anserina
Potentilla argentea
Potentilla heptaphylla
Potentilla reptans
Primula veris
Prunella vulgaris
Prunus avium
Prunus padus
Prunus spinosa
Pulmonaria officinalis
Pyrus pyraster
Quercus cerris
Quercus robur
Ranunculus acris
Ranunculus auricomus agg.
Ranunculus bulbosus
Ranunculus polyanthemos
Ranunculus repens
Reynoutria japonica (neo)
Rhamnus cathartica
Rhinanthus minor
Ribes rubrum (neo)
Ribes uva-crispa
Robinia pseudoacacia (neo)
Rorippa amphibia
Rosa canina
Rubus caesius
Rumex acetosa
Rumex acetosella
Rumex crispus
Rumex hydrolapathum
Rumex obtusifolius
Rumex sanguineus
Rumex thyrsiflorus (neo)
Sagina procumbens
Sagittaria sagittifolia
Salix alba
Salix cinerea
Salix euxina (= *S. fragilis*)
Salvia pratensis
Sambucus nigra
Sanguisorba officinalis
Scabiosa ochroleuca
Scorzoneroides autumnalis
Scrophularia nodosa
Scutellaria galericulata
Securigera varia
Senecio vulgaris
Serratula tinctoria
Setaria pumila
Setaria verticillata
Setaria viridis
Silaum silaus
Silene baccifera
Silene latifolia subsp. *alba*
Silene nutans
Silene vulgaris
Sinapis arvensis
Sisymbrium loeselii (neo)
Sisymbrium officinale
Solanum dulcamara
Solanum nigrum
Sonchus arvensis
Sonchus asper
Sonchus oleraceus
Sorbus torminalis
Sparganium erectum
Stachys sylvatica
Stellaria graminea
Stellaria holostea
Stellaria nemorum
Stellaria palustris
Stratiotes aloides
Symphyotrichum lanceolatum (neo)
Symphytum officinale
Syringa vulgaris (neo)
Tanacetum corymbosum
Tanacetum vulgare
Taraxacum sect. *Taraxacum*
Tilia cordata
Tilia platyphyllos
Tragopogon orientalis
Trifolium campestre
Trifolium dubium
Trifolium fragiferum
Trifolium pratense
Trifolium repens
Trisetum flavescens
Tussilago farfara
Typha angustifolia
Typha latifolia
Ulmus laevis
Ulmus minor
Urtica dioica
Urtica urens
Valeriana officinalis
Valerianella locusta
Verbena officinalis
Veronica arvensis
Veronica chamaedrys
Veronica maritima
Veronica polita
Veronica serpyllifolia
Veronica sublobata
Veronica vindobonensis
Viburnum lantana
Viburnum opulus
Vicia angustifolia
Vicia cracca
Vicia dumetorum
Vicia hirsuta
Vicia lathyroides
Vicia sepium
Vicia tenuifolia
Vicia tetrasperma
Vinca minor
Viola hirta
Viola mirabilis
Viola odorata
Viola pumila
Viola reichenbachiana
Viola riviniana
Viscum album subsp. *album*

(10c) Pavelka Meadow

The Pavelka Meadow (*Pavelkova louka*) is situated between the northern border of the Lednice Chateau Park and the Dyje River 1.2–1.7 km NE of the chateau chapel. It is one of the few well-preserved meadows upstream of the town of Břeclav. It is regularly mown once or twice a year. The meadow vegetation represents a transition between the continental floodplain meadows of the association *Cnidio dubii-Deschampsietum cespitosae* (alliance *Deschampsion cespitosae*) and mesophilous meadows of the alliance *Arrhenatherion elatioris*. Mesophilous species of the alliance *Arrhenatherion elatioris* may have spread since the elimination of floodings. Most of the species typical of floodplain meadows are, however, still present, including *Cardamine matthioli*, *Carex melanostachya*, *C. praecox*, *Cerastium dubium*, *Cnidium dubium*, *Euphorbia lucida*, *Filipendula vulgaris*, *Galium boreale*, *Inula salicina*, *Ophioglossum vulgatum*, *Viola elatior*, *V. pumila* and *V. stagnina*.

Appendix 10c Selected species of vascular plants of the Pavelka Meadow near Lednice based on the records from 1997. For published records see Danihelka et al. (1995) and Danihelka & Šumberová (2004).

Acer campestre
Agrostis stolonifera
Achillea pratensis
Allium scorodoprasum
Alnus glutinosa
Alopecurus aequalis
Alopecurus pratensis
Anthoxanthum odoratum
Anthriscus sylvestris
Arabis nemorensis
Aristolochia clematitis
Arrhenatherum elatius
Artemisia vulgaris
Astragalus glycyphyllos
Atriplex patula
Betonica officinalis
Bidens frondosus (neo)
Brachypodium sylvaticum
Bromus sterilis
Calystegia sepium
Campanula patula
Capsella bursa-pastoris
Cardamine matthioli
Cardamine parviflora
Carduus crispus
Carex hirta
Carex melanostachya
Carex praecox
Carex riparia
Carex spicata
Carex vulpina
Centaurea jacea subsp. *angustifolia*
Cerastium dubium
Cerastium holosteoides
Chaerophyllum temulum
Chenopodium album
Cichorium intybus
Cirsium arvense
Cirsium canum
Cnidium dubium
Colchicum autumnale
Convolvulus arvensis
Conyza canadensis (neo)
Cornus sanguinea
Dactylis glomerata
Deschampsia cespitosa
Eleocharis palustris agg.
Elymus repens
Epilobium tetragonum
Equisetum arvense
Erigeron annuus (neo)
Euphorbia esula
Euphorbia lucida
Festuca arundinacea
Festuca pratensis
Festuca rupicola
Filipendula ulmaria
Filipendula vulgaris
Fragaria viridis
Frangula alnus
Fraxinus angustifolia subsp. *danubialis*
Galium aparine
Galium boreale
Galium palustre
Geum urbanum
Glechoma hederacea
Glyceria maxima
Gnaphalium uliginosum
Holcus lanatus
Humulus lupulus
Inula britannica
Inula salicina
Iris pseudacorus
Lamium purpureum
Lapsana communis
Lathyrus pratensis
Leonurus marrubiastrum
Leucanthemum vulgare
Linaria vulgaris
Linum catharticum
Lolium perenne
Lotus corniculatus
Lotus tenuis
Lycopus exaltatus
Lychnis flos-cuculi
Lysimachia nummularia
Lysimachia vulgaris
Lythrum salicaria
Lythrum virgatum
Matricaria chamomilla
Mentha arvensis
Moehringia trinervia
Myosotis arvensis
Myosotis ramosissima
Myosotis sparsiflora
Myosoton aquaticum
Odontites vernus subsp. *serotinus*
Ophioglossum vulgatum
Papaver rhoeas
Pastinaca sativa
Persicaria amphibia
Phalaris arundinacea
Phleum pratense
Pilosella rothiana
Pimpinella major
Plantago lanceolata
Plantago major
Plantago uliginosa
Poa annua
Poa palustris
Poa pratensis agg.
Poa trivialis
Polygonum aviculare agg.
Potentilla anserina
Potentilla reptans
Prunella vulgaris
Ranunculus acris
Ranunculus auricomus agg.
Ranunculus repens
Rhamnus cathartica
Rorippa austriaca
Rosa canina
Rubus caesius
Rumex acetosa
Rumex crispus
Rumex sanguineus
Salix cinerea
Salvia pratensis
Sanguisorba officinalis
Scutellaria hastifolia

Serratula tinctoria
Silaum silaus
Silene vulgaris
Stachys palustris
Stellaria graminea
Stellaria palustris
Symphytum officinale
Tanacetum vulgare
Taraxacum sect. *Taraxacum*
Torilis japonica
Trifolium campestre
Trifolium dubium
Trifolium hybridum
Trifolium pratense
Trifolium repens
Trisetum flavescens
Ulmus minor
Urtica dioica
Valeriana officinalis
Valerianella locusta
Veronica arvensis
Veronica chamaedrys
Veronica scutellata
Veronica serpyllifolia
Vicia angustifolia
Vicia cracca
Vicia dumetorum
Vicia hirsuta
Vicia tetrasperma
Viola elatior
Viola hirta
Viola pumila
Viola stagnina

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11 Dyje-Morava floodplain near Lanžhot

Jiří Danihelka, Vít Grulich & Kateřina Šumberová

Introduction

The roughly triangular area bordered by the Dyje and Morava Rivers just above their confluence is known as *Soutok* in Czech (meaning *Confluence*) or *Thaya-March Zwickel* in German (*Thaya* = *Dyje*, *March* = *Morava*). It is situated in the south-eastern tip of the Czech Republic south of the towns of Břeclav and Lanžhot. The Dyje River forms the border between the Czech Republic and Austria, the Morava River the border between the Czech Republic and Slovakia. From the north, the area is bordered by arable land and the road from Lanžhot to the bridge over the Morava River. The floodplain forests and meadows here extend over an area of approximately 50 km^2. The area is closed to cars, but it can be visited by bicycle, which is particularly convenient to reach its remote southern parts.

Flooded continental meadows in the Dyje-Morava floodplain near Lanžhot. Photo M. Chytrý.

Geology, geomorphology, soils, climate and hydrology

The broad Dyje-Morava floodplain is situated at an altitude of 148–153 m. It is formed of Quaternary fluvial deposits including loam, sand and gravel. The floodplain is generally flat, and the only topographic features rising above the surrounding landscape are sandy elevations that do not exceed a height of a few meters. These elevations are known as *hrúd* in the local Czech dialect or *Parzen* in the dialect of Austrian villages on the opposite bank of the Dyje River. They most likely represent eolian deposits. These deposits cover a more extensive area, but apart from the *hrúd*s they are buried under a thick layer of Holocene alluvial loams, mostly deposited since the Middle Ages following deforestation of the upper parts of the catchment areas. The *hrúds* are fairly common along the Dyje River, whereas only a few can be found along the Morava River. The reason for this is the presence of different rocks in the catchment areas of the two rivers and their tributaries. The Dyje drains a geologically variable area and its alluvial deposits are far from uniform, containing a high proportion of sand. In contrast, the catchment area of the Morava is mainly in the area of Carpathian flysch and

Carboniferous sediments in central and northern Moravia which results in the uniformity of its alluvial deposits. Oxbows and pools in various stages of in-filling are characteristic elements of the floodplain. There are also man-made features here such as canals, ditches and abandoned sand and loam pits filled with water.

The soils are relatively uniform. Fluvisols and gleysols prevail in the flooded areas and cambisols and arenosols are found on the sandy elevations.

The area is situated in the warmest part of the Czech Republic. Its climate is subcontinental, summer-warm and dry. The mean annual temperatures are 9–10 °C. The mean temperature in the growing season (April–September) is 16–17 °C. The warmest and coldest months are July and January with mean temperatures of 19–20 °C and –1 to –2 °C, respectively. The annual precipitation sums are 500–550 mm, of which 300–325 mm falls in the growing season. Monthly precipitation sums vary considerably, and long periods of drought are common.

The entire area used to be flooded frequently. Floods regularly occurred in spring when snow melted in the Bohemian-Moravian Highlands and the mountains of eastern and northern Moravia. They could, however, also be caused by heavy rains in the catchment area of both rivers at any time of the year. Since the construction of the Nové Mlýny reservoirs on the Dyje River upstream of the town of Břeclav during the 1970s and 1980s and the construction of dikes along both rivers, flooding was almost eliminated, and the area is flooded only during long-lasting and extremely heavy rain events, such that seen in July 1997. All these interventions in the water regime have also resulted in a considerable drop in the ground water level.

Large individuals of Quercus robur in the Dyje-Morava floodplain are remnants of former pasture woodlands. In the current dense forests, the old generation of oak is being replaced by Fraxinus angustifolia, Tilia cordata, Carpinus betulus and Acer campestre. Photo M. Chytrý.

Archaeological sites

An important Early Medieval archaeological site is situated on the northern edge of the *Soutok* area, about 3.3 km SSE of Břeclav. Remnants of ramparts, once surrounding a fortified settlement, are clearly visible in this place, referred to as *Pohansko* (meaning *Pagan's Place*). Numerous archaeological finds, combined with written sources, suggest that the settlement was one of the major centres of Great Moravia, an early medieval state formed by the western Slavic tribes in the 830s. This dukedom encompassed large parts of the present territory of Moravia, Bohemia and Slovakia and a number of adjacent areas in the late 9th century. It collapsed at the turn of the 10th century after being invaded by the Hungarians. The ruling class accepted Christianity from Constantinople based on political consideration. The Byzantine missionaries Saints Cyril and Methodius, who arrived in 863, introduced the Church Slavonic language based on the contemporary South Slavic dialect from the Thessalonica area in northern Greece. Cyril also created the Glagolitic alphabet (*Glagolitsa*) which was later replaced by the Cyrillic script among the orthodox eastern and southern Slavs.

Remnants of two churches and many other structures from the Great Moravian period have been excavated in *Pohansko*. The foundation of some of these structures can be seen. The *Pohansko* hunting manor, built in 1812 or somewhat later in the Empire style for the Liechtenstein family, holds an archaeological exhibition. The *Pohansko* site is now a part of the Lednice-Valtice Cultural Landscape, a UNESCO World Heritage Site.

History of botanical research

Despite its remarkable flora and vegetation, the Dyje-Morava floodplain south of Břeclav and Lanžhot was largely ignored by 19th-century botanists. The reason for this may have been its remote location and bureaucratic difficulties as the area was used by the Liechtenstein family as a hunting ground. The first botanist ever to visit this area was probably Franz Petrak, later a mycologist at the Natural History Museum in Vienna, in June 1912. He issued specimens of *Iris spuria* and *Plantago altissima* collected on this occasion in his exsiccate collection *Flora Bohemiae & Moraviae exsiccata*. Both species, whose natural occurrence in the Czech Lands was restricted to this part of the country, have not been seen here for almost a century.

The area was soon closed to ordinary citizens after the Communists seized power in Czechoslovakia in 1948, and any botanical research became almost impossible. Some forestry research was, however, performed, which recorded some plant species new to the country's flora, such as the sub-Mediterranean *Fraxinus angustifolia* (Samek 1956) and *Carex strigosa* (Horák & Dvořák 1968). In 1973, Eduard Průša made a detailed forestry survey of the old-growth forest reserves *Ranšpurk* and *Cahnov-Soutok* which was published a decade later (Průša 1985). Vít Grulich, then botanist at the Mikulov District Museum, visited the area several times during the 1980s. His visits yielded remarkable plant records, such as the montane species *Veronica montana* (Grulich 1985). The meadow plots studied in the 1960s as part of the International Biological Programme (IBP; Balátová-Tuláčková 1966, 1968, 1970), now destroyed by ploughing, were situated between the southern edge of the town of *Lanžhot* and the northern border of the *Soutok* area; the ecological findings reported here nevertheless remain relevant to the meadows described below.

A period of intense botanical research began in 1990 after the collapse of the Communist regime when the area was opened to the public. A grid mapping of the flora was launched in 1992 (Danihelka et al. 1995; Danihelka 2003; Danihelka & Šumberová 2004). The area was also visited by the Summer School of Field Botany organized by the Czech Botanical Society in Břeclav in 1995 (Danihelka & Grulich 1996). A detailed survey of flora and vegetation was led by Professor Jiří Vicherek of Masaryk University in Brno in 1996–1998. Studies were published on the flora and vegetation of wetlands (Šumberová 1999), tall-forb vegetation (Šumberová 1997) and dry grasslands on sandy elevations (Chytrý et al. 1997). The findings of Professor Vicherek's team were summarized in a botanical monograph of the area (Vicherek et al. 2000). The occurrence of *Urtica kioviensis*, species missing from the Czech flora at that time, was reported from here by Danihelka & Lepší (2004).

The old-growth reserves *Ranšpurk* and *Cahnov-Soutok* were re-surveyed by the team of Tomáš Vrška in 1994–1995. A comparison with the data collected by E. Průša in the early 1970s made it possible to evaluate the dynamics of these forests after the implementation of water management measures and under strong grazing pressure from ungulates in a game preserve (Vrška 1997, 1998; Vrška et al. 2006). Complete lists of plant species of all forest compartments were made by researchers based at Mendel University in Brno (Řepka et al. 2015).

An almanac focusing on the natural history of the Dyje-Morava floodplain, its economic use, forest management and archaeology was published by Hrib & Kordiovský (2004). The natural history and economic use of the Dyje and Morava floodplain in the adjacent part of Lower Austria are described in the excellent monograph *Fließende Grenzen* (Kelemen & Oberleitner 1999).

Vegetation and historical development of the floodplain

Forests cover about 4200 ha, i.e. 84% of the area. Hardwood floodplain forest of the association *Fraxino pannonicae-Ulmetum* (alliance *Alnion incanae*) is the most widespread. Sandy or loamy elevations in the floodplain, which are flooded only rarely and for short periods of time, are covered by oak-hornbeam forests (alliance *Carpinion betuli*). Softwood floodplain forests of the association *Salicetum albae* (alliance *Salicion albae*) are developed only in small patches in wet depressions or immediately flanking the rivers.

Aquatic vegetation is a remarkable feature of the southern Moravian floodplains. Communities of the alliances *Lemnion minoris*, *Hydrocharition morsus-ranae*, *Potamion*, *Nymphaeion albae* and *Ranunculion aquatilis* are found in still and slow running water. Most water bodies are surrounded by reed vegetation, mainly stands of *Glyceria maxima* (association *Glycerietum maximae*, alliance *Phragmition australis*), and by tall-forb vegetation of the alliance *Eleocharito palustris-Sagittarion sagittifoliae*. Communities of short amphibious plants develop in places where the water table drops down to expose the water-saturated bottom for a considerable part of the growing season. A community dominated by the perennial *Eleocharis acicularis* (association *Limosello aquaticae-Eleocharitetum acicularis*, alliance *Eleocharition acicularis*) and annual vegetation with *Limosella aquatica* (association *Cyperetum micheliani*, alliance *Eleocharition ovatae*) have been recorded in a few places, the latter mainly in man-made habitats such as the beds of sand pits and channels. Communities of annual and short-lived thermophilous wetland species such as *Cerastium dubium*, *Lythrum hyssopifolia*, *Mentha pulegium*, *Pulicaria vulgaris* and *Veronica anagalloides* (alliance *Verbenion supinae*) are of particular interest. Nitrophilous vegetation of the association *Polygono brittingeri-Chenopodietum rubri* and stands of *Bidens frondosus* (both of the alliance *Bidention tripartitae*) are common on bare wet soils in natural habitats such as pools, oxbows and river banks.

Tall-sedge beds of the alliance *Magno-Caricion gracilis*, river-fringing herbaceous vegetation of the alliance *Senecionion fluviatilis*, and wet to mesic meadows of the alliances *Deschampsion cespitosae*, *Molinion caeruleae* and *Arrhenatherion elatioris* are the most common of the many types of marsh and wetland vegetation. Continental alluvial meadows of the alliance *Deschampsion cespitosae* are the most widespread, whereas the *Molinion* and *Arrhenatherion* meadows have a limited distribution on the lower parts of the sandy elevations (*hrúd*s) and in marginal parts of the floodplain which are only rarely flooded (Balátová-Tuláčková 1966, 1968, 1993).

Dry grasslands of the association *Potentillo heptaphyllae-Festucetum rupicolae* (alliance *Koelerio-Phleion phleoidis*) growing on higher sandy elevations are remarkable vegetation of the floodplain (Chytrý et al. 1997). The occurrence of dry-grassland species in the floodplain seems to be partly of a relict nature. Archaeological finds show that the floodplain was not completely flat until the 9th century. Sand dunes and higher river terraces were still preserved at that time and supported drought-adapted vegetation. Palaeobotanical studies (Opravil 1983, 1992, 2000; Opravil in Hrib & Kordiovský 2004: 105–112) also indicate that hardwood floodplain forests prevailed at that time, whereas sand dunes and river terraces were covered by oak-hornbeam forests (*Carpinion betuli*). No dry grasssland species could, however, have survived in the oak-hornbeam forests. A plausible explanation for the current occurrence of many dry grassland species is that the forest canopy was generally sparser than today, including patches of open thermophilous oak forests and canopy openings in the matrix of hardwood floodplain forests and oak-hornbeam forests. It may also be assumed that there was already some grazing of livestock from settlements situated in today's floodplain and nearby at that time (Dvořák & Klanicová in Hrib & Kordiovský 2004: 497–513).

Large deforested areas must have existed in the floodplain in the Great Moravia period (9th century), which were used to a large extent for the cultivation of cereals and pastoralism (Doláková et al. 2010). Archaeological finds have provided evidence that *Cornus mas*, *Ligustrum vulgare*, *Prunus fruticosa* and *P. spinosa* grew in the vicinity of the fortified *Pohansko* settlement. This is in agreement with the finding of remains of *Otis tarda* (Opravil 1992), which is a bird confined to the open landscape. It may be assumed that dry grasslands similar to those of today occurred in some places in the area. The water table was relatively stable throughout the year, while floods were rather rare and less intense than they are now. In the 11th and 12th centuries, however, people colonized and deforested the upper parts of the Dyje and Morava catchment areas, mainly in the Bohemian-Moravian Highlands and eastern Moravia, which dramatically altered the hydrological regime of the lowland rivers. Floods became more frequent and even occurred several times a year, and the amount of material transported from the areas upstream increased. The original rugged terrain of the floodplain was filled in with several metres of alluvial loam (Opravil 1983). This enabled softwood and hardwood forest to spread at the expense of oak-hornbeam and thermophilous oak forests. Dry grasslands were preserved only on the tops of the highest *hrúd*s which were only exceptionally or never flooded. However, modern forestry considerably reduced the area of softwood forests with *Salix alba*.

Flora

The flora of the Dyje-Morava floodplain includes about 873 species with various distribution ranges (Vicherek et al. 2000). The occurrence of species with continental ranges extending to southern Siberia and the occurrence of Pontic-Pannonian species is of particular interest as several species in these groups reach their north-western distribution limits in southern Moravia. The first group mentioned is represented by *Cnidium dubium*, *Scutellaria hastifolia* (both at their western distribution limit), *Allium angulosum* and *Juncus atratus* in wet meadows, as well as *Astragalus danicus*, *Phelipanche arenaria*, *Scorzonera purpurea*, *Veronica prostrata* and *Thymus pannonicus* in dry places on sandy elevations. The group of Pontic-Pannonian species includes *Carex buekii*, *Leucojum aestivum* and *Thalictrum lucidum* in wetlands, as well as *Achillea setacea*, *Erysimum diffusum*, *Hierochloë repens*, *Linaria genistifolia*, *Ranunculus illyricus* and *Verbascum phoeniceum* in dry places on the sandy elevations, as well as the epiphytic hemiparasite *Loranthus europaeus*. The sub-Atlantic distribution type is represented by a few species which are, however, rather conspicuous in the vegetation, for example *Carex strigosa* and *Silaum silaus* in forests and wet meadows and *Armeria elongata*, *Corynephorus canescens* (now probably vanished), *Hypochaeris radicata* and *Jasione montana* in dry sandy places.

The occurrence of *Corydalis pumila*, *Galanthus nivalis*, *Galium odoratum*, *Isopyrum thalictroides*, *Polygonatum multiflorum*, *Primula veris* and *Viola mirabilis* in the oak-hornbeam forests on sandy elevations is remarkable from the viewpoint of plant geography and vegetation history. Their presence may be considered as relict of the pre-flood period as they are also present in the forests of the hilly landscape adjacent to the Dyje floodplain. Some other species confined to this type of forests, e.g. *Allium ursinum*, *Dentaria bulbifera*, *Maianthemum bifolium*, *Senecio ovatus*, *Symphytum tuberosum* and *Veronica montana*, are absent from or very rare in the adjacent hilly landscape. These species may have been brought to this area by the river from the flysch fringes of the Carpathians where they are quite common.

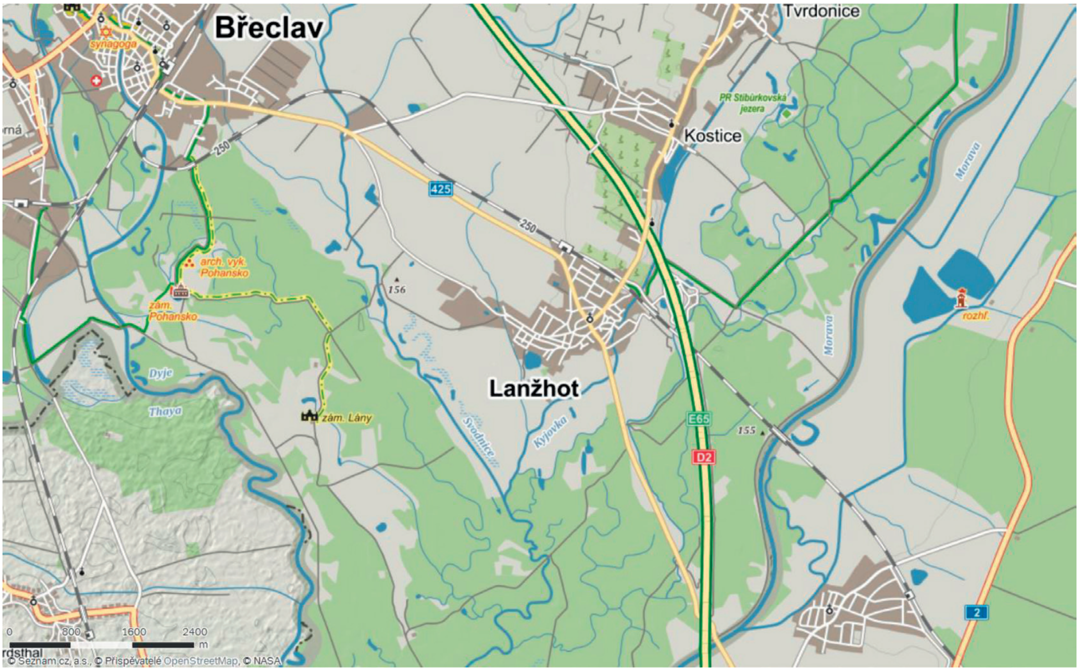
Management of forests and meadows

In the Middle Ages, most of the forests were managed as coppice with a short rotation time, probably 7–10 years. Cattle grazing was also common, opening up canopy and creating park-like wood pastures with groups of trees and shrubs and solitary oaks. Though the law issued in the 1750s banned livestock grazing in forests, its application was slow and grazing was common in the area even a century later. However, the Liechtenstein family, which owned most of the forest in the area, managed to stop this practice in 1873 with a court ruling (Vrška 1997). Wood pastures were then afforested, though some more than 200-year-old oaks may still be seen in a few places, including two nature reserves with old-growth forests. After the mid-19th century, most forests were established by planting or sowing which required some degree of soil cultivation. Such forest compartments were leased to local peasants for a few years for the cultivation of maize, potatoes or sugar beet, which protected young trees from competition from tall-growing nitrophilous vegetation.

The cultivation of soil using heavy machinery was introduced in the area from the late 1950s onwards. Wet depressions were filled-in with soil and stumps pulled up by bulldozers. The whole clearing was then ploughed. Crushers were introduced in the late 1990s to prepare clearings for planting young trees. Even afterwards, the soil was sometimes cultivated as deep as 40 cm under the surface. This type of management has a negative impact on both flora and fauna, most apparently on the spread of alien herb species (Čížek et al. 2007).

The area was used for hunting by the Liechtenstein family, the owners of the estate until 1945. Already then, there was some fence to prevent damage on crops in the arable land adjacent to the area. The game preserve called *Soutok* with red deer (*Cervus elaphus*) and fallow deer (*Dama dama*) was established in the late 1960s. The area was fenced and used as hunting ground for high-ranking Communists and other members of the establishment. Game numbers were enormous in the 1980s and reached a maximum in 1989, though no reliable numbers are available. The game eliminated the natural regeneration of forests. The number of animals was considerably reduced after 1989, though the game preserve is still there and the damaging influence of large herbivores on natural regeneration is still evident.

The area also harbours about 800 ha of floodplain meadows. Most of these were part of the Liechtenstein estate, though some were owned and used by peasants from Lanžhot or the villages of Bernhardsthal, Rabensburg and Hohenau in the nearby part of Lower Austria. They were mown for hay in late spring and mown again or grazed in summer by both cattle and sheep. The low-productive grasslands on sandy elevations may have been used merely as pastures. After 1948, the meadows were managed by various cooperative farms and by the state-owned forest enterprise. Some meadows were damaged by ploughing, the application of fertilizers or the sowing of mixtures of forage species, though most recovered under stable management. Livestock decreased markedly after 1989 and so did demand for hay. Since 1996, all the meadows in the area have been managed by the state-owned forest enterprise. While some meadows are well managed, other compartments have been damaged by unsuitable management such as mulching or changes in water regime or completely abandoned and afforested.



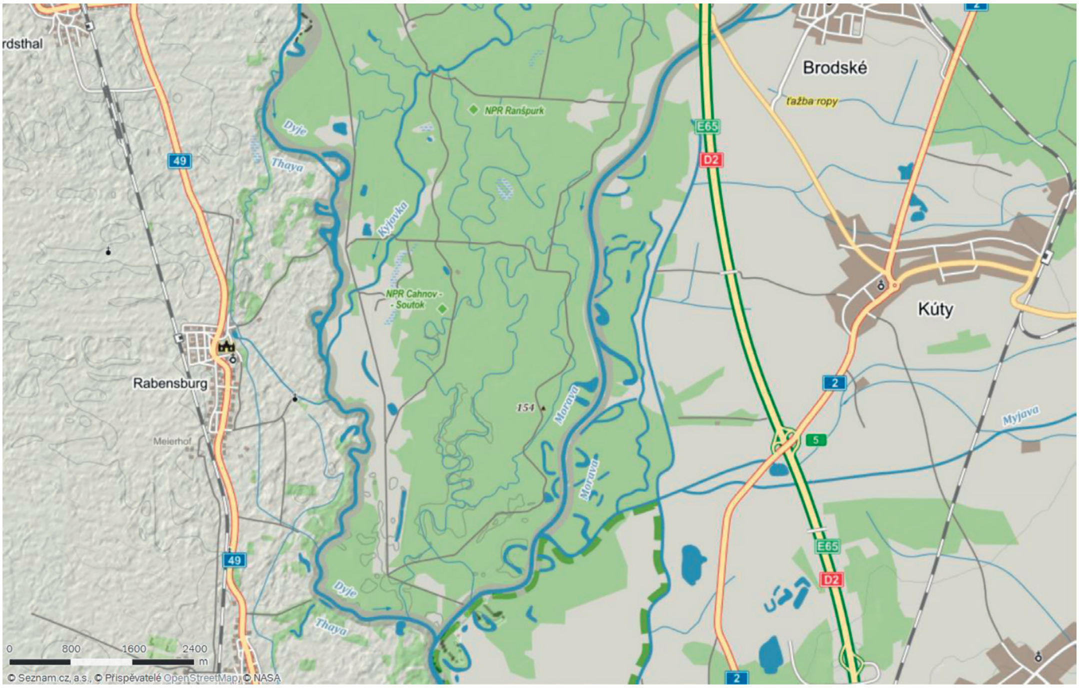
The Dyje-Morava floodplain near Lanžhot (northern part).

Nature conservation

Two National Nature Reserves, *Ranšpurk* and *Cahnov-Soutok*, were established in the area in 1949 to protect remnants of old-growth forests. Both names are derived from the names of villages on the right bank of the Dyje River in Lower Austria, the former being the Czech name for Rabensburg, the latter for Hohenau an der March (in Czech *Cáhnov*, from the medieval *z'Hohenouwe*).

Both reserves protect parts of the hardwood forest taken out of economic use in the early 1930s. There has been no logging in either reserve since that time, though they have been affected by changes in water regime caused by river regulation and ungulate grazing which has eliminated natural regeneration. The *Ranšpurk* reserve was fenced in 1992, opening the way to massive natural regeneration of most woody species with the exception of *Quercus robur* (Vrška et al. 2006). Both reserves are important sites to study the natural dynamics of lowland forests. This zero-management regime (with only the elimination of alien woody species) is nevertheless known to reduce biodiversity, for which reason it is desirable to combine it with the reintroduction of coppicing with standards in other places.

The whole *Soutok* area is part of the Site of Community Importance (SCI) *Soutok-Podluží* within the Natura 2000 network which was established to protect large areas of alluvial forests and alluvial meadows. In spite of this, there are only two nature reserves covering less than 1% of the area. The area has been part of the Lower Morava Biosphere Reserve since 2003, but this does not imply any legal protection under Czech law. Repeated proposals have been made for making the whole area part of a Protected Landscape Area. Unfortunately, this plan has been opposed primarily by the Židlochovice State Forest Enterprise and the current staff of the Lower Morava Biosphere Reserve.



The Dyje-Morava floodplain near Lanžhot (southern part).

Appendix 11 Selected species of vascular plants in the Dyje-Morava floodplain at *Soutok*. See Vicherek et al. (2000) for a complete list including example maps illustrating local distribution patterns.

Achillea setacea
Ajuga genevensis
Alcea biennis
Alisma lanceolatum
Alisma plantago-aquatica
Allium angulosum
Allium ursinum
Amaranthus albus (neo)
Arabis nemorensis
Armeria elongata subsp. *elongata*
Artemisia campestris
Asperula cynanchica
Avenula pubescens
Batrachium aquatile
Batrachium baudotii
Batrachium circinatum
Batrachium trichophyllum
Biscutella laevigata subsp. *varia*
Brachypodium pinnatum
Brassica nigra (neo)
Bromus benekenii
Bromus erectus
Butomus umbellatus
Callitriche cophocarpa
Callitriche palustris
Callitriche hamulata
Caltha palustris
Campanula bononiensis
Cardamine parviflora
Carex acutiformis
Carex buekii
Carex caryophyllea
Carex divulsa
Carex fritschii
Carex hartmanii
Carex melanostachya
Carex pallescens
Carex praecox
Carex stenophylla
Carex strigosa
Carex supina
Carex tomentosa
Centaurium pulchellum
Cerastium brachypetalum
Cerastium dubium
Cerastium glutinosum
Cerastium lucorum
Cerastium semidecandrum
Cerastium tenoreanum
Ceratophyllum submersum
Chamaecytisus ratisbonensis
Chenopodium urbicum
Cirsium canum
Clematis integrifolia
Cnidium dubium
Corynephorus canescens
Cruciata pedemontana
Crypsis schoenoides
Cuscuta lupuliformis
Cyperus fuscus
Cyperus michelianus
Dianthus pontederae
Dipsacus pilosus

Draba nemorosa
Dysphania pumilio (neo)
Echinocystis lobata (neo)
Eleocharis acicularis
Eleocharis palustris
Eleocharis uniglumis
Epipactis albensis
Epipactis helleborine
Eryngium campestre
Erysimum diffusum
Euphorbia lucida
Euphorbia palustris
Festuca rupicola
Festuca valesiaca
Filago vulgaris
Filipendula ulmaria
Fraxinus angustifolia subsp. *danubialis*
Gagea minima
Gagea pratensis
Gagea pusilla
Galium odoratum
Galium rivale
Gentiana pneumonanthe
Geranium sanguineum
Glyceria fluitans
Glyceria maxima
Gnaphalium uliginosum
Gratiola officinalis
Helictochloa pratensis
Hesperis sylvestris
Hieracium umbellatum
Hierochloë repens
Hottonia palustris
Hydrocharis morsus-ranae
Hypochaeris radicata
Inula salicina
Iris sibirica
Iris spuria (vanished)
Iris variegata
Isopyrum thalictroides
Juncus atratus
Juncus bufonius
Koeleria macrantha
Lathyrus palustris
Leucojum aestivum
Limosella aquatica
Linaria genistifolia
Lindernia procumbens
Listera ovata
Loranthus europaeus
Lotus tenuis
Luzula campestris
Luzula divulgata
Maianthemum bifolium
Malus sylvestris
Melica transsilvanica
Mentha pulegium
Molinia arundinacea
Muscari comosum
Myosotis sparsiflora
Myriophyllum spicatum
Najas marina
Najas minor
Nuphar lutea
Oenanthe aquatica
Ononis spinosa
Ophioglossum vulgatum
Orchis morio
Ornithogalum boucheanum
Papaver maculosum
Paris quadrifolia
Peplis portula
Petrorhagia prolifera
Peucedanum cervaria
Peucedanum oreoselinum
Phelipanche arenaria
Pilosella officinarum
Plantago altissima (vanished)
Plantago uliginosa
Poa bulbosa
Populus nigra
Potamogeton acutifolius
Potamogeton lucens
Potamogeton nodosus
Potamogeton pusillus
Potamogeton trichoides
Potentilla argentea
Potentilla erecta
Potentilla incana
Potentilla recta
Potentilla supina
Primula veris
Pulicaria dysenterica
Pulicaria vulgaris
Pyrus pyraster
Quercus robur
Ranunculus bulbosus
Ranunculus flammula
Ranunculus illyricus
Ranunculus polyanthemos
Rhinanthus minor
Rubus bifrons
Rubus clusii
Rumex acetosella
Rumex conglomeratus
Rumex hydrolapathum
Rumex maritimus
Rumex sanguineus
Rumex stenophyllus
Sagittaria sagittifolia
Saxifraga bulbifera
Scirpoides holoschoenus
Scutellaria galericulata
Scutellaria hastifolia
Sedum acre
Sedum sexangulare
Senecio jacobaea
Senecio ovatus
Senecio sarracenicus
Serratula tinctoria
Seseli annuum
Silaum silaus
Silene nutans
Silene otites
Sparganium emersum
Sparganium erectum
Stellaria nemorum
Stellaria palustris
Stipa borysthenica
Succisa pratensis
Symphyotrichum lanceolatum (neo)
Symphytum tuberosum
Teucrium chamaedrys
Teucrium scordium
Thalictrum flavum
Thalictrum lucidum
Thymus pannonicus
Trapa natans
Trifolium fragiferum
Trifolium medium
Trifolium ochroleucon
Turritis glabra
Urtica kioviensis
Utricularia australis
Valeriana officinalis
Verbascum blattaria
Verbascum chaixii subsp. *austriacum*
Verbascum lychnitis
Verbascum phoeniceum
Veronica anagallis-aquatica
Veronica anagalloides
Veronica catenata
Veronica maritima
Veronica montana
Veronica prostrata
Veronica scutellata
Veronica spicata
Veronica vindobonensis
Viola canina
Viola elatior
Viola hirta
Viola pumila
Viola stagnina
Viola tricolor subsp. *curtisii*
Viscaria vulgaris
Wolffia arrhiza

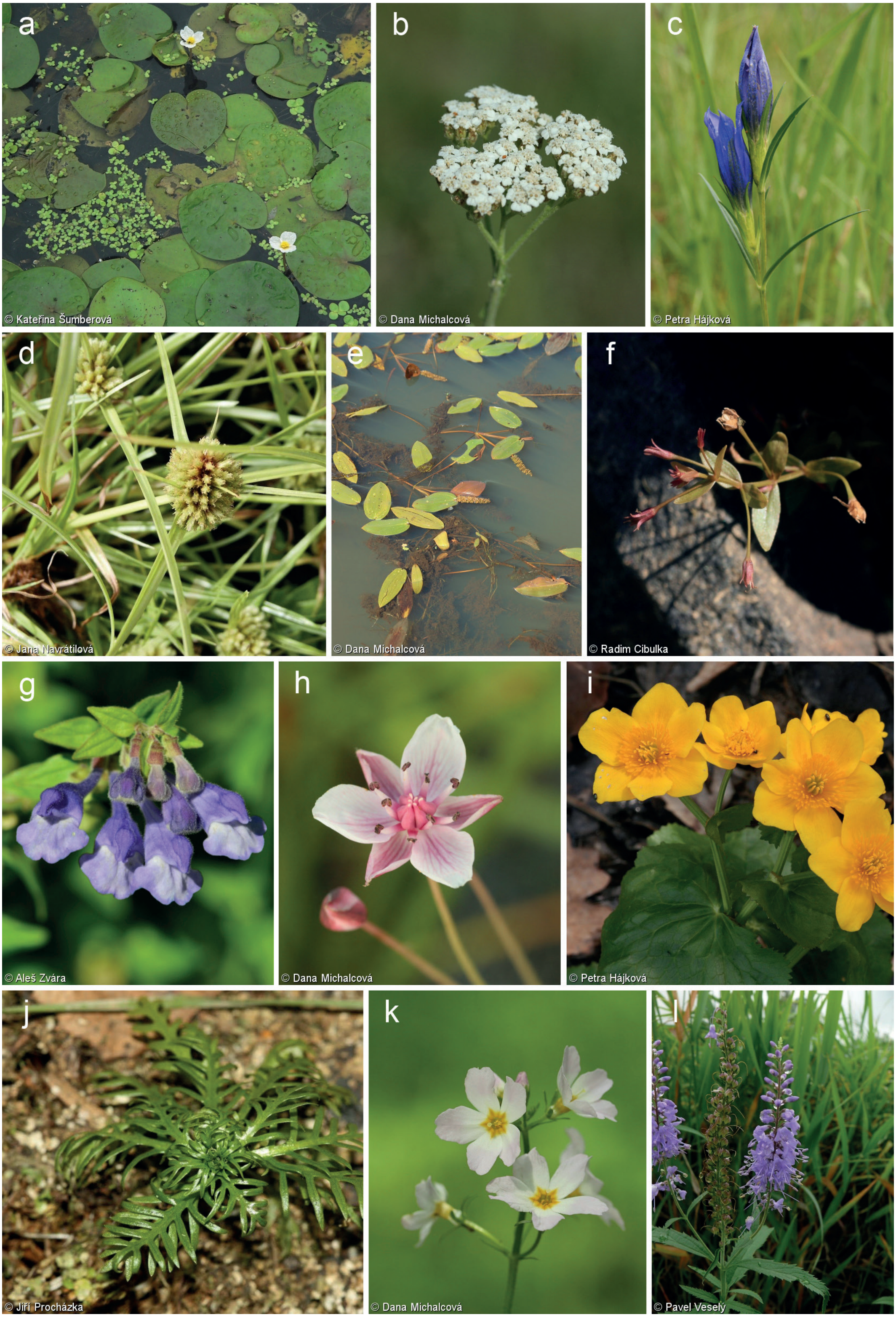


Plate 11 Plants of the Dyje-Morava floodplain near Lanžhot: (a) *Hydrocharis morsus-ranae*, (b) *Achillea setacea*, (c) *Gentiana pneumonanthe*, (d) *Cyperus michelianus*, (e) *Potamogeton nodosus*, (f) *Lindernia procumbens*, (g) *Scutellaria hastifolia*, (h) *Butomus umbellatus*, (i) *Caltha palustris*, (j–k) *Hottonia palustris*, (l) *Veronica maritima*.

Hardwood floodplain forests in the Dyje-Morava floodplain are rich in spring geophytes such as Corydalis cava and Anemone ranunculoides. Photo M. Chytrý.

The Pohansko hunting manor is one of the remarkable buildings in the cultural landscape of the Liechtenstein estate. Photo M. Chytrý.

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12 *Špidláky* Nature Reserve

Pavel Novák & Jan Roleček

Introduction

The *Špidláky* Nature Reserve is situated between the villages of Čejč and Čejkovice in southern Moravia about 40 km SE of Brno. It protects remnants of species-rich dry grassland preserved on steep slopes known locally as *špidláky* and one of the few globally known populations of the Pannonian steppe endemic *Artemisia pancicii*. The reserve consists of five grassland areas in the intensively-used agricultural landscape at altitudes of 190–240 m covering a total of 21 ha.

Late vernal aspect of semi-dry grasslands of the association Polygalo majoris-Brachypodietum pinnati at the Špidláky Nature Reserve. The blue inflorescences are Salvia pratensis. Photo M. Chytrý.

Geology, soils and climate

The prevailing bedrock is the Neogene calcareous powder sand of the Vienna Basin deposited over the Palaeogene flysch sediments of the Western Carpathians. Sand is covered by Pleistocene loess in places. The dominating soil type is chernozem, with locally-occurring patches of luvisols and leptosols. The area is part of the Pannonian biogeographical province with a relatively continental climate, and is among the warmest and driest places in the Czech Republic: the mean annual temperature exceeds 9 °C and annual precipitation sum is about 530 mm.

History of botanical research

The surroundings of Čejč attracted the attention of botanists since the very beginning of the research into the Moravian flora. The earliest report is that by Hochstetter (1825), who explored the area before Čejč Lake (see below) and nearby Kobylí Lake were drained. He noted both the presence of *Crambe tataria*, *Gypsophila paniculata* and *Potentilla patula* in dry grasslands on the slopes, and *Carex distans* and *Scorzonera parviflora* in the saline habitats on the lake shores. Further descriptions were provided by Bayer (1853) and Wiesner (1854). Bubela (1882), visiting the area 30 years later, found both lakes already drained but the halophilous flora was still present.

Vegetation

The vegetation includes dry grasslands on steep sunny slopes classified as the alliance *Festucion valesiacae*. They are dominated by narrow-leaved tussocky graminoids, e.g. *Festuca rupicola*, *F. valesiaca*, *Carex humilis* and three *Stipa* species. Herbs include thermophilous drought-tolerant species such as *Artemisia campestris*, *Asperula cynanchica*, *Astragalus austriacus*, *Dorycnium germanicum* and *Iris pumila*. Competitively weak steppe species, e.g. *Astragalus exscapus*, *Inula oculus-christi* and *Taraxacum serotinum*, appear in disturbed patches (former rabbit colonies, landslides, field borders; Danihelka & Grulich 2000).

Broad-leaved semi-dry grasslands of the alliance *Cirsio-Brachypodion pinnati* occur on deeper soils and north-facing slopes. They are mostly dominated by *Brachypodium pinnatum* and are rich in herbs such as *Cirsium pannonicum*, *Echium maculatum*, *Polygala major*, *Prunella grandiflora*, *Thesium linophyllon* and *Salvia pratensis*. Such stands are classified as the association *Polygalo majoris-Brachypodietum pinnati*. Small patches with more humid soils are covered by extensively mown meadows of the association *Brachypodio pinnati-Molinietum arundinaceae*. Their species composition includes herbs of mesic, base-rich, though nutrient-poor sites (e.g. *Astragalus danicus*, *Crepis praemorsa*, *Filipendula vulgaris*, *Potentilla alba* and *Primula veris*) and graminoids such as *Bromus erectus*, *Carex montana* and *Koeleria pyramidata*. The community lacks strong dominants and is extremely rich in species. It also contains populations of rare light-demanding species such as *Daphne cneorum* and *Klasea lycopifolia* and some orchids such as *Gymnadenia conopsea* and *Orchis ustulata* (Vicherek & Unar 1971; Ambrozek 1989). It is close in species composition to the famous extremely species-rich grasslands in the White Carpathian Mountains.

Scrub with a species-poor herb layer (alliance *Berberidion vulgaris*) is common in the reserve. Thermophilous herbaceous fringes (alliance *Geranion sanguinei*) occur in places, often dominated by *Geranium sanguineum* or *Peucedanum cervaria*. Weed communities of the alliance *Caucalidion* with thermophilous and basiphilous annual species such as *Nigella arvensis* and *Silene noctiflora* develop along the borderline between dry grasslands and cereal fields in some years.

Flora

The flora of the reserve consists of about 260 species of vascular plants and its composition is typical of the dry grasslands of the north-western part of the Pannonian phytogeographical province. A small population of the Pannonian endemic *Artemisia pancicii* is the most valuable in this respect. This species has only three extant populations in the Czech Republic, though a few populations are also known in eastern Austria and northern Serbia (Danihelka 1995; Danihelka & Marhold 2003). It belongs to a group of taxa closely related to *Artemisia laciniata*. Species from this group are broadly distributed in continental parts of Eurasia but have small isolated populations in the west, sometimes described as local endemics (*A. oelandica* in southern Sweden, *A. insipida* in south-eastern France), sometimes considered conspecific with eastern Eurasian populations (*A. armeniaca* in eastern Spain). These isolated populations are probably relics of the Pleistocene and early Holocene forest-steppe vegetation (Ehrendorfer 1964).

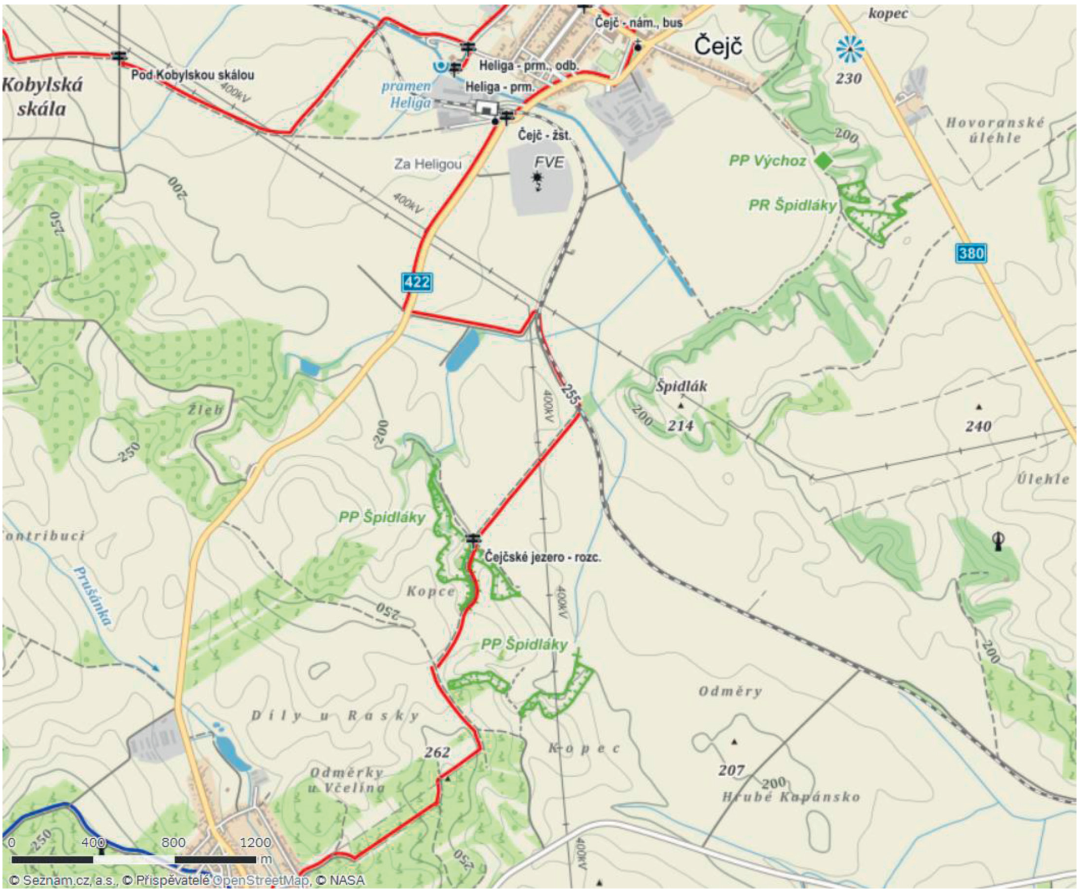
Other characteristic species include drought-tolerant to mesophilous continental elements such as *Astragalus exscapus*, *Carex supina*, *Echium maculatum*, *Galium boreale* subsp. *exoletum*, *Hypericum elegans*, *Iris pumila*, *Klasea lycopifolia*, *Oxytropis pilosa*, *Phlomis tuberosa* and *Viola ambigua*, and (sub-continental) sub-Mediterranean elements such as *Lotus borbasii* and *Seseli pallasii*. Some of these species reach their north-western distribution limit in southern Moravia.

The steppe has various colourful seasonal aspects. The vernal aspect is characterized by *Adonis vernalis*, *Gagea transversalis*, *Iris pumila* and *Pulsatilla grandis*, the late vernal aspect by *Crambe tataria*, *Euphorbia epithymoides* and *Salvia pratensis*. In summer, several yellow-flowering species of *Inula* and *Eryngium campestre* come into bloom. The late summer aspect is distinctive for two *Asteraceae* species, *Aster amellus* and *Galatella linosyris*.

Čejč Lake

The Čejč Lake (*Čejčské jezero*) once existed in the depression between the north-eastern and south-western parts of the reserve. This was a shallow brackish lake of about 1 km^2, one of the largest in the Czech Republic (which is poor in natural lakes) and one of the westernmost steppic lakes in Eurasia. It originated in the Pleistocene and completely vanished after draining around 1860.

The Čejč Lake hosted well-developed halophytic vegetation with succulent therophytes such as *Salicornia prostrata* (association *Salicornietum prostratae*, alliance *Salicornion prostratae*) and low-growing annual grasslands with *Crypsis aculeata* (association *Crypsietum aculeatae*, alliance *Cypero-Spergularion salinae*). Many halophilous species (e.g. *Crypsis aculeata*, *Glaux maritima*, *Plantago maritima* and *Tripolium pannonicum*) survived drainage, but disappeared in the following decades due to cultivation of the area (Vicherek 1973; Grulich 1987). The brackish lake surrounded by slopes with species-rich dry grasslands used to be an excellent piece of archaic forest-steppe landscape.



The Špidláky Nature Reserve between the villages Čejč (in the north) and Čejkovice (in the south).

Appendix 12 Selected species of vascular plants of the *Špidláky* Nature Reserve.

Acinos arvensis
Achillea collina
Achillea pannonica
Adonis vernalis
Allium sphaerocephalon
Alyssum alyssoides
Anthericum ramosum
Anthoxanthum odoratum
Anthyllis vulneraria
Arabidopsis thaliana
Arenaria serpyllifolia
Arrhenatherum elatius
Artemisia campestris
Artemisia pancicii
Asparagus officinalis
Asperula cynanchica
Asperula tinctoria
Aster amellus
Astragalus austriacus
Astragalus danicus
Astragalus exscapus
Astragalus onobrychis
Betonica officinalis
Bothriochloa ischaemum

Brachypodium pinnatum
Briza media
Bromus erectus
Bromus inermis
Bromus japonicus
Bupleurum falcatum
Campanula glomerata
Campanula moravica
Campanula sibirica
Carduus nutans
Carex caryophyllea
Carex humilis
Carex michelii
Carex montana
Carex supina
Carlina acaulis
Carlina vulgaris
Centaurea jacea
Centaurea scabiosa
Centaurea stoebe
Cerastium glutinosum
Chamaecytisus austriacus
Chamaecytisus ratisbonensis
Chamaecytisus virescens
Cirsium pannonicum
Conyza canadensis (neo)
Crambe tataria
Crepis praemorsa
Cynoglossum officinale
Dactylis glomerata
Daphne cneorum
Daucus carota
Dianthus pontederae
Dorycnium germanicum
Echium maculatum
Echium vulgare
Elymus hispidus
Erodium cicutarium
Erophila verna
Eryngium campestre
Euphorbia cyparissias
Euphorbia epithymoides
Falcaria vulgaris
Festuca rupicola
Festuca valesiaca
Filipendula vulgaris
Fragaria viridis
Gagea transversalis
Galatella linosyris
Galium boreale subsp. *exoletum*
Galium glaucum
Galium verum
Geranium sanguineum
Gymnadenia conopsea
Gypsophila paniculata
Helictochloa pratensis
Hieracium umbellatum
Hypericum elegans
Hypericum perforatum
Inula ensifolia
Inula germanica
Inula hirta
Inula oculus-christi
Iris pumila
Klasea lycopifolia
Knautia arvensis agg.
Koeleria macrantha
Koeleria pyramidata
Lappula squarrosa
Lathyrus pannonicus subsp. *collinus*
Leontodon hispidus
Lepidium draba
Leucanthemum vulgare
Lilium martagon
Linum catharticum
Lotus borbasii
Lotus corniculatus
Medicago falcata
Medicago minima
Melica transsilvanica
Microthlaspi perfoliatum
Muscari comosum
Muscari tenuiflorum
Nigella arvensis
Nonea pulla
Odontites luteus
Onobrychis arenaria
Ononis spinosa
Onopordum acanthium
Orchis ustulata
Ornithogalum kochii
Ornithogalum umbellatum
Orobanche alba
Oxytropis pilosa
Peucedanum cervaria
Phleum phleoides
Phlomis tuberosa
Phragmites australis
Picris hieracioides
Pilosella densiflora
Pilosella rothiana
Pimpinella saxifraga
Plantago lanceolata
Plantago media
Poa angustifolia
Polygala comosa
Polygala major
Potentilla alba
Potentilla incana
Primula veris
Prunella grandiflora
Pulsatilla grandis
Ranunculus illyricus
Ranunculus polyanthemos
Reseda lutea
Rhinanthus major
Robinia pseudoacacia (neo)
Rosa spinosissima
Rumex acetosa
Salvia nemorosa
Salvia pratensis
Scabiosa canescens
Scabiosa ochroleuca
Scorzonera austriaca
Scorzonera purpurea
Securigera varia
Senecio jacobaea
Serratula tinctoria
Seseli annuum
Seseli hippomarathrum
Seseli pallasii
Silene latifolia subsp. *alba*
Silene nutans
Silene otites
Silene viscosa
Stachys recta
Stellaria graminea
Stipa capillata
Stipa pennata
Stipa pulcherrima
Tanacetum corymbosum
Taraxacum serotinum
Tephroseris integrifolia
Teucrium chamaedrys
Thalictrum minus
Thesium linophyllon
Thymus pannonicus
Tragopogon orientalis
Trifolium alpestre
Trifolium montanum
Trifolium pratense
Trinia glauca
Verbascum phoeniceum
Veronica praecox
Veronica prostrata
Veronica spicata
Veronica triphyllos
Veronica verna
Veronica vindobonensis
Vicia cracca
Vicia tenuifolia
Vincetoxicum hirundinaria
Viola ambigua
Viola arvensis
Viola hirta
Viola rupestris

Plate 12 Plants of the *Špidláky* Nature Reserve: (a) *Salvia pratensis*, (b) *Betonica officinalis*, (c) *Festuca valesiaca*, (d) *Geranium sanguineum*, (e) *Euphorbia epithymoides*, (f) *Echium maculatum*, (g) *Verbascum phoeniceum*, (h) *Astragalus exscapus*, (i) *Adonis vernalis*, (j) *Astragalus onobrychis*, (k) *Astragalus danicus*, (l) *Artemisia pancicii*.

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13 Hodonínská Dúbrava Wood

Jan Roleček

Introduction

Hodonínská Dúbrava (meaning *Oakwood near Hodonín*) is the south-western part of the largest forest complex in the predominantly treeless lowland area of southern Moravia. The forest is situated north of the town of Hodonín near the Czech-Slovak border. It covers a plain above the floodplain of the Morava River at an altitude of about 175 m. The bedrock determines the habitat diversity of the area: thick layers of Tertiary mineral-rich water-holding sediments are overlain by nutrient-poor acidic Pleistocene eolian sand accumulations of variable thickness. The mean annual temperature is about 9.5 °C and the annual precipitation sum is about 550 mm. The site is protected as a National Nature Monument and Site of Community Importance.

Open-canopy old-growth oak forest of the association Carici fritschii-Quercetum roboris in Hodonínská Dúbrava Wood. Signs of former coppicing are visible on trees. Photo J. Roleček.

Vegetation and flora

In the north-eastern part of the wood (called *Bzenecká Dúbrava*), there are layers of eolian sand up to 30 m thick that support drought-tolerant psammophytic vegetation, now mostly replaced by Scots pine (*Pinus sylvestris*) plantations. In contrast, Hodonínská Dúbrava in the south-west has a mildly undulating topography of sandy plains and low dunes with sand layers just a few metres thick. Soil conditions are thereby influenced by the underlying impermeable base-rich sediments that determine a fine-scale mosaic of dry and wet, base-rich and base-poor sites (Novák & Pelíšek 1943). About 150 ha of old-growth subcontinental oakwood has been preserved on dry and mesic sites. This vegetation type is characterized by open canopy dominated by *Quercus robur* or (in some places) *Betula pendula*, with an understorey rich in light-demanding herbs and dominated by *Brachypodium pinnatum*, *Carex fritschii*, *C. michelii*, *Convallaria majalis*, *Festuca ovina* subsp. *guestfalica* and *Molinia arundinacea*. Characteristic species include *Asperula tinctoria*, *Betonica officinalis*, *Geranium sanguineum*, *Iris variegata*, *Laserpitium prutenicum*, *Melampyrum cristatum*, *Potentilla alba*, *Serratula tinctoria* and *Valeriana stolonifera* subsp. *angustifolia*. Populations of some species that are highly endangered in the Czech Republic also occur here, including *Daphne cneorum*, *Drymocallis rupestris*, *Festuca amethystina*, *Gladiolus palustris* and *Thalictrum simplex* subsp. *galioides*. This community can be classified as the association *Carici fritschii-Quercetum roboris* (alliance *Aceri tatarici-Quercion*), which is known only from the north-western edge of the Pannonian Basin, but is close in species composition to some oak forests on sandy substrates in Hungary (Šmarda 1961; Chytrý & Horák 1997; Roleček 2004, 2007). It is one of the species-richest forest communities in the Czech Republic and Hodonínská Dúbrava features the best-preserved and largest remnant of this vegetation type in its distribution range. Relatively species-poor acidophilous oak forests of the alliance *Quercion roboris* occur on base-poor soils; these are enriched by drought-tolerant species such as *Agrostis vinealis*, *Carex ericetorum*, *Verbascum phoeniceum* and *Veronica spicata* in the driest places. The prevailing vegetation includes, however, species-poor plantations of *Quercus robur* and *Pinus sylvestris* and successional closed-canopy stands of *Quercus robur* mixed with *Tilia cordata* or the invasive woody species *Robinia pseudoacacia* and *Prunus serotina*.

Deeper depressions are occupied by marsh vegetation of the alliances *Magno-Caricion elatae* and *Phragmition australis* dominated by tall sedges (*Carex acutiformis*, *C. elata*) or *Phragmites australis* or overgrow with hygrophilous scrub of the alliance *Salicion cinereae* (mostly dominated by *Salix aurita*) or alder carrs of the alliance *Alnion glutinosae* (mostly dominated by *Alnus glutinosa*). Many regionally-rare species of nutrient-poor wetlands occur here including *Carex buxbaumii*, *C. lasiocarpa*, *Hottonia palustris*, *Spiraea salicifolia* and *Utricularia vulgaris*. Shallow depressions may have mineral-poor soils and harbour a wet type of acidophilous oak forest (association *Holco mollis-Quercetum roboris*, alliance *Quercion roboris*) with a herb layer usually dominated by tall grasses, mostly *Molinia arundinacea*, in places also *Calamagrostis canescens* and *Deschampsia cespitosa*.

Waterlogged depressions in Hodonínská Dúbrava Wood are filled in with shallow organic sediments which contain a record of the environmental history of this area. Hottonia palustris is flowering in some depressions in spring. Photo J. Roleček.

Environmental history

The organic infill of wet depressions has enabled palaeoecological reconstruction of the wood history (Jamrichová et al. 2013). The oak has been present since the mid-Holocene; however, it markedly increased in abundance only in the Middle Ages, probably due to its intentional preference as a species of high economic value. Previously, hazel (*Corylus avellana*), alder (*Alnus glutinosa*) and spruce (*Picea abies*) used to be more abundant. Detailed research into the management history (Šmarda 1961; Szabó 2013; Szabó & Hédl 2013) has shown that the wood also used to be influenced by other human activities, particularly wood pasture and haymaking. There was also a short period of coppicing between the 18th and 19th centuries whose legacy can be still recognized in the oldest stands (multi-stemmed trees, swollen or curved trunk bases with the remains of coppice stools). These traditional management practices kept the forest open and enabled the colonization and long-term survival of many rare light-demanding species. However, clear-cutting with intensive site preparation began to be practised in the 1950s, including area-wide soil tillage and stump removal by digging and later bulldozing. This practise was abandoned in the 1990s due to poor oak growth on sandy soils impoverished by topsoil removal. Recently, stumps have been retained in clearcuts and oaks (*Quercus robur*) or pines (*Pinus sylvestris*) planted in stripes tilled by tractor. This modern industrial management caused the retreat of many endangered species and supported the massive spread of some expansive or invasive herbs and grasses such as *Arrhenatherum elatius*, *Calamagrostis epigejos*, *Solidago gigantea* and *Symphyotrichum lanceolatum* (Řepka 2009).

Hodonínská Dúbrava Wood on the north-western edge of the town of Hodonín.

Appendix 13 Selected species of vascular plants in Hodonínská Dúbrava Wood based on the unpublished field records of R. Řepka.

Acer campestre
Aegopodium podagraria
Agrimonia eupatoria
Agrimonia procera
Agrostis canina
Agrostis capillaris
Agrostis vinealis
Achillea collina
Achillea pannonica
Ajuga genevensis
Ajuga reptans
Alliaria petiolata
Allium oleraceum
Allium scorodoprasum
Allium senescens subsp. *montanum*
Allium vineale
Alnus glutinosa
Angelica sylvestris
Anthericum ramosum
Anthoxanthum odoratum
Aquilegia vulgaris
Arabidopsis thaliana
Arabis hirsuta

Arenaria serpyllifolia
Arrhenatherum elatius
Artemisia pontica
Artemisia vulgaris
Asparagus officinalis
Asperula cynanchica
Asperula tinctoria
Astragalus glycyphyllos
Avenula pubescens
Betonica officinalis
Betula pendula
Betula pubescens
Bistorta officinalis
Brachypodium pinnatum
Brachypodium sylvaticum
Briza media
Bromus benekenii
Bromus inermis
Buglossoides purpurocaerulea
Bupleurum falcatum
Calamagrostis canescens
Calamagrostis epigejos
Calluna vulgaris
Campanula cervicaria
Campanula glomerata
Campanula patula
Campanula persicifolia
Campanula rotundifolia agg.
Campanula trachelium
Cardamine impatiens
Cardamine parviflora
Carex acuta
Carex acutiformis
Carex brizoides
Carex buxbaumii
Carex caryophyllea
Carex cespitosa
Carex curvata
Carex disticha
Carex elata
Carex elongata
Carex ericetorum
Carex flacca
Carex fritschii
Carex hartmanii
Carex hirta
Carex humilis
Carex lasiocarpa
Carex leporina
Carex michelii
Carex montana
Carex muricata
Carex nigra
Carex otomana
Carex pallescens
Carex panicea
Carex pilosa
Carex praecox
Carex remota
Carex riparia
Carex spicata
Carex supina
Carex sylvatica
Carex tomentosa
Carex vesicaria
Carex vulpina
Carlina vulgaris
Carpinus betulus
Centaurea jacea
Centaurea scabiosa
Centaurea stoebe
Centaurea triumfetti
Centaurium erythraea
Cerastium arvense
Chamaecytisus ratisbonensis
Chamaecytisus supinus
Circaea lutetiana
Cirsium palustre
Cirsium vulgare
Clematis recta
Clinopodium vulgare
Cnidium dubium
Colchicum autumnale
Convallaria majalis
Cornus mas
Cornus sanguinea
Corylus avellana
Corynephorus canescens
Crataegus spp.
Crepis praemorsa
Cruciata laevipes
Cruciata verna
Cytisus nigricans
Dactylis glomerata
Dactylis polygama
Dactylorhiza fuchsii
Danthonia decumbens
Daphne cneorum
Dentaria bulbifera
Deschampsia cespitosa
Dianthus armeria
Dianthus pontederae
Dianthus superbus
Dictamnus albus
Digitalis grandiflora
Drymocallis rupestris
Elymus caninus
Elymus hispidus
Elymus repens
Epipactis helleborine agg.
Equisetum arvense
Equisetum hyemale
Equisetum palustre
Eryngium campestre
Euonymus europaeus
Euphorbia cyparissias
Euphorbia esula
Euphorbia illirica
Festuca amethystina
Festuca heterophylla
Festuca ovina subsp. *guestfalica*
Festuca pulchra
Festuca rubra
Festuca rupicola
Filipendula ulmaria
Filipendula vulgaris
Fragaria moschata
Fragaria vesca
Fragaria viridis
Frangula alnus
Galeobdolon montanum
Galium album
Galium aparine
Galium boreale
Galium odoratum
Galium palustre
Galium pumilum
Galium rivale
Galium uliginosum
Galium verum
Genista germanica
Genista tinctoria
Geranium sanguineum
Gladiolus palustris
Glechoma hederacea
Glyceria fluitans
Helictochloa pratensis
Herniaria glabra
Hieracium diaphanoides
Hieracium laevigatum
Hieracium lachenalii
Hieracium maculatum
Hieracium murorum
Hieracium sabaudum
Hieracium umbellatum
Holcus lanatus
Holcus mollis
Humulus lupulus
Hylotelephium maximum
Hypericum montanum
Hypericum perforatum
Impatiens parviflora (neo)
Inula britannica
Inula hirta
Inula salicina
Iris graminea
Iris pseudacorus
Iris sibirica
Iris variegata
Isolepis setacea
Jasione montana
Juncus alpinoarticulatus
Juncus articulatus
Juncus atratus
Juncus bufonius
Juncus conglomeratus
Juncus effusus
Juncus tenuis (neo)
Knautia arvensis
Knautia kitaibelii

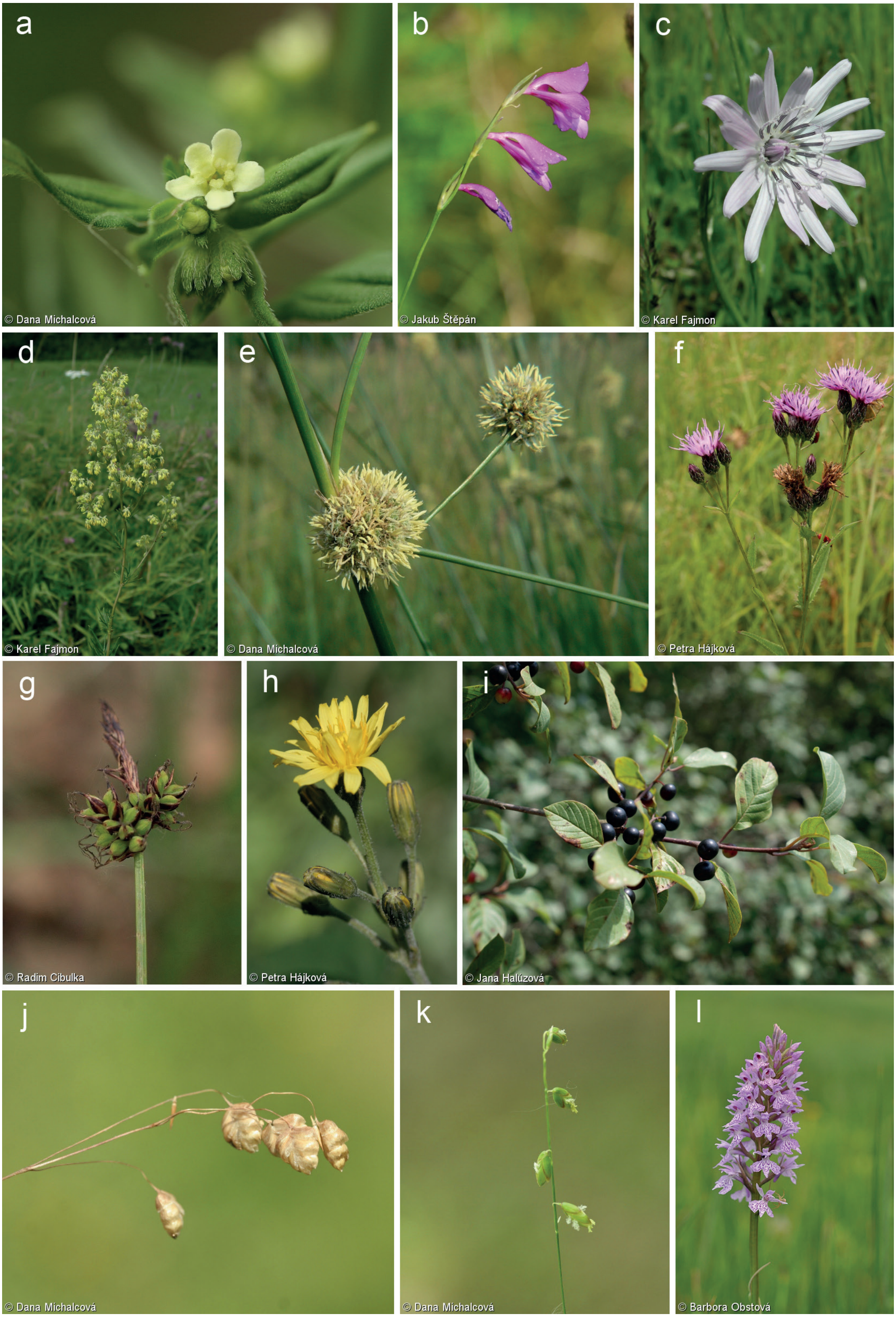

Plate 13 Plants of Hodonínská Dúbrava Wood: (a) *Lithospermum officinale*, (b) *Gladiolus palustris*, (c) *Scorzonera purpurea*, (d) *Thalictrum simplex* subsp. *galioides*, (e) *Scirpoides holoschoenus*, (f) *Serratula tinctoria*, (g) *Carex fritschii*, (h) *Crepis praemorsa*, (i) *Frangula alnus*, (j) *Briza media*, (k) *Melica picta*, (l) *Dactylorhiza fuchsii*.

Species-rich herb layer of the Quercus robur forest in Hodonínská Dúbrava Wood with Convallaria majalis, Euphorbia cyparissias, Inula salicina, Lysimachia vulgaris and Potentilla alba. Photo M. Chytrý.

Koeleria macrantha
Koeleria pyramidata
Laserpitium prutenicum
Lathyrus niger
Leontodon hispidus
Leonurus cardiaca
Leucanthemum vulgare agg.
Ligustrum vulgare
Lilium martagon
Listera ovata
Lithospermum officinale
Lotus corniculatus
Luzula campestris
Luzula divulgata
Luzula multiflora
Luzula pallescens
Lycopus europaeus
Lysimachia nummularia
Lysimachia vulgaris
Lythrum salicaria
Maianthemum bifolium
Malus sylvestris
Melampyrum cristatum
Melampyrum nemorosum
Melampyrum pratense
Melica nutans
Melica picta
Melica uniflora
Melittis melissophyllum
Moehringia trinervia
Molinia arundinacea
Molinia caerulea
Muscari comosum
Nardus stricta
Neottia nidus-avis
Origanum vulgare
Ornithogalum kochii
Orobanche kochii
Oxalis stricta (neo)
Paris quadrifolia
Peucedanum cervaria
Peucedanum oreoselinum
Phleum phleoides
Phragmites australis
Pilosella cymosa
Pilosella echioides
Pilosella officinarum
Pilosella onegensis
Pilosella rothiana
Pimpinella saxifraga
Pinus sylvestris
Plantago arenaria
Plantago lanceolata
Plantago major
Platanthera bifolia
Platanthera chlorantha
Poa angustifolia
Poa nemoralis
Poa palustris
Poa trivialis
Polygonatum multiflorum
Polygonatum odoratum
Populus alba

Populus tremula
Potentilla alba
Potentilla argentea
Potentilla erecta
Potentilla heptaphylla
Potentilla recta
Primula veris
Prunella vulgaris
Prunus avium
Prunus padus
Prunus serotina (neo)
Prunus spinosa
Pulmonaria angustifolia
Pulmonaria obscura
Pyrola minor
Pyrus pyraster
Quercus cerris
Quercus petraea
Quercus robur
Quercus rubra (neo)
Ranunculus acris
Ranunculus auricomus agg.
Ranunculus polyanthemos
Rhamnus cathartica
Robinia pseudoacacia (neo)
Rosa canina
Rosa gallica
Rubus caesius
Rubus fruticosus agg.
Rubus idaeus
Rumex acetosa
Rumex acetosella
Rumex thyrsiflorus (neo)
Salix aurita
Salvia pratensis
Sanguisorba officinalis
Scabiosa canescens
Scabiosa ochroleuca
Scirpoides holoschoenus
Scorzonera humilis
Scorzonera purpurea
Scrophularia nodosa
Scrophularia umbrosa
Scutellaria galericulata
Securigera varia
Sedum sexangulare
Selinum carvifolia
Senecio jacobaea
Serratula tinctoria
Silene nutans
Silene vulgaris
Solidago virgaurea
Stachys recta
Stellaria graminea
Succisa pratensis
Symphyotrichum lanceolatum (neo)
Tephroseris integrifolia
Teucrium chamaedrys
Thalictrum lucidum
Thalictrum minus
Thalictrum simplex subsp. *galioides*
Thesium linophyllon
Thymus pannonicus
Thymus serpyllum
Tilia cordata
Tilia platyphyllos
Trifolium alpestre
Trifolium arvense
Trifolium campestre
Trifolium medium
Trifolium montanum
Trifolium pratense
Trifolium rubens
Trisetum flavescens
Turritis glabra
Ulmus laevis
Urtica dioica
Vaccinium myrtillus
Valeriana stolonifera subsp. *angustifolia*
Verbascum chaixii subsp. *austriacum*
Verbascum lychnitis
Verbascum nigrum
Verbascum phoeniceum
Veronica chamaedrys
Veronica maritima
Veronica officinalis
Veronica spicata
Veronica vindobonensis
Viburnum opulus
Vicia angustifolia
Vicia cassubica
Vicia cracca
Vicia pisiformis
Vicia sepium
Vicia tenuifolia
Vincetoxicum hirundinaria
Viola canina
Viola hirta
Viola reichenbachiana
Viola riviniana
Viola rupestris
Viscaria vulgaris

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14 White Carpathian Mountains

14

Jan W. Jongepier, Ivana Jongepierová, Milan Chytrý & Vít Grulich

Introduction

The White Carpathian Mountains (*Bílé Karpaty*) are a mountain range in the east of southern Moravia, but the south-eastern-most part of the mountains is situated on Slovak territory. Before 1918, the range formed the border between the Austrian and the Hungarian part of Austro-Hungary.

Species-rich semi-dry meadow in the White Carpathians with Galium verum and Betonica officinalis. Photo J. Říhová.

Geology, geomorphology and soils

The area consists predominantly of flysch deposits from the Eocene period (Lower Tertiary), composed of alternating sandstone and claystone layers. The presence of calcareous deposits filling up the oldest fissures is quite common. The sandstone is usually cemented by lime, and only in the central part of the mountain range acidic sandstone cemented by silica is present. Among Quaternary covering deposits, loess and silty loams prevail in relatively large areas. In stream and river valleys alluvial deposits are widely distributed. Loamy to clayey slope deposits are encountered in some parts with rugged terrain. In the vicinity of springs originating from flysch layers particularly rich in lime, calcareous tufa has developed at many sites.

The western part of the White Carpathians is made up of hills with gentle, rarely steep slopes and open, shallow valleys. The central part of the mountains consists of one or two parallel main ranges with, namely on the Slovak side, numerous side ranges projecting far from the main range. The central and north-eastern part of the White Carpathians is more mountainous in character. The border range is divided into several massifs (e.g. *Žalostiná*, *Javořina* and *Lopeník*). Landslides are a common feature on steep slopes, particularly near springs, apparent by the many uneven slopes. Rock cliffs are present only on Slovak territory. The lowest point of the area is the margin of the Morava River floodplain near the village of Sudoměřice (166 m a.s.l.), the highest is the summit of Mount Velká Javořina (970 m a.s.l.).

In the south-western part of the White Carpathians, gleyic chernozems and gleyic phaeozems cover large areas. These soils are heavy and dry out in summer. During periods of drought, deep and broad fissures often develop. Gleyic phaeozem is quite often found in depressions. Cambisols and chernozems have developed on loess. Heavy, often gleyic to pellic cambisols, saturated with bases, are found at higher altitudes, whereas unsaturated cambisols occur only rarely. Leptosols (pararendzinas) are found on outcrops of the calcareous flysch bedrock (Kuča et al. 1992; Jongepierová 2008; Konvička et al. 2012).

Climate

The climate of the south-western part of the White Carpathians is relatively warm and moderately humid. Measured near the town of Strážnice (ca. 180 m a.s.l.), the mean annual temperature is about 9.5 °C, and the annual precipitation amounts to almost 600 mm. The climate in the central and north-eastern parts of the White Carpathians is moderately warm, at higher altitudes cooler, but considerably warmer than at similar altitudes in northern and western Moravia. At the village of Strání (ca. 400 m a.s.l.) the mean annual temperature is about 7.5 °C and the annual precipitation sum is about 800–900 mm. The highest mountain tops have a mean annual temperature of less than 6 °C. Precipitation here is generally higher than in other parts of southern Moravia. The large and deep valleys, running across the main range, affect the air circulation and are the cause of a more humid mesoclimate. Dry winds from the south-east, blowing over the range of the White Carpathians, have also a profound influence on the climate of the western foothills. Particularly in spring they cause strong wind erosion (Kuča et al. 1992; Jongepierová 2008; Konvička et al. 2012).

Landscape history

The fact that the White Carpathian Mountains harbour very species-rich grasslands, including a number of rare and disjunctly distributed species, is explained not only by specific local environmental factors, but also by their long history dating back to the early Holocene. Available phytogeographical, archaeological and palaeoecological data suggest the prehistoric origin of the White Carpathian grasslands (Hájková et al. 2011). Also the high concentration of rare heliophilous species with a disjunct distribution in the south-western part of the area suggests a long-term persistence. Archaeological finds provide evidence for the existence of prehistoric human settlements in this region since the Neolithic. Macrofossil, mollusc and pollen analyses also indicate the existence of a cultural landscape with a mosaic of open grasslands, natural forests and fields in prehistoric times.

The first people must have arrived in the White Carpathians in the Palaeolithic and Mesolithic. In the Neolithic, settling became more extensive. Higher elevations along the main ridge, creating a natural border between Moravia and Hungary (incl. nowadays' Slovakia), remained untouched until the late 12th century. Since the early 13th century the area has gradually been settled and villages and towns were founded. This development was disturbed by frequent attacks of Hungarians, Cumans, Tartars, Turks and other troops who destroyed complete villages (Kuča et al. 1990; Jongepierová 2008).

History of botanical research

The first detailed botanical research in the White Carpathians was carried out in the first half of the 20th century. The species-rich grasslands of the area impressed Josef Podpěra (Podpěra 1951), the first Professor of Botany at Masaryk University, Brno. In the first half of the 20th century, primary school teacher Stanislav Staněk recorded the flora of the area in detail (Staněk et al. 1996) and prepared proposals for nature reserves. The natural values of the meadows, especially plant communities, were documented by Sillinger (1929).

After WWII, two Summer Schools of Field Botany of the Czechoslovak Botanical Society were held in the area, confirming and updating the data collected by Staněk (Elsnerová et al. 1984; Grulich 1989). A syntaxonomic review of the White Carpathian grasslands was published by Tlusták (1975). In the 1980s the orchid flora of the area was studied (Tlusták & Jongepierová-Hlobilová 1990). Since

1995, Michal Hájek (Hájek 1998; Balátová-Tuláčková & Hájek 1998) and colleagues have been studying spring-fen vegetation. In 1986, the Botanical Section of the Protected Landscape Area Authority started coordinating botanical research (Rydlo 2000; Otýpková 2001) and initiating a range of research projects in the area, e.g. vegetation monitoring (especially the effect of different management practices), re-creation of species-rich meadows, and establishing a plant distribution database. Also, inventories of bryophytes (Pospíšil 1994), lichens and fungi have been carried out (Antonín et al. 2010). The late Leoš Klimeš (Klimeš 1995, 1997, 1999, 2008; Klimeš et al. 2000, 2001, 2013; Jongepierová et al. 1994) studied the effects of grassland management and the phenomenon of extremely high species richness of the White Carpathian grasslands from the late 1980s until 2008). Details of previous research can be found in the book *Grasslands of the White Carpathian Mountains* (Jongepierová 2008). A significant activity was the grid mapping of plants and animals in the Protected Landscape Area during 2003–2006. All newly collected and older data have been entered into a database, currently containing nearly half a million records. This became the basis of a distribution atlas (Jongepier & Pechanec 2006; Otýpková et al. 2011) and an annotated checklist of vascular plants growing in the area (Jongepier & Jongepierová 2006).

Vegetation

The White Carpathian Mountains are partly situated in the region of thermophilous flora and partly in that of mesophilous flora, including the colline and supracolline vegetation belts. On convex slopes in the lower south-western part of the area, thermophilous oak forests of the association *Melico pictae-Quercetum roboris* (alliance *Quercion petraeae*) used to prevail in the natural vegetation cover. In the course of time, most of these forests have been transformed into species-rich semi-dry grasslands with scattered trees and during the past century many of the remaining stands have been converted to mesophilous *Carpinion betuli* forests. Perialpine thermophilous oak forests of the association *Euphorbio-Quercetum* (alliance *Quercion pubescenti-petraeae*) used to occur to a limited extent and only a few fragments have remained.

The prevailing forest type at lower to middle altitudes is Carpathian oak-hornbeam forests of the association *Carici pilosae-Carpinetum betuli* (alliance *Carpinion betuli*), locally also with European beech (*Fagus sylvatica*) in the tree layer. Pannonian oak-hornbeam forests of the association *Primulo veris-Carpinetum betuli* occur as small patches, usually in contact with thermophilous oak forests.

Alluvial ash-alder forests of the association *Stellario nemorum-Alnetum glutinosae* (alliance *Alnion incanae*) are confined to stream valleys. Occurrence of seepage forests of the association *Carici remotae-Fraxinetum excelsioris* (alliance *Alnion incanae*) is limited to small spring areas on slopes.

Beech forests (alliance *Fagion sylvaticae*) represent the potential natural vegetation of the ridge and the NE part of the mountains. The absence of *Abies alba* from these forests – except for the extreme north – is a remarkable phenomenon. *Carici pilosae-Fagetum sylvaticae* is the most common association. At higher altitudes it is locally replaced by mesotrophic (*Galio odorati-Fagetum sylvaticae*) to euthrophic (*Mercuriali perennis-Fagetum sylvaticae*) associations of beech forests on mineral-rich soils and by acidophilous beech forests (association *Luzulo luzuloidis-Fagetum sylvaticae*, alliance *Luzulo-Fagion sylvaticae*) on acidic sandstone. Steep slopes support ravine forests of the alliance *Tilio platyphylli-Acerion*, mainly belonging to the association *Mercuriali perennis-Fraxinetum excelsioris*.

The White Carpathian grasslands are mostly represented by semi-dry meadows of the association *Brachypodio pinnati-Molinietum arundinaceae* (transitional between the alliances *Bromion erecti* and *Cirsio-Brachypodion pinnati*), well known for their extraordinary species diversity, including most of the rare species with a disjunct distribution. Mesophilous meadow vegetation of the alliance *Arrhenatherion elatioris* is found at more nutrient-rich sites, often in the close vicinity of villages, on former arable land, and in fertilized *Brachypodio-Molinietum* stands. Scrub and forest margins may be accompanied by forest fringe vegetation of the alliance *Geranion sanguinei* or, at higher altitudes, the alliance *Trifolion medii*. These vegetation types are often difficult to delimit from the neighbouring grasslands, in which a range of forest-fringe herb species often occur.

Higher altitudes support Western Carpathian meadows and pastures of the association *Anthoxantho odorati-Agrostietum tenuis* (alliance *Cynosurion cristati*). Species-poor stands of the association *Lolio perennis-Cynosuretum cristati* from the same alliance are found on intensively grazed pastures.

Along small rivers and streams, in grassland depressions and in the surroundings of springs, various types of wetland have developed. Most often these are wet *Cirsium* meadows of the alliance *Calthion palustris*, represented mainly by the association *Cirsietum rivularis* but also by several associations according to water and nutrient level and disturbance regime. Only locally and patchily, also wet alluvial meadows of the alliance *Deschampsion cespitosae* (mostly the association *Holcetum lanati*) occur. At nutrient-poor sites, intermittently wet *Molinia* meadows of the association *Molinietum caeruleae* (alliance *Molinion caeruleae*) can be found, however, rather as transitional types to semi-dry *Brachypodio-Molinietum* meadows than in their typical form. Meadow springs, usually including tufa formation, host a very specific vegetation. Most of these stands, rich in calciphilous wetland specialists, can be classified as the association *Carici flavae-Cratoneuretum filicini* (alliance *Caricion davallianae*).

As for synanthropic vegetation, weed communities on calcareous soils belonging to the *Caucalidion* alliance are especially noteworthy. On arable and fallow land in warmer parts of the region they locally host many vanishing weed species.

Flora

The area possesses approximately 1500 vascular plant taxa (species and subspecies) on an area of some 600 km², which can be divided into different phytogeographical elements. A considerable number of species reach the border of their distribution range or have isolated occurrences in the White Carpathians.

The undergrowth of beech and oak-hornbeam forests at lower altitudes of the entire Western Carpathians is characterized by *Carex pilosa*, *Euphorbia amygdaloides*, *Hacquetia epipactis*, *Salvia glutinosa* and *Symphytum tuberosum*. At the highest altitudes of the mountain massifs of *Javořina* and *Lopeník* several montane species, e.g. *Aconitum variegatum*, *Cicerbita alpina*, *Geranium sylvaticum*, *Lunaria rediviva* and *Silene dioica*, grow. Contact with the Pannonian phytogeographical province is most pronounced in deforested parts at lower altitudes of the White Carpathians. Here, *Buglossoides purpurocaerulea*, *Cornus mas*, *Euonymus verrucosus* and *Viburnum lantana* are commonly encountered. The meadows and dry grasslands in the south-western part of the White Carpathians are or were inhabited by numerous xerophilous species, e.g. *Astragalus danicus*, *Echium maculatum*, *Iris variegata*, *Klasea lycopifolia*, *Linum flavum*, *Polygala major*, *Stipa tirsa*, *Veronica orchidea* and *V. spuria*. Some of these species have large continental distribution ranges reaching far to the east up to southern Siberia.

Some species, confined to calcareous substrata in higher Central European mountain ranges, have spread into the White Carpathians only via the Váh River Valley in Slovakia; this group includes *Carex alba*, *C. ornithopoda* and *Hippocrepis comosa*.

Danthonia alpina and *Globularia bisnagarica* can be mentioned as examples of sub-Mediterranean species. *Laserpitium latifolium*, *Senecio umbrosus* and *Stachys alpina* are predominantly calciphilous species with distribution ranges surrounding the high Central European mountain systems. Several plant species, such as *Allium victorialis*, *Aposeris foetida*, *Crocus albiflorus*, *Lathyrus pannonicus* subsp. *pannonicus*, *Pedicularis exaltata*, *Potentilla micrantha*, the subendemic *Tephroseris longifolia* subsp. *moravica*, and also the now extinct *Gentiana acaulis*, have remarkable isolated occurrences in the White Carpathians.

The White Carpathians host a total of 37 species of orchid. Another three species, *Herminium monorchis*, *Orchis coriophora* and *Spiranthes spiralis*, used to occur here but are now extinct. *Gymnadenia conopsea*, *Orchis mascula*, *O. militaris* and *Traunsteinera globosa* are rather common in the area. *Anacamptis pyramidalis*, *Gymnadenia densiflora*, *Ophrys holoserica* subsp. *holubyana* and *Orchis pallens* are rare or absent elsewhere in the Czech Republic.

Heavy soils rich in nutrients support subhalophilous plants, such as *Carex distans*, *C. hordeistichos*, *Lotus maritimus* and *L. tenuis*.

Nature conservation

For its diverse nature, the White Carpathians have been under protection as a Protected Landscape Area since 1980. The protected area is ca. 750 km² in size and was included in the world network of UNESCO Biosphere Reserves in 1996. In 2000, it was also awarded the European Diploma by the Council of Europe. Within the broader protected area a total of 54 nature reserves with stricter conservation regime have been designated, varying in size from less than 1 ha to 700 ha. The total area of species-rich grassland sites on the territory of the *Bílé Karpaty* Protected Landscape Area amounts to 4000 ha (40 km²).

Unfortunately, not all of the past White Carpathian richness has been preserved. Establishing nature reserves took a long time: some of the proposals took 45 years to be implemented. For instance, large areas of the driest grasslands with *Stipa tirsa* were devastated during the 1960s and 1970s, so that only a few tussocks of this feather grass have survived.

Species richness of the White Carpathian grasslands

In a global review of the highest counts of vascular plant species occurring in plots of different sizes (Wilson et al. 2012), five world records were reported from the Čertoryje meadows in the south-western part of the White Carpathians: 13, 44, 105, 116 and 131 species for plots of 0.004, 0.25, 16, 25 and 49 m^2, respectively. In 2014, a world record of 43 species at 0.1 m^2 was equalled at the same locality (Chytrý, Dřevojan & Fajmon, unpubl. data) and a new world record count of 109 species in a plot of 16 m^2 was obtained in the Porážky meadows, also in the south-western White Carpathians (Hájek & Hájková, unpubl. data). Such extremely high local species richness is characteristic of many grassland sites throughout the White Carpathians. Although comparative studies have shown that grasslands in the nearby regions are never so rich, the White Carpathian forests are generally not richer than those in other areas of Central Europe (Merunková et al. 2012; Michalcová et al. 2014).

Despite intensive research devoted to the diversity phenomena of these grasslands since the 1990s, the causes of this extremely high species richness are not entirely clear. Several mechanisms seem to be involved, acting in concert.

1. The White Carpathian grasslands have probably existed continuously for millenia, enabling an accumulation of many species at individual sites over time (Hájková et al. 2011).
2. The grassland area in the White Carpathians is large, which reduces the chance of random extinctions of rare species (Michalcová et al. 2014).
3. The grassland species pool in the area is relatively large, but not larger than in adjacent areas, which lack extremely species-rich grasslands. An important factor is probably efficient seed dispersal between different habitats and sites, e.g. the spread of forest species to grasslands. This is supported by a high heterogeneity of land-cover combined with geological uniformity of the area. As soils are rather homogeneous across the White Carpathians, most species can spread across extensive areas and create large populations. The high alpha diversity of grasslands is consequently coupled with a low beta diversity, i.e. different sites are very similar in species composition (Michalcová et al. 2014).
4. Although soil conditions are rather homogeneous on the coarse scale, they are heterogeneous on the fine scale. The area is rich in small landslides, some of them associated with spring fens, which increase environmental heterogeneity and support coexistence of many species due to spatial mass effects.
5. The environmental conditions associated with these grasslands are intermediate, involving no extreme values of factors known to influence grassland species richness, such as productivity, moisture, nutrient availability and soil pH (Merunková et al. 2012).
6. Long-term continuous low-intensity management, mostly hay-making once a year, creates a disturbance of medium intensity needed to maintain high local species richness (Klimeš et al. 2000, 2013).
7. In addition to management, asymmetric competition and local extinction of competitively weak species is possibly reduced as a result of occasional summer drought events on deep flysch-derived soils, which may be sufficient to reduce potential dominant species but insufficient to cause extinction of most grassland species (Klimeš 2008).

Grassland management and restoration

Although the White Carpathian grasslands are composed of native, naturally occurring grassland species, these habitats have been preserved from forest spread by humans and their existence has always depended on regular mowing or livestock grazing. Particularly in the south-west, hay meadows used to be mown once a year, mainly in July. This was done so late because making hay too early would cause the meadows to dry out, whereas late cutting enabled most plants to flower and produce seed. If spring was dry as well, the meadows were left unmown for regeneration. Dry meadows were neither irrigated nor fertilized, wet meadows were left undrained. The aftermath was harvested only in valleys.

Common pastures and fallow land were grazed for part of the year. The former were mostly used by local landowners, who usually kept two shepherds to tend the animals. One looked after cattle, the other after pigs, goats and sheep. Grazing started early in spring and lasted until the first frost. The shepherds drove the animals out every morning and back to the sheds again in the evening. In winter, livestock was kept in, so forage was required. Although young tree twigs were cut and dried for this purpose, hay-making was more widespread in the area.

The process of establishing cooperative and state farms during the Communist era (1948–1989) was aimed at large-scale agricultural production, which included measures like ploughing of grasslands, land consolidation, elimination of hedges, trees and shrubs, excessive fertilization, grassland 'improvement' (drainage, adding forage plant varieties, etc.), and pasturing with high cattle densities. On the other hand, steep slopes with landslides were gradually encroached by scrub since they became practically inaccessible to modern agricultural machines. Some remote grasslands escaped from intensive agriculture and have been preserved as nature reserves.

The socio-economic changes after the Velvet Revolution of 1989 meant a transformation of agricultural production which caused farmers to sell part of their cattle and sheep, and abandon some of the land, threatening both biodiversity and scenery. This trend has been slowed down by subsidy policies. Since 1999, subsidies are provided to support not only production but also landscape conservation and management. Other recent positive changes in the area are the conversion of a considerable area of arable land to grassland and a strong expansion of organic farming.

Currently (2011–2016) management of the most valuable sites is financed from a LIFE+ project. The meadows are managed by landowners, tenants or, where interest in their maintenance is lacking, also by non-governmental organizations and land trusts. Large meadow complexes are mown with tractors. On uneven, sloping meadows the grassland is cut with small mowers or scythes. The biomass is mostly used as fodder, a part is burnt or deposited elsewhere. In the large nature reserves, extensive pasturing on the hay meadows is allowed only exceptionally.

Since the mid-1980s also hundreds of hectares of abandoned grassland have been restored. These are particularly found on steep hills, in areas with rough terrain and in remote places, where mowing with regular agricultural equipment is difficult. Such sites are invaded by scrub, mostly *Crataegus* sp., *Prunus spinosa* and *Rosa* sp., and some may eventually turn into woodland. Restoration of these sites includes cutting scrub with chain-saws, removing litter and subsequent burning of biomass at the site, followed by regular mowing in the years after.

Botanical monitoring has shown that on dry sites complete restoration takes only a few years. In one case four orchids – *Anacamptis pyramidalis*, *Coeloglossum viride*, *Ophrys apifera* and *O. fuciflora* – were found to appear only three years after the scrub had been eliminated. Sites overgrown by *Molinia arundinacea* see a much slower return to species-rich meadows (several decades). The burning of biomass has not shown to cause excessive ruderalization. Bonfire sites are soon covered by meadow grasses and forbs.

Grassland management is an indispensable measure to preserve the species-rich grasslands. However, in a special experiment it was demonstrated that while abandonment causes loss of plant diversity in productive grasslands (dominated by *Molinia arundinacea* or *Calamagrostis epigejos*), it does not in less productive, species-rich (*Bromus erectus* dominated) grasslands, at least not in the short term (Klimeš et al. 2013).

In the past years the area of species-rich grasslands has been enlarged not only by restoration of abandoned areas, but also by regrassing of ex-arable land (Jongepierová & Malenovský 2012). Since the 1990s, about 7000 ha of arable land has been turned back into dry or mesic grasslands by sowing commercial grass-legume seed mixtures (the majority) and by spontaneous succession (over 200 ha). Since 1999, arable land has also been sown with a locally prepared regional seed mixture of dry grassland species on a total area of over 500 ha. This mixture is prepared by the *Bílé Karpaty* Local Chapter of the Czech Union for Nature Conservation (a non-governmental organization based in Veselí nad Moravou) in cooperation with the *Bílé Karpaty* Protected Landscape Area Authority. Part of the seed, mostly herbs, is cultivated in special seedbeds, whereas grass seed used to be acquired by means of a combine harvester, but since 2007 with a brush-harvester, operating in existing species-rich grasslands. The White Carpathians is the only region in the Czech Republic where a species-rich mixture of regional grasses and herbs has been sown on a large area.

Several studies have been conducted to assess processes of grassland re-creation. In 1999, a small-scale experiment was set up on an ex-arable field in the area to compare different methods of re-establishing species-rich grassland vegetation. After ten years the vegetation in experimental plots was found to gradually converge towards ancient meadow vegetation, although still relatively poor in species (Jongepierová et al. 2007; Mitchley at al. 2012). In 2009–2014 vascular plant succession was monitored in 80 large fields restored with a regional seed mixture, commercial seed mixtures, or by means of spontaneous succession (Prach et al. 2013, 2014). Results showed that the latter two lead to establishment of more mesic vegetation (alliance *Arrhenatherion elatioris*) whereas dry grassland vegetation (alliance *Bromion erecti*) developed after sowing regional seed mixtures. Many non-sown grassland species appeared to have colonized the fields thanks to the rich species pool occurring in the vicinity of the re-created grasslands.

Excursion sites

The most attractive botanical sites – large meadows, including a mosaic of semi-dry and mesic species-rich grasslands and sloping spring fens with solitary oaks – are situated in the south-western part of the White Carpathian Mountains (Jongepier & Jongepierová 2009). They include *Kútky* (113 ha), *Čertoryje* (695 ha), *Zahrady pod Hájem* (162 ha), *Machová* (243 ha), *Jazevčí* (352 ha) and *Porážky* (421 ha) Nature Reserves. However, also the extensive old-growth beech forests in the north-east (on both sides of the Vlára pass) are a habitat of great value. The centre of the area, around the village of Starý Hrozenkov, offers a picturesque patchwork of solitary farmsteads and houses surrounded by orchards, pastures, meadows and forests on rolling hills interwoven with streams.

A popular tourist destination is Mount Velká Javořina (970 m), the highest peak in the White Carpathians, with views stretching far into Moravia and Slovakia and the old-growth forest containing beech trees hundreds of years old. Historic sights include the neo-Gothic Nový Světlov Chateau in Bojkovice, the Romanesque castle ruins in Brumov, the open-air museum in Strážnice with examples of traditional village architecture, and the modern architecture of the spa Luhačovice. The White Carpathians are also rich in folklore, expressed in folk architecture and ornaments, dance, music and folk costumes. Particularly in the summer months several folklore festivals take place.

The south-western part of the White Carpathian Mountains. The green dashed lines indicate the Protected Landscape Areas Bílé Karpaty (in the Czech Republic, identical with the UNESCO Biosphere Reserve Bílé Karpaty) and Biele Karpaty (in Slovakia).

(14a) Čertoryje meadows

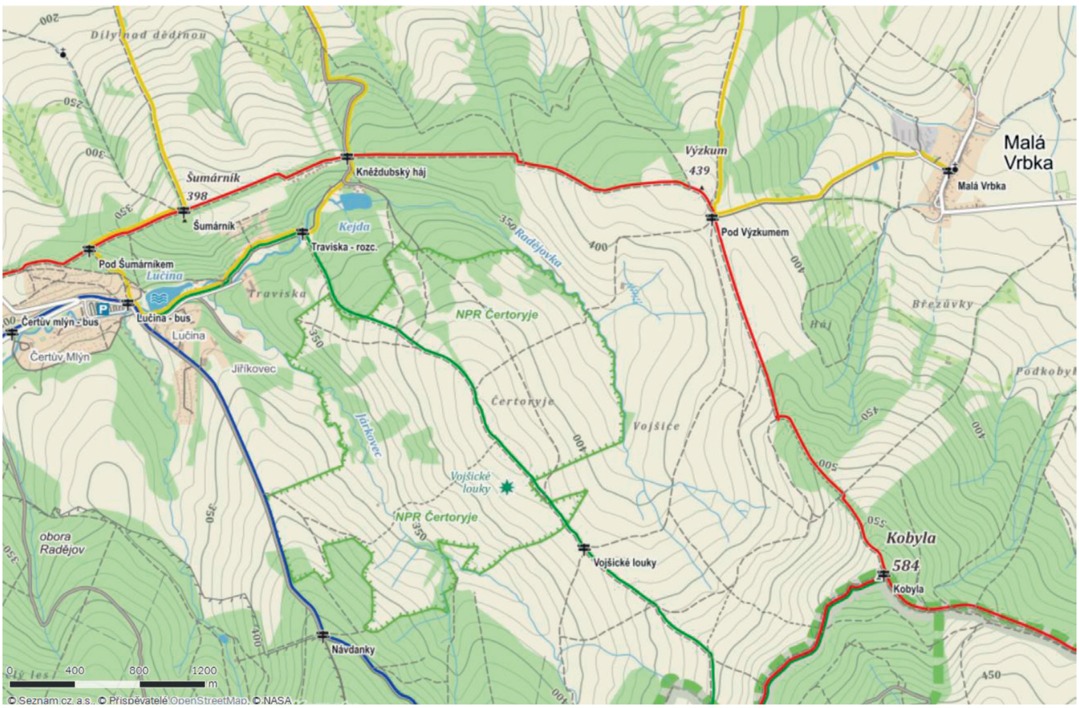
The *Čertoryje* National Nature Reserve is a complex of species-rich grasslands, comprising three hillsides divided up by two streams, located close to the state border with Slovakia between the towns of Strážnice and Velká nad Veličkou. Its total area (incl. buffer zone) is 6.95 km²; its altitude is 320–584 m. The meadows are dotted with solitary individuals and groups of trees, in particular *Quercus robur*, *Q. petraea*, *Tilia cordata* and *Sorbus torminalis*, and include several vegetation types, from dry grassland to small springs and fens. Unmown parts develop into oak-hornbeam woodland, on south-facing slopes into oak groves.

Many solitary oak trees are attacked by the hemiparasite *Loranthus europaeus* and suffer from tracheomycosis, a fungal disease. This is the reason why some oak saplings are fenced in to protect them from being mown or browsed by game.

From 2000 to 2003 the eastern buffer zone, an area of over 80 ha which had been illegally ploughed in the 1970s and then managed as arable land, was restored ('regrassed') with a regional seed mixture. The reserve is annually mown once a year, between May and September, temporarily leaving parts unmown to maintain flowering plants which provide food and shelter to insects.

Patches of spring fens occur in a matrix of semi-dry meadows in small depressions left after land slides. Like this one in the Čertoryje meadows, they can be clearly recognized by white inflorescences of Eriophorum angustifolium and E. latifolium. Photo I. Jongepierová.

The Čertoryje meadows in the White Carpathians extend over an area of about 7 km². Scattered trees and shrubs are a characteristic feature of these extensively managed meadows. The semi-dry grasslands at this site hold several world records for the fine-scale species richness of vascular plants. Photo M. Chytrý.



The Čertoryje meadows between the settlement of Lučina and the village of Malá Vrbka in the south-western part of the White Carpathians*.*

(14b) Zahrady pod Hájem meadows

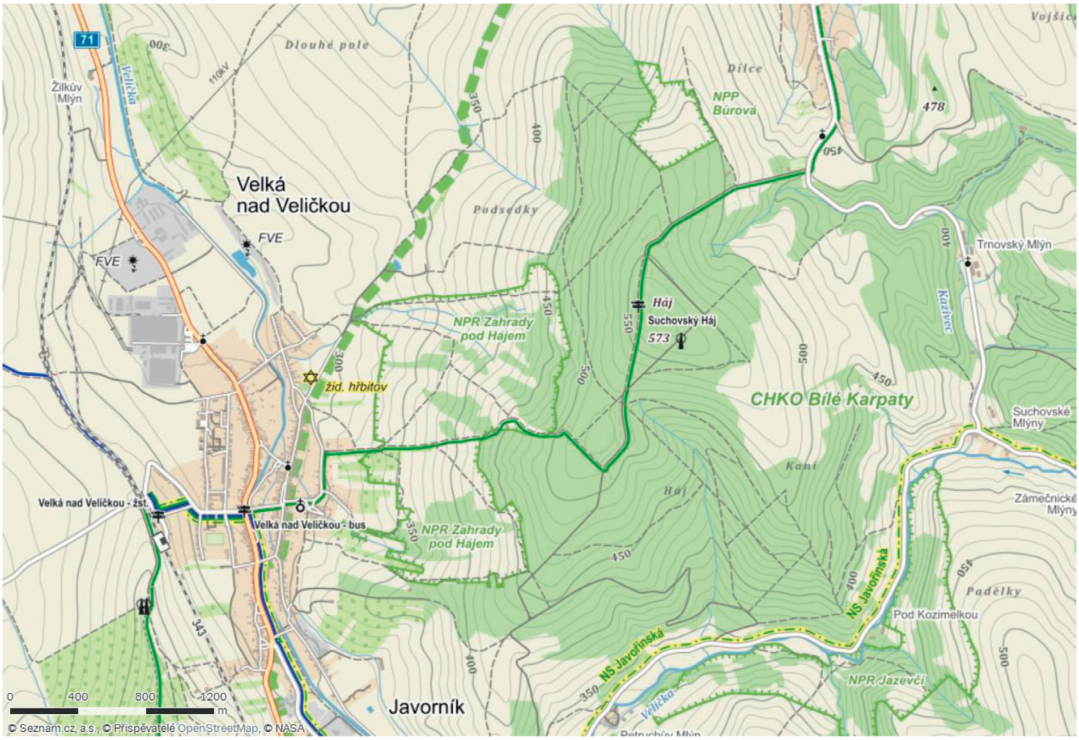
Neighbouring the village of Velká nad Veličkou on its east side, at an area of 162 ha and an altitude of 300–480 m, the *Zahrady pod Hájem* National Nature Reserve is made up of strips of meadows and old orchards, separated by hedges and groves. Dry grasslands occur on shallow marly soils. At its lower edge some small fields host a remarkable arable weed flora. The reserve also includes a three-hectare orchard in which old and local fruit varieties have been brought together.

Species-rich grassland with Melampyrum cristatum in the Zahrady pod Hájem meadows. Photo I. Jongepierová.

Appendix 14 Selected species of vascular plants in the Čertoryje and Zahrady pod Hájem meadows.

Achillea collina
Aconitum lycoctonum
Agrimonia eupatoria
Agrostis capillaris
Agrostis vinealis
Allium carinatum
Allium scorodoprasum
Anacamptis pyramidalis
Anemone sylvestris
Antennaria dioica
Anthericum ramosum
Anthoxanthum odoratum
Anthyllis vulneraria
Aquilegia vulgaris
Arabis hirsuta
Asperula cynanchica
Asperula tinctoria
Aster amellus
Astragalus cicer
Astragalus danicus
Astrantia major
Avenula pubescens
Betonica officinalis
Brachypodium pinnatum
Briza media
Bromus commutatus
Bromus erectus
Buglossoides purpurocaerulea
Bupleurum falcatum
Calamagrostis arundinacea
Campanula cervicaria
Campanula glomerata
Campanula persicifolia
Carex caryophyllea
Carex flacca
Carex michelii
Carex montana
Carex panicea
Carex pilosa
Carex tomentosa
Carlina biebersteinii subsp. *brevibracteata*
Centaurea scabiosa
Centaurea stenolepis
Centaurea triumfetti
Centaurium erythraea
Chamaecytisus virescens
Cirsium canum
Cirsium oleraceum
Cirsium pannonicum
Clematis recta
Coeloglossum viride
Colchicum autumnale
Cornus mas
Crepis praemorsa
Cruciata verna
Cynosurus cristatus

Plate 14a Plants of the White Carpathian meadows: (a) *Pulmonaria angustifolia*, (b) *Orchis pallens*, (c) *Carex michelii*, (d) *Anacamptis pyramidalis*, (e) *Astragalus danicus*, (f) *Potentilla alba*, (g) *Geranium sanguineum*, (h) *Rosa gallica*, (i) *Ophrys holoserica* subsp. *holubyana*, (j) *Campanula cervicaria*, (k) *Dorycnium herbaceum*, (l) *Centaurea stenolepis*.



The Zahrady pod Hájem meadows near the town of Velká nad Veličkou.

Danthonia alpina
Dianthus carthusianorum
Digitalis grandiflora
Dorycnium germanicum
Dorycnium herbaceum
Elymus hispidus
Epipactis muelleri
Equisetum telmateia
Erysimum odoratum
Euphorbia illirica
Euphorbia virgata
Festuca heterophylla
Festuca rubra
Festuca rupicola
Filipendula vulgaris
Galium album
Galium boreale
Galium pumilum
Galium verum
Genista tinctoria
Gentiana cruciata
Gentiana pneumonanthe
Geranium sanguineum
Gladiolus imbricatus
Gymnadenia conopsea
Hacquetia epipactis
Helianthemum grandiflorum subsp. *obscurum*
Hieracium umbellatum
Hypericum perforatum
Hypochaeris maculata
Inula ensifolia
Inula hirta
Inula salicina
Iris graminea
Iris variegata
Juncus inflexus
Klasea lycopifolia
Knautia kitaibelii
Koeleria macrantha
Koeleria pyramidata
Laserpitium latifolium
Laserpitium prutenicum
Lathyrus latifolius
Lathyrus niger
Lathyrus pannonicus subsp. *collinus*
Leucanthemum margaritae
Libanotis pyrenaica
Lilium bulbiferum
Lilium martagon
Linum catharticum
Linum flavum
Listera ovata
Loranthus europaeus
Lotus maritimus
Medicago falcata
Melampyrum arvense
Melampyrum cristatum
Melampyrum nemorosum
Melica picta
Melittis melissophyllum
Molinia arundinacea
Muscari comosum
Nepeta nuda
Ononis spinosa
Ophioglossum vulgatum
Ophrys apifera
Ophrys holoserica subsp. *holubyana*
Orchis mascula subsp. *speciosa*
Orchis militaris
Orchis morio
Orchis pallens
Orchis purpurea
Orchis ustulata
Origanum vulgare
Ornithogalum brevistylum
Orobanche alba
Orobanche lutea
Peucedanum cervaria
Phleum phleoides
Phlomis tuberosa
Pilosella bauhini
Pilosella densiflora
Pilosella leucopsilon
Pilosella officinarum
Platanthera bifolia
Platanthera chlorantha
Pleurospermum austriacum

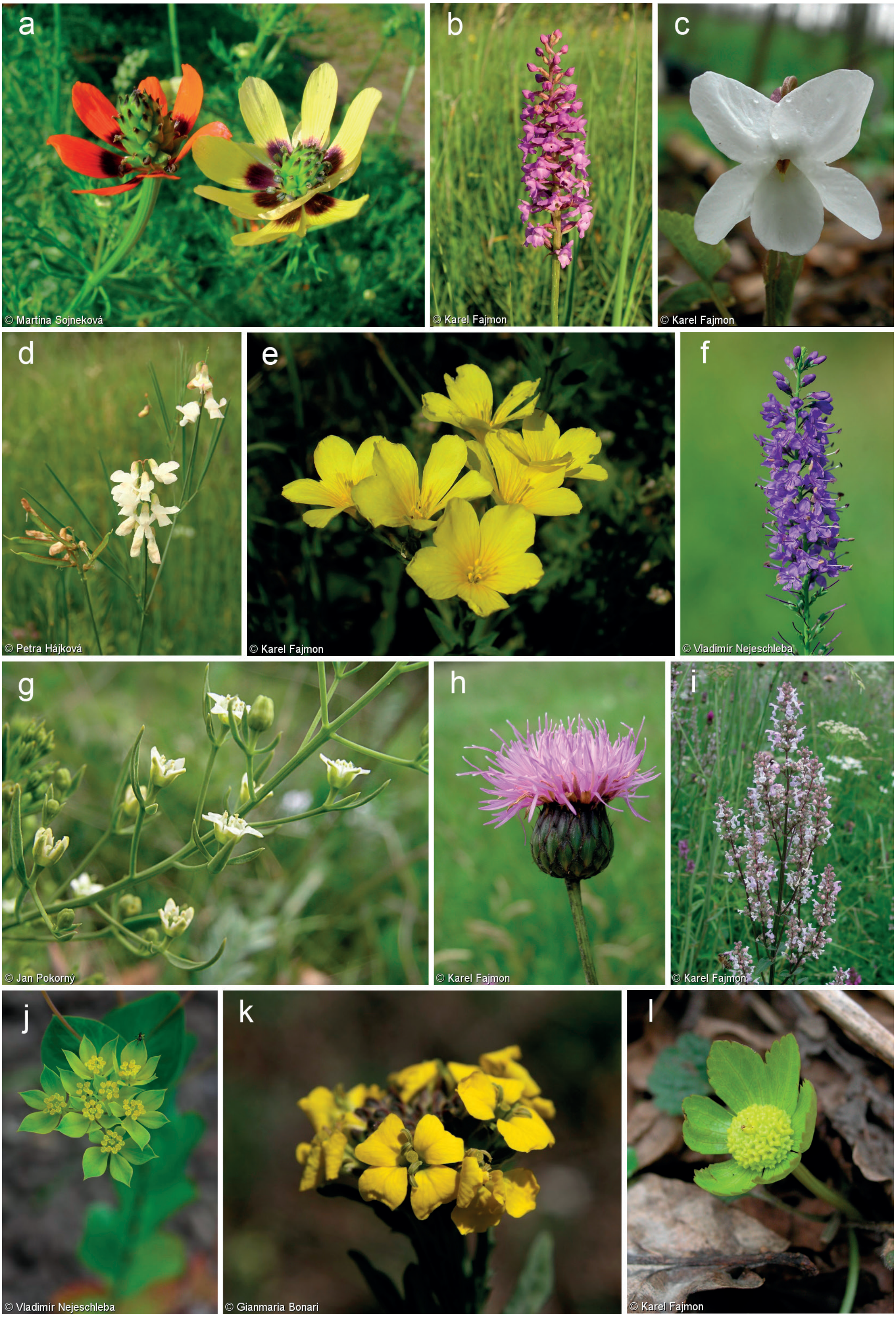


Plate 14b Plants of the Zahrady pod Hájem meadows and adjacent habitats: (a) *Adonis aestivalis*, (b) *Gymnadenia densiflora*, (c) *Viola alba*, (d) *Lathyrus pannonicus*, (e) *Linum flavum*, (f) *Veronica spuria*, (g) *Thesium linophyllon*, (h) *Klasea lycopifolia*, (i) *Nepeta nuda*, (j) *Bupleurum rotundifolium*, (k) *Erysimum odoratum*, (l) *Hacquetia epipactis*.

Poa angustifolia
Polygala major
Polygala multicaulis
Polygonatum multiflorum
Polygonatum odoratum
Potentilla alba
Potentilla erecta
Potentilla heptaphylla
Primula veris
Prunella grandiflora
Prunella laciniata
Pulmonaria angustifolia
Pulmonaria mollis
Pulsatilla grandis
Ranunculus polyanthemos
Rhinanthus major
Rhinanthus minor
Rosa gallica
Salvia pratensis
Salvia verticillata
Sanguisorba minor
Sanguisorba officinalis
Scabiosa ochroleuca
Scilla vindobonensis
Scorzonera hispanica
Scorzonera purpurea
Securigera varia
Selinum carvifolia
Senecio jacobaea
Senecio umbrosus
Serratula tinctoria
Seseli annuum
Silaum silaus
Silene nutans
Solidago virgaurea
Sorbus torminalis
Stachys recta
Staphylea pinnata
Succisa pratensis
Symphytum tuberosum
Tanacetum corymbosum
Thalictrum lucidum
Thalictrum minus
Thalictrum simplex subsp. *galioides*
Thesium linophyllon
Thymus pannonicus
Thymus pulegioides
Tragopogon orientalis
Traunsteinera globosa
Trifolium alpestre
Trifolium medium
Trifolium montanum
Trifolium ochroleucon
Trifolium rubens
Trisetum flavescens
Valeriana stolonifera subsp. *angustifolia*
Veronica orchidea
Veronica spuria
Veronica teucrium
Viburnum lantana
Viburnum opulus
Vicia tenuifolia
Vincetoxicum hirundinaria
Viola alba
Viola canina
Viola hirta

Spring-fen species
Carex distans
Carex flava
Carex paniculata
Dactylorhiza incarnata
Dactylorhiza majalis
Epipactis palustris
Eriophorum angustifolium
Eriophorum latifolium
Gymnadenia densiflora
Succisa pratensis
Taraxacum sect. *Palustria*
Triglochin palustris
Valeriana dioica

Arable weeds
Adonis aestivalis
Allium rotundum
Anthemis cotula
Bifora radians
Bupleurum rotundifolium
Caucalis platycarpos
Conringia orientalis
Euphorbia exigua
Euphorbia falcata
Galium spurium
Galium tricornutum
Kickxia elatine
Kickxia spuria
Lathyrus aphaca (neo)
Neslia paniculata
Nonea pulla
Ranunculus arvensis
Sherardia arvensis
Silene noctiflora
Stachys annua
Thymelaea passerina
Valerianella dentata

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15 Hrubý Jeseník Mountains

Radim Hédl & Martin Kočí

Introduction

Hrubý Jeseník is the second highest mountain range in the Czech Republic (Mount Praděd, 1491 m). It belongs to the Sudetes, a mountain range stretching from eastern Germany to the north-east of the Czech Republic, forming a natural border between Poland and the Czech Republic. It was elevated during the Variscan Orogeny in the Palaeozoic and subsequently flattened by erosion. The Hrubý Jeseník is situated on the borderline between two historical lands, Moravia to the south-west and Silesia to the north-east. The excursion will lead to two remarkable sites at the heart of the main mountain range south of Mount Praděd: Mount Petrovy kameny (1446 m) and the glacial cirque Velká kotlina.

Treeless summits of the Hrubý Jeseník Mountains with grasslands of Avenella flexuosa and heathlands of Calluna vulgaris and Vaccinium myrtillus. Photo M. Kočí.

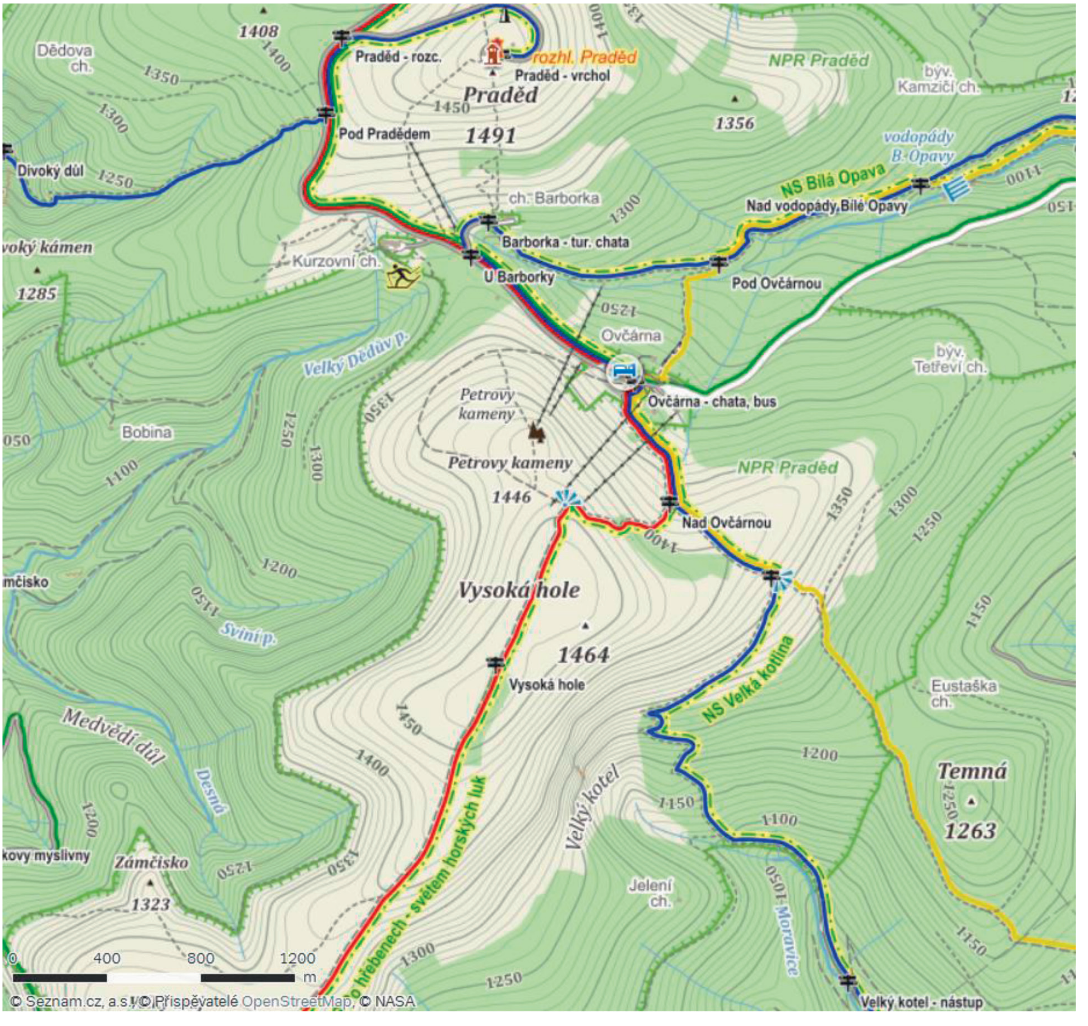
Geology, soils and climate

The Hrubý Jeseník Mountains are formed mainly of metamorphic siliceous rocks including phyllite, gneiss and schist. Acidic soils ranging from cambisols to podzols and leptosols generally dominate the area. The soils of the treeless summits are relatively shallow and stony. In these conditions, the prevailing soil types are dystric cambisols and skeletic podzols. The climate is temperate, with cold winters and cool summers. At the summit of the Hrubý Jeseník, the mean annual temperature is about 1 °C and the annual precipitation sum is about 1200 mm. There are 200 rainy days annually, while the snow cover lasts on average for 167 days at the climate station on Mount Praděd (Tejnská & Tejnský 1972; Lednický et al. 1973).

Landscape history

The natural upper timberline in the Hrubý Jeseník Mountains runs at an altitude of about 1350 m and is formed by small clumps of *Picea abies*. In glacial cirques, it can be also formed by *Fagus sylvatica* or *Betula carpatica*. The timberline is characterized by the natural absence of the dwarf mountain pine (*Pinus mugo*), which commonly occurs on the timberline in other Central European mountain ranges such as the Krkonoše Mountains (the highest mountain group of the Sudetes), the Carpathians and the Alps. The combination of diffuse, spruce-formed timberline with treeless alpine grasslands gives the main range of the Hrubý Jeseník Mts its unique appearance (Jeník & Hampel 1992).

The whole area has been subjected to human impact for several hundred years. This has included mountain summer grazing, hay making and forest cutting (Rybníček & Rybníčková 2004). The natural timberline has been artificially lowered during the last two millennia, chiefly to make space for livestock grazing (Treml et al. 2008; Novák et al. 2010). The mean altitude of the timberline in the Hrubý Jeseník is currently 1310 m, with a maximum of 1405 m (Treml & Banaš 2000). There were several chalets and cattle watering sites in the close surroundings of both Velká kotlina and Petrovy kameny. Pasturing continued until the 1940s. The current vegetation is characterized by forests, mountain meadows and pastures, alpine grasslands and heathlands and patches of mires. Forests cover about 80% of the Hrubý Jeseník Mountains, dominated by Norway spruce (*Picea abies*) and European beech (*Fagus sylvatica*).



The summit area of the Hrubý Jeseník Mountains with the mountains Praděd, Petrovy kameny, Vysoká hole and the Velká kotlina (= Velký kotel) glacial cirque.

Nature conservation

The summit area of the Hrubý Jeseník came under conservation, with six small nature reserves established in the 1940s–1960s being merged into the single 2031-ha *Praděd* reserve in 1991. The *Jeseníky* Protected Landscape Area (744 km^2) was established in 1969. Several areas protected under Natura 2000 have been declared in recent years. Human pressure persists, mainly from tourism and skiing, in spite of strict protection. There is a ski slope leading just beneath the summit of Petrovy kameny. During the 1960s–1990s, the whole Sudetes region underwent a period of air pollution and acid rainfall deposition, lowering the soil pH and affecting biological diversity (Hédl et al. 2011). The abandonment of pasturing has probably decreased the diversity of the grasslands above the timberline, resulting in extensive growths of *Vaccinium myrtillus*.

Plantations of non-native dwarf mountain pine (*Pinus mugo*) and the introduction of chamois (*Rupicapra rupicapra*), both supported by the forest management authorities, are two specific anthropogenic influences. Dwarf pine was introduced in order to elevate the timberline and prevent soil erosion, but it is spreading and beginning to occupy native alpine and subalpine grasslands and heathlands. Pine is also preventing the natural activity of avalanches and landslides. In the most sensitive areas, such as the glacial cirques of Velká kotlina and the adjacent Malá kotlina, pine has mostly been removed by cutting, though it remains elsewhere, still significantly changing local snow conditions. The chamois was brought from the Alps in 1912–1913 and its current population is about 150 animals. It causes damage to rare endemic plants in the Velká kotlina cirque, but its extermination is problematic in view of public resistance. The state enterprise *Forests of the Czech Republic* claim both dwarf pine and chamois to be a valuable heritage left by past generations of foresters.

(15a) Ovčárna chalet and Sedlové peatbog

The starting point of the excursion is the *Ovčárna* chalet (*Schäferei* in German, both meaning *Shepherd Hut*) at an altitude of 1300 m, which is one of the oldest chalets in the Hrubý Jeseník Mountains. Once a relatively modest wooden shepherd's hut and later also a tourist shelter, Ovčárna was built in its current location in 1863 and it has grown into a hotel accessible by an asphalted road. Ovčárna is situated on the slope of Mount Petrovy kameny and above the steep valley slopes of the stream *Bílá Opava* with remnants of pristine mountain spruce forest. Professor Friedrich Kolenati, a distinguished naturalist working in the Hrubý Jeseník in the 19th century, died suddenly at Ovčárna in July 1864.

One of the few summit peatbogs of the Hrubý Jeseník Mountains is located near Ovčárna in the mountain saddle between Mount Praděd and Mount Petrovy kameny. Its unofficial name is *Sedlové rašeliniště* (*Saddle Peatbog*). Raised bogs of the Hrubý Jeseník Mountains are about 6000–7000 years old originating in the Atlantic period (Dudová et al. 2012). The peat layer in *Sedlové rašeliniště* is formed of Sphagna and is only 130 cm deep. This bog is characterized by a hummock-and-hollow microtopography. Hummocks host the associations *Andromedo polifoliae-Sphagnetum magellanici* and *Eriophoro vaginati-Sphagnetum recurvi* (alliance *Sphagnion magellanici*), whereas hollows are occupied by *Carex limosa*, *C. rostrata*, *Eriophorum angustifolium*, forming the vegetation of the association *Drepanoclado fluitantis-Caricetum limosae* (alliance *Sphagnion cuspidati*). The bog is generally species poor, but some interesting species can be found there, in addition to the above-mentioned *Cyperaceae* also *Andromeda polifolia* and *Listera cordata*.

(15b) Mount Petrovy kameny

Mount Petrovy kameny (1446 m) is located in the main range of the Hrubý Jeseník between Mount Praděd and Mount Vysoká hole. It is topped by a seven-metres-high rock (both the Czech name *Petrovy kameny* and the German name *Peterstein* mean *Peter's Rock*). It consists of phyllite and quartzite. The rock itself is not accessible to the public because of the occurrence of rare flora and fauna, most importantly two endemic vascular plant species *Campanula gelida* and *Poa riphaea*. Both species are currently confined to the summit rock and its immediate surroundings (Kaplan 2012; Hoták et al. 2013). The former is related to *Campanula scheuchzeri* growing in the Alps and the latter to *Poa glauca* distributed in the Alps, Scandinavia and the Arctic. Rare plant species occurring on this site include *Anemonastrum narcissiflorum*, *Campanula rotundifolia* subsp. *sudetica* (endemic to the Sudetes), *Cardamine resedifolia*, *Hieracium chrysostyloides* (endemic to the Eastern Sudetes) and *Salix herbacea*.

A slope of Mount Petrovy kameny above the Ovčárna chalet with subalpine tall-forb vegetation with Adenostyles alliariae. Photo M. Kočí.

The vegetation around the summit rock on Petrovy kameny can be characterized as alpine tundra. It is a cold, treeless environment with abundant precipitation and long-lasting snow cover, although the snow on the windward slopes and summits is often swept by strong winds to leeward sites with subalpine tall-forb vegetation (Kočí 2001). The uneven distribution of snow cover on the treeless summit of the Hrubý Jeseník Mountains largely determines the distribution of plant communities (Klimešová 1993). Typical species of these communities are short grasses including *Avenella flexuosa*, *Festuca supina* and *Nardus stricta*. Alpine heathlands are another important component of alpine tundra and include *Calluna vulgaris*, *Empetrum hermaphroditum*, *Vaccinium myrtillus* and *V. vitis-idaea*. *Carex bigelowii*, *Ligusticum mutellina* and *Homogyne alpina* are other characteristic species. The tall-forb vegetation of lower slopes bordering the timberline spruce forests is dominated by abundant populations of *Athyrium distentifolium*. Several rare species of *Hieracium* can be found in the alpine tundra, e.g. *H. alpinum*, *H. chlorocephalum* and *H. stygium*. *Viola lutea* subsp. *sudetica* (endemic to Central European mountain areas), *Bistorta officinalis*, *Campanula barbata* and *Gentiana punctata* (once nearly extinct due to collection for medicinal purposes) are also characteristic flowering components of the local alpine tundra. Endemic butterflies *Erebia sudetica sudetica* and *E. epiphron* are also worth mentioning (Kuras et al. 2001).

Plant communities occurring on the summit and upper slopes of Petrovy kameny can be described in terms of the Braun-Blanquet system as follows. The alpine heathland belongs to the associations *Avenello flexuosae-Callunetum vulgaris* and *Junco trifidi-Empetretum hermaphroditi* (alliance *Loiseleurio procumbentis-Vaccinion*). The alpine grasslands of the alliance *Juncion trifidi* comprise the associations *Cetrario-Festucetum supinae* on wind-exposed sites and *Carici bigelowii-Nardetum strictae* in better-protected places with slightly deeper snow cover. The tall-forb communities of the lower slopes near *Ovčárna* belong to the class *Mulgedio-Aconitetea*, mainly to fern communities of the alliance *Dryopterido filicis-maris-Athyrion distentifolii*. Plantations of non-native dwarf mountain pine are floristically and physiognomically analogous to the natural stands of the association *Dryopterido dilatatae-Pinetum mugo* (alliance *Pinion mugo*).

Plate 15a–b Plants of the summit area of the Hrubý Jeseník Mountains (surrounding of the Ovčárna chalet, Sedlové peatbog and Mount Petrovy kameny): (a) *Eriophorum vaginatum*, (b) *Carex limosa*, (c) *Andromeda polifolia*, (d) *Listera cordata*, (e) *Carex pauciflora*, (f) *Empetrum hermaphroditum*, (g) *Carex bigelowii*, (h) *Bistorta officinalis*, (i) *Salix herbacea*, (j) *Campanula gelida*, (k) *Cardamine resedifolia*, (l) *Poa riphaea*.

The top of Mount Petrovy kameny with the rock outcrop of the same name. Mount Praděd, the highest mountain in the Hrubý Jeseník, in the background. Photo M. Kočí.

(15c) Velká kotlina cirque

Introduction

The glacial cirque of Velká kotlina is the most prominent botanical locality in the Hrubý Jeseník Mountains. Similar cirques in Central Europe can be found from the Vosges in eastern France to the Eastern Carpathians in Ukraine, often hosting a similar composition of plant species and communities. The floristic richness and uniqueness of Velká kotlina had already been recognized and reported by early botanists in the late 18th century (Jeník et al. 1983). Velká kotlina is not a purely natural environment. It was visited and influenced by humans early in history, for example there was a cattle stable nearby. Velká kotlina was declared State Nature Reserve in 1955 and became part of the large *Praděd* National Nature Reserve, a strictly protected area with limited human intervention, in 1991.

Velká kotlina is situated at altitudes of between 1100 and 1464 m, on the south-eastern slope of the main range of the Hrubý Jeseník Mountains. It comprises a range of ecological conditions taking in wind-swept upper slopes, steep rocky slopes, and shrubberies and forests on the lower slopes and bottom. There is a strong accumulation of snow in this leeward valley with the last remnants remaining until early summer. Snow accumulation and subsequent erosion can also be factors of long-term shaping of the cirque, besides local glacier detectable by relics of two moraines (Steffanová 2010). An important biodiversity hotspot is the rock outcrops in the centre of the cirque because of the admixture of calcium carbonate and crystalline limestone particles to the otherwise prevailing acidic phyllite. Habitat diversity is further enhanced by the presence of 43 springs and resulting streams. Avalanches are an environmental factor of key importance. They regularly disturb vegetation and the soil surface and prevent trees growing below the natural timberline in the central part of the cirque, allowing only shrubs or herbs to become established on suitable sites.

The Velká kotlina cirque is the most species-rich botanical locality in the Sudetes. Its central part is naturally treeless due to disturbance by avalanches. Shrubberies and woodlands of Salix silesiaca and Betula carpatica develop on slopes with a lower frequency of avalanches. Photo M. Kočí.

Vegetation

The plant communities of Velká kotlina were systematically surveyed by Jeník et al. (1980). They distinguished 29 associations (including 16 newly described) belonging to 15 alliances and 10 classes of the Braun-Blanquet system. Some of them were delimited too narrowly and are not recognized in recent literature, but others represent meaningful concepts accepted in further revisions. The vegetation on base-rich rock outcrops is represented by the association *Saxifrago paniculatae-Agrostietum alpinae* (alliance *Agrostion alpinae*), described from this locality and endemic to Velká kotlina. Communities of snow beds (class *Salicetea herbaceae*) are not present in typical form; *Salix herbacea* occurs on rock outcrops and wind-swept grasslands of the alliance *Juncion trifidi*. The upper slopes of the main range of the Hrubý Jeseník and suitable sites on the lower slopes within the cirque are covered with *Nardus stricta* grasslands and heathlands. The most important associations are *Festuco supinae-Nardetum strictae* and *Thesio alpini-Nardetum strictae* of nutrient-enriched and moist locations (this species-rich association was described from this locality), both belonging to the alliance *Nardion strictae*, and *Festuco supinae-Vaccinietum myrtilli* (alliance *Genisto pilosae-Vaccinion*) characterized by dense coverage of *Vaccinium myrtillus*.

A true richness of vegetation types can be observed in the tall-forb vegetation of the class *Mulgedio-Aconitetea*. Five alliances follow the ecological gradient from the valley bottom to the upper slopes. The alliance *Calamagrostion villosae* represents species-poor tall grasslands, the main association being *Crepido conyzifoliae-Calamagrostietum villosae*. The alliance *Calamagrostion arundinaceae* with the association *Bupleuro longifolii-Calamagrostietum arundinaceae* includes nutrient- and species-rich communities with many rare species. The alliance *Adenostylion alliariae* represents vegetation of nutrient-rich, moist soils with many species of broad-leaved forbs. A characteristic association is *Ranunculo platanifolii-Adenostyletum alliariae*; two other associations of this luxuriant, species-rich vegetation, *Laserpitio archangelicae-Dactylidetum glomeratae* and *Trollio altissimi-Geranietum sylvatici*, are probably endemic to the Hrubý Jeseník Mountains and are best developed in Velká kotlina. The alliance of subalpine fall-fern vegetation *Dryopterido filicis-maris-Athyrion distentifolii* includes the associations *Adenostylo alliariae-Athyrietum distentifolii* and *Daphno mezerei-Dryopteridetum filicis-maris*. Finally the alliance of the subalpine deciduous shrublands, *Salicion silesiacae* with the association *Salici silesiacae-Betuletum carpaticae*, occurs in the Hrubý Jeseník mainly here and occupies less-frequented avalanche tracks.

Vegetation of numerous springs in Velká kotlina can be classified to the class *Montio-Cardaminetea* and the alliance *Swertio perennis-Dichodontion palustris*. Three associations found here are *Crepido paludosae-Philonotidetum seriatae* (with a prevalence of mosses), *Swertietum perennis* and *Cardaminetum* *opicii*. There are also fens, including a peculiar association *Bartsio alpinae-Caricetum nigrae* (alliance *Caricion canescenti-nigrae*) which comprises a mixture of fen and spring species.

Forest vegetation is developed at the edges of the cirque and surrounding slopes. It includes mountain conifer forests (alliance *Piceion abietis*), partly left to natural development, and deciduous and mixed forests, mostly acidophilous and mesic beech forests (alliances *Fagion sylvaticae* and *Luzulo-Fagion sylvaticae*). Rare vegetation of the association *Athyrio distentifolii-Fagetum sylvaticae* combines elements of beech forests and tall-forb vegetation.

Flora

The floristic diversity of the Velká kotlina cirque has been studied for more than two hundred years and extensive information has been accumulated. A critical field revision of the flora of Velká kotlina in 1971–1978 by Jeník et al. (1983) confirmed the occurrence of 356 species, subspecies and hybrids of vascular plants on an area of about just 1 km^2, while records of 283 taxa listed in the literature were not confirmed in the field. Of these 126 probably occurred historically, while 157 taxa were doubtful. Some corrections have been made since this revision, for example Kočí (2005) counted 385 species verified in the field or documented in reliable recent literature. A realistic estimate of the floristic richness of the site is between 350 and 500 vascular plant species. In addition, over 320 species of bryophytes were confirmed recently (Kučera et al. 2009) and the surveys of various groups of animals also reported a high species diversity.

Plantago atrata subsp. *sudetica* and *Dianthus carthusianorum* subsp. *sudeticus* are two endemic subspecies occurring solely on the rocks of Velká kotlina. In addition, *Carlina biebersteinii* subsp. *sudetica* is endemic to the site and a few sites in the close surroundings (Bureš 2013). Two species with a broad Eurasian continental distribution, *Conioselinum tataricum* and *Crepis sibirica*, have their westernmost isolated localities in the Hrubý Jeseník Mountains. Species typical of lowland habitats, reaching their altitudinal maxima for the Czech Republic in Velká kotlina include *Campanula persicifolia*, *Carex montana*, *Convallaria majalis*, *Gagea lutea*, *G. minima* and *Prunella grandiflora*. In contrast, *Agrostis alpina*, *Carex bigelowii*, *Hieracium alpinum*, *Juncus trifidus* and *Salix herbacea* are species typical of alpine habitats. *Hieracium villosum*, *Polystichum lonchitis*, *Rhodiola rosea* and *Thymus pulcherrimus* subsp. *sudeticus* can be named among the rare species with preference of base-rich substrates (Bureš & Burešová 1989).

The great botanical diversity of the Velká kotlina cirque

The extreme species richness and uniqueness of Velká kotlina has been a puzzle for generations of botanists, zoologists and ecologists. Common species intermingle with extremely rare species, some of which have here a single occurrence in the Czech Republic or Central Europe. Alpine and subalpine species can be found together with species normally growing at low altitudes forming luxuriant vegetation. Various ecological extremes can be found in a relatively small area. There is probably a complex of factors contributing to the unique combination of species and their assemblages, with avalanches, geology, the presence of many streams and relatively warm conditions due to the leeward position of Velká kotlina being the most important (Klimeš & Rauch 1997).

In an attempt to explain the great floristic and vegetation diversity of the glacial cirques of the Sudetes, Jeník (1961) proposed a theory that these cirques (there are about ten similar sites in the Krkonoše and Hrubý Jeseník Mountains) are part of *anemo-orographic systems*. Such systems consist of three main components: (1) a valley on the west-facing slope open to the direction of prevailing winds, into which air masses are forced and accelerate when reaching a mountain range; (2) flat plateaus on the mountain summits, typical of these old mountain ranges, where the wind speed is highest; (3) glacial cirques on the leeward side of the mountain range where air streams slow down and release solid particles brought from a distance. These may be dust, snow or seeds and other plant propagules. Rich soils on the cirque bottom, snow accumulation and avalanches result directly from these processes. Wind dispersal of plant propagules may be responsible for isolated localities of lowland species in the cirques. Snow accumulation and subsequent erosion may also be factors in the long-term shaping of the Velká kotlina cirque, as the presence of a true glacier moraine is uncertain.

Appendix 15 Selected species of vascular plants in the summit area of the Hrubý Jeseník Mountains near the Ovčárna chalet, on the Sedlové peatbog, Mount Petrovy kameny and in the Velká kotlina cirque.

Acer pseudoplatanus
Achillea millefolium subsp. *sudetica*
Aconitum lycoctonum
Aconitum plicatum
Aconitum variegatum
Adenostyles alliariae
Agrostis alpina
Alchemilla glabra
Allium schoenoprasum
Allium victorialis
Alnus alnobetula (introduced)
Andromeda polifolia
Anemone ranunculoides
Anemonastrum narcissiflorum
Antennaria dioica
Arabidopsis arenosa
Arabis sudetica
Aruncus dioicus
Asplenium viride
Aster alpinus
Athyrium distentifolium
Athyrium filix-femina
Avenella flexuosa
Bartsia alpina
Betula carpatica
Blechnum spicant
Bistorta officinalis
Botrychium lunaria
Bupleurum longifolium subsp. *vapincense*
Calamagrostis arundinacea
Calamagrostis villosa
Calluna vulgaris
Campanula barbata
Campanula gelida
Campanula latifolia
Campanula persicifolia
Campanula rotundifolia subsp. *sudetica*
Cardamine amara subsp. *opicii*
Cardamine resedifolia
Carduus personata
Carex aterrima
Carex atrata
Carex bigelowii
Carex buxbaumii
Carex capillaris
Carex demissa
Carex flava
Carex lepidocarpa
Carex limosa
Carex montana
Carex pauciflora
Carex rostrata
Carex vaginata
Carlina acaulis
Carlina biebersteinii subsp. *sudetica*
Cerastium fontanum
Cicerbita alpina
Cirsium heterophyllum
Cirsium palustre
Coeloglossum viride
Conioselinum tataricum
Convallaria majalis
Corallorhiza trifida
Corydalis cava
Corylus avellana
Cotoneaster integerrimus
Crepis conyzifolia
Crepis mollis subsp. *mollis*
Crepis sibirica
Dactylorhiza fuchsii var. *psychrophila*
Daphne mezereum
Delphinium elatum
Deschampsia cespitosa
Dianthus carthusianorum subsp. *sudeticus*
Dianthus superbus subsp. *alpestris*
Digitalis grandiflora
Doronicum austriacum
Drosera rotundifolia
Dryopteris expansa
Dryopteris filix-mas
Empetrum hermaphroditum
Epilobium alpestre
Epilobium alsinifolium
Epilobium anagallidifolium
Epilobium nutans
Eriophorum angustifolium
Eriophorum latifolium
Eriophorum vaginatum
Euphrasia officinalis subsp. *picta*
Fagus sylvatica
Festuca supina
Filipendula ulmaria
Gagea lutea
Gagea minima
Gentiana punctata
Gentiana verna
Geranium sylvaticum
Gnaphalium norvegicum
Gymnadenia conopsea
Hedysarum hedysaroides
Helianthemum grandiflorum subsp. *grandiflorum*
Helictochloa planiculmis
Hieracium alpinum
Hieracium engleri
Hieracium inuloides
Hieracium prenanthoides
Hieracium silesiacum
Hieracium villosum
Homogyne alpina
Hylotelephium maximum
Hypochaeris uniflora
Juncus squarrosus
Juncus trifidus
Juniperus communis subsp. *nana*
Laserpitium archangelica
Ligusticum mutellina
Lilium martagon
Listera cordata
Listera ovata
Lunaria rediviva
Luzula sudetica
Luzula sylvatica
Lycopodium clavatum
Maianthemum bifolium
Milium effusum
Molinia caerulea
Moneses uniflora
Nardus stricta
Paris quadrifolia
Parnassia palustris
Phleum alpinum
Phyteuma orbiculare
Phragmites australis
Picea abies
Pilosella aurantiaca
Pinguicula vulgaris
Pinus mugo (introduced)
Plantago atrata subsp. *sudetica*
Pleurospermum austriacum
Poa alpina
Poa chaixii
Poa riphaea
Polygonatum verticillatum
Polystichum lonchitis
Potentilla aurea
Potentilla erecta
Primula elatior
Prunella grandiflora
Pseudorchis albida
Pyrola minor
Ranunculus platanifolius
Rhinanthus riphaeus
Rhodiola rosea
Ribes alpinum
Rosa pendulina
Rubus saxatilis
Rumex arifolius
Sagina saginoides
Salix hastata
Salix herbacea
Salix silesiaca
Saxifraga paniculata
Scrophularia scopolii

Sedum alpestre
Scabiosa lucida subsp. *lucida*
Scorzonera humilis
Sedum alpestre
Selaginella selaginoides
Solidago virgaurea subsp. *minuta*
Sorbus aucuparia var. *glabrata*
Stachys alpina
Streptopus amplexifolius
Swertia perennis
Tephroseris crispa
Thalictrum minus
Thelypteris limbosperma
Thesium alpinum
Thymus pulcherrimus subsp. *sudeticus*
Tilia platyphyllos
Traunsteinera globosa
Trichophorum alpinum
Trientalis europaea
Trollius altissimus
Vaccinium myrtillus
Vaccinium oxycoccos
Vaccinium uliginosum
Vaccinium vitis-idaea
Valeriana tripteris
Veratrum album subsp. *lobelianum*
Viola biflora
Viola lutea subsp. *sudetica*
Viola palustris

Praděd (1491 m), the highest mountain of Moravia with Picea abies forest and alpine grasslands above the timberline. The tall fern in the foreground is Athyrium distentifolium. Photo M. Kočí.

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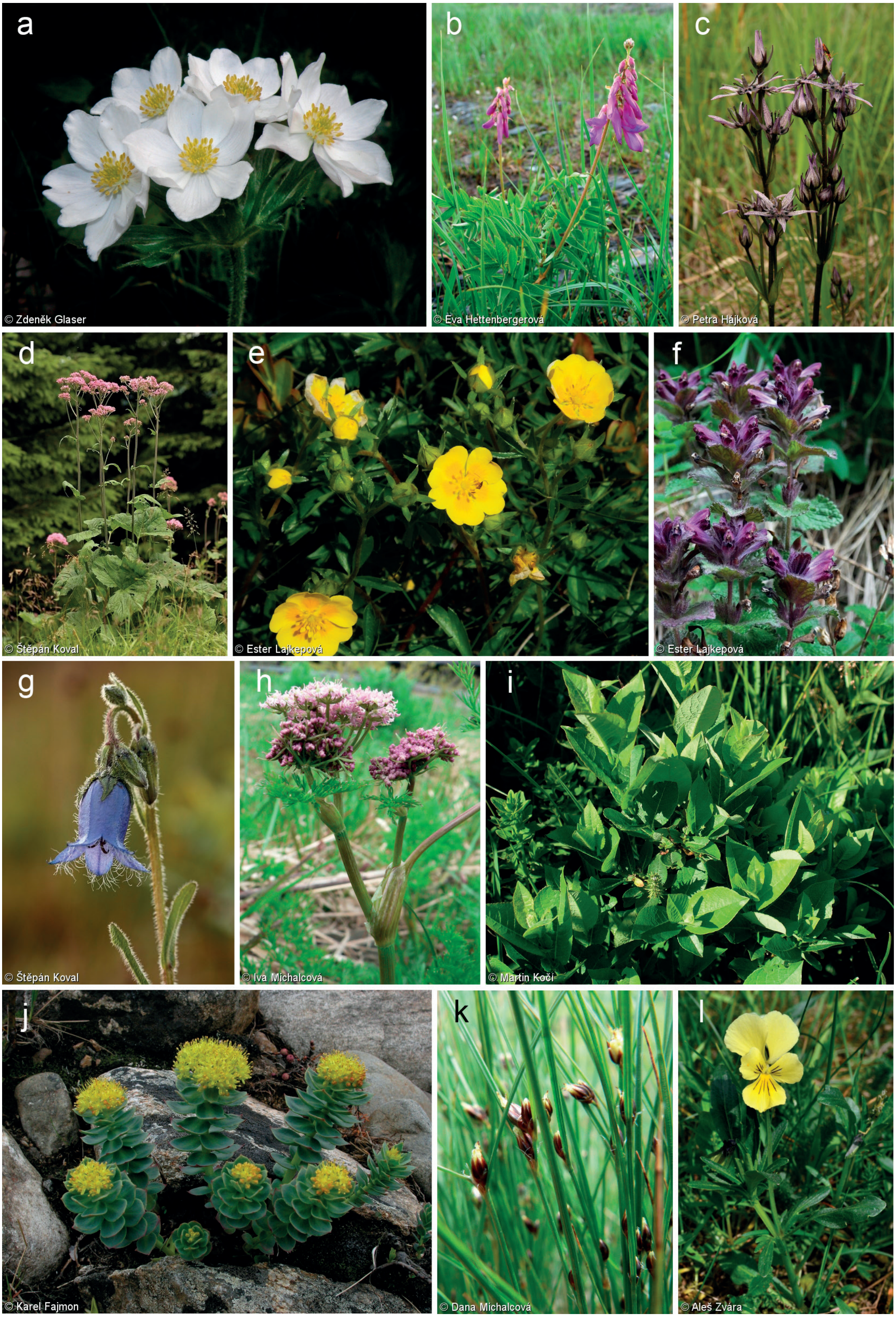

Plate 15c Plants of the Velká kotlina cirque: (a) *Anemonastrum narcissiflorum*, (b) *Hedysarum hedysaroides*, (c) *Swertia perennis*, (d) *Adenostyles alliariae*, (e) *Potentilla aurea*, (f) *Bartsia alpina*, (g) *Campanula barbata*, (h) *Ligusticum mutellina*, (i) *Salix hastata*, (j) *Rhodiola rosea*, (k) *Juncus trifidus*, (l) *Viola lutea* subsp. *sudetica*.

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16 Botanical Garden of the Faculty of Science, Masaryk University, Brno

Magdaléna Chytrá & Milan Chytrý

Introduction

The Botanical Garden of the Faculty of Science, Masaryk University, is located near Brno's centre at the intersection of the streets Kotlářská and Veveří, adjacent to the Faculty of Science's Kotlářská Campus. The garden was founded in 1922 by Josef Podpěra, the first Professor of Botany at the newly established Masaryk University (founded in 1919), on a 1.5-ha plot that was previously used as the kitchen garden of the former almshouse whose buildings were transferred to the new Faculty of Science (Vacek & Bureš 2001). Being mainly a plant geographer, Podpěra designed the garden following both systematic and ecological-phytogeographical principles. The systematic part of the garden contained plants arranged by families, though there were also displays of the Linnaean system, Mendel's hybridization experiments, and medicinal and crop plants. The ecological-phytogeographical part represented major plant communities of southern Moravia and Central European mountain ranges and examples of various plant formations of temperate Eurasia. This original historical design has, with small changes, been maintained to this day. The first three greenhouses were built in 1924–1926, one with a pool for *Victoria regia* which first came into bloom in 1926 and immediately became an extremely popular attraction with the people of Brno. The garden was damaged during WWII by bombing by Allied air forces and by tree cuttings, but was restored after the war. In the late 1940s and 1950s, it was involved in applied projects to support socialist agriculture, in particular an attempt to introduce almond plantations in southern Moravia, though it later resumed its primary focus on education. The current greenhouses were built in 1995–1997. Although the Department of Botany and Zoology was moved from the Kotlářská Campus in 2006, the garden remains in this original location and also serves the public and other education institutions in addition to Masaryk University.

Greenhouses at the Botanical Garden of the Faculty of Science, Masaryk University, in Brno city centre. Photo M. Chytrá.

The garden is a popular place in the city of Brno, regularly visited by many people. It is open daily throughout the year, with free access to the outdoor section and a moderate entrance fee to the greenhouses. The garden organizes annual exhibitions of carnivorous plants (May), succulents (September), tropical and subtropical crop plants (October) and exotic birds (November). Perhaps the most attractive annual event in the garden for the general public is the Jazz Evening held in August when *Victoria cruziana* opens its flowers after sunset. There are many sculptures and other art works in the garden, both in the greenhouses and outdoors. The oldest is a frog sculpture with a fountain from 1947 at one of the pools. The compositions made from various rock types in front of the greenhouses were built by the sculptor Jan Šimek in 1997 (Chytrá 2012).

About 2500 plant species have been planted in the outdoor collections and another 2500 species in the greenhouses. The garden and the adjacent area of the Faculty of Science's Kotlářská Campus together harbour more than 1000 individuals of 520 species of woody plants and recent surveys recorded 48 species of bryophytes and more than 90 species of macromycetes (Chytrá 2012).

Outdoor collections

The outdoor plant collections include the Plant System with about 1500 species from 85 families of vascular plants situated on an area of 0.3 ha in front of the greenhouses. There is also an example of the Linnaean System. The remaining outdoor parts of the garden comprise plant assemblages organized according to ecological and phytogeographical principles following the original design of Josef Podpěra (Chytrá et al. 2010; Chytrá 2012). The plant communities of southern Moravia and mountains of Central Europe are represented for example by:

- *Oak-hornbeam forest*, the predominant type of potential natural vegetation of southern Moravia, with trees of *Carpinus betulus* and *Quercus petraea*, shrubs of *Acer campestre* and *Ligustrum vulgare*, herbaceous species such as *Hepatica nobilis*, *Pulmonaria obscura*, *Stellaria holostea* and spring geophytes including *Anemone nemorosa*, *A. ranunculoides*, *Corydalis cava* and *Isopyrum thalictroides.*
- *Carpathian beech forest* with species typical of the mountain forests of eastern Moravia and Slovakia, in addition to *Fagus sylvatica* most notably *Carex pilosa*, and also *Actaea spicata*, *Dentaria bulbifera*, *Galium odoratum*, *G. sylvaticum*, *Hordelymus europaeus*, *Polygonatum multiflorum* and *Viola reichenbachiana*.
- *Montane spruce forest and tall-forb grassland* give an impression of the mountain vegetation of the Western Carpathians and the Sudetes, including *Picea abies*, shrubs of *Lonicera nigra* and *Rosa pendulina*, numerous ferns (e.g. *Athyrium filix-femina*, *Dryopteris filix-mas* and *Polystichum aculeatum*) and tall herbs such as *Aruncus dioicus*, *Cicerbita alpina* and *Veratrum album* subsp. *lobelianum*.
- *Floodplain forest and meadow* containing, in particular, the flora of the lower Dyje and Morava floodplains in southern Moravia, e.g. *Euphorbia lucida*, *E. palustris*, *Filipendula ulmaria*, *Gratiola officinalis*, *Iris pseudacorus*, *Leucojum aestivum* and *Lythrum salicaria*.
- *Forest-steppe vegetation* represents famous sites in southern Moravia, notably the Pavlov Hills and the Pouzdřany Steppe. These plant groups include various species of *Festuca* and *Stipa*, *Adonis vernalis*, *Allium flavum*, *Iris pumila*, *Potentilla incana* and many other continental or southern European species.
- *Sand-dune vegetation* gives an impression of the sand-dune area near the Morava River between the towns of Hodonín and Bzenec in south-eastern Moravia and in south-western Slovakia, with species such as *Armeria elongata*, *Dianthus serotinus*, *Gypsophila paniculata* and *Peucedanum oreoselinum*.
- *Serpentinite vegetation* is a representation of the Mohelno Serpentinite Steppe in south-western Moravia, including *Allium flavum*, *Bothriochloa ischaemum*, *Festuca pallens*, *Genista pilosa*, *Stipa dasyphylla* and *Teucrium chamaedrys*.
- *Mire vegetation* presents examples of species of Central European bogs and minerotrophic mires with various species of *Carex* and *Eriophorum*, and *Menyanthes trifoliata* in pools.
- *Aquatic and wetland vegetation* is displayed in several garden pools, including species typical of wetlands in the Dyje and Morava River floodplains in southern Moravia. *Stratiotes aloides* is a remarkable species that was introduced to the garden from southern Moravian floodplain pools before WWII. It later became extinct in the wild and the native plant material preserved in the garden was used as a source for the re-establishment of its populations on original sites.

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- *Weed vegetation of arable land* is presented in a small cereal field, including both common weeds and those that have experienced a dramatic decline in Central Europe due to agricultural intensification since the mid-20th century.

The geographical plant groups include *European temperate mountain flora* displaying plants from the Alps, Carpathians, Pyrenees and Apennines, *Balkan mountain flora*, *Eurasian continental temperate flora* (the Caucasus, Siberia and the Himalayas), *East Asian temperate flora* (mainly China and Japan), *Mediterranean and sub-Mediterranean flora* and a group of *North American woody plants*. There is a roof garden on the top of the greenhouses featuring succulents and other drought-adapted plants.

Garden section with Japanese and East Asian temperate flora. Photo M. Chytrá.

Greenhouses

The greenhouses consist of five tunnel-like structures of which the largest (10.5 m high) is situated in the middle. Four are used for public exhibition and the fifth serves as a nursery. The total area of the greenhouses is 1200 m^2. The following collections are harboured in the greenhouses:

- *The tropical collection* is dominated by a pool with the South American nymphaeoid *Victoria cruziana* which has replaced *V. regia* planted in the old greenhouse in the 1920s–1930s. Other items in the collection are mainly various crops and ornamental plants such as *Begonia*, *Carica papaya*, *Cocos nucifera*, *Cyperus papyrus*, *Gossypium*, *Musa*, *Pandanus*, *Sarracenia*, *Theobroma cacao*, *Vanilla planifolia* and various orchids.
- *The collection of ferns*, *fern allies and cycads* includes *Blechnum*, *Dicksonia*, *Lygodium*, *Platycerium*, *Selaginella*, *Ceratozamia mexicana*, *Cycas circinalis*, *C. revoluta*, *Dioon edule*, *Encephalartos altensteinii*, *E. villosus*, *Stangeria eriopus* and *Zamia furfuracea*.
- *The subtropical and Mediterranean collection* with evergreen shrubs and trees, palms and lianas displays species such as *Araucaria bidwillii*, *A. cunninghamii*, *Bougainvillea glabra*, *Ceratonia siliqua*, *Chamaerops humilis*, *Eriobotrya japonica*, *Eucalyptus camaldulensis*, *Laurus nobilis*, *Myrtus communis*, *Olea europaea*, *Passiflora edulis*, *Podocarpus neriifolius*, *P. salicifolius*, *Strelitzia nicolai*, *Vitis voinieriana*, *Washingtonia filifera* and the recently added *Wollemia nobilis*, an Australian ‘living fossil’ from the *Araucariaceae* family.

- *The Bromeliaceae collection* contains *Aechmea*, *Ananas commosus*, *Billbergia*, *Guzmania*, *Neoregelia*, *Tillandsia* and many others.
- *The collection of Cactaceae and other succulents* tends to be the most highly appreciated by visitors. It displays *Agave*, *Aloe*, *Echinocactus grusonii*, *Haworthia*, *Nolina recurvata*, *Opuntia* and many other species of *Cactaceae*, *Crassulaceae* and *Euphorbiaceae*.

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List of vegetation units mentioned in the text

The following list contains vegetation units of the Braun-Blanquet phytosociological system mentioned in the text with author citations and position in the syntaxonomical hierarchy of classes (two-letter codes), alliances (three-letter codes) and associations (five-character codes). The concept, nomenclature and coding of syntaxa follows the monograph *Vegetation of the Czech Republic* (Chytrý 2007–2013). Note that this is *not* a complete list of vegetation units occurring at the excursion sites.

AA. *Loiseleurio-Vaccinietea* Eggler ex Schubert 1960
Alpine heathlands
AAA. *Loiseleurio procumbentis-Vaccinion* Br.-Bl. in Br.-Bl. et Jenny 1926
AAA01. *Avenello flexuosae-Callunetum vulgaris* Zlatník 1925
AAA02. *Junco trifidi-Empetretum hermaphroditi* Šmarda 1950

AB. *Juncetea trifidi* Hadač in Klika et Hadač 1944
Alpine grasslands on base-poor soils
ABA. *Juncion trifidi* Krajina 1933
ABA01. *Cetrario-Festucetum supinae* Jeník 1961
ABB. *Nardo strictae-Caricion bigelowii* Nordhagen 1943
ABB01. *Carici bigelowii-Nardetum strictae* (Zlatník 1928) Jeník 1961

AC. *Elyno-Seslerietea* Br.-Bl. 1948
Alpine grasslands on base-rich soils
ACA. *Agrostion alpinae* Jeník et al. 1980
ACA02. *Saxifrago paniculatae-Agrostietum alpinae* Jeník et al. 1980

AD. *Mulgedio-Aconitetea* Hadač et Klika in Klika et Hadač 1944
Subalpine tall-forb and deciduous-shrub vegetation
ADA. *Calamagrostion villosae* Pawłowski et al. 1928
ADA02. *Crepido conyzifoliae-Calamagrostietum villosae* (Zlatník 1925) Jeník 1961
ADB. *Calamagrostion arundinaceae* (Luquet 1926) Jeník 1961
ADB01. *Bupleuro longifolii-Calamagrostietum arundinaceae* (Zlatník 1928) Jeník 1961
ADC. *Salicion silesiacae* Rejmánek et al. 1971
ADC01. *Salici silesiacae-Betuletum carpaticae* Rejmánek et al. 1971
ADD. *Adenostylion alliariae* Br.-Bl. 1926
ADD01. *Ranunculo platanifolii-Adenostyletum alliariae* (Krajina 1933) Dúbravcová et Hadač ex Kočí 2001
ADD03. *Trollio altissimi-Geranietum sylvatici* Jeník et al. 1980
ADD04. *Laserpitio archangelicae-Dactylidetum glomeratae* Jeník et al. 1980
ADE. *Dryopterido filicis-maris-Athyrion distentifolii* (Holub ex Sýkora et Štursa 1973) Jeník et al. 1980
ADE01. *Daphno mezerei-Dryopteridetum filicis-maris* Sýkora et Štursa 1973
ADE02. *Adenostylo alliariae-Athyrietum distentifolii* (Zlatník 1928) Jeník 1961

TA. *Crypsietea aculeatae* Vicherek 1973
Vegetace jednoletých halofilních travin
Vegetation of annual graminoids in saline habitats
TAA. *Cypero-Spergularion salinae* Slavnić 1948
TAA01. *Crypsietum aculeatae* Wenzl 1934

TB. *Thero-Salicornietea strictae* Tüxen in Tüxen et Oberdorfer 1958
Vegetace jednoletých sukulentních halofytů
Vegetation of annual succulent halophytes
TBA. *Salicornion prostratae* Géhu 1992
TBA01. *Salicornietum prostratae* Soó 1964

TD. *Molinio-Arrhenatheretea* Tüxen 1937
Meadows and mesic pastures
TDA. *Arrhenatherion elatioris* Luquet 1926
TDA01. *Pastinaco sativae-Arrhenatheretum elatioris* Passarge 1964
TDA02. *Ranunculo bulbosi-Arrhenatheretum elatioris* Ellmauer in Mucina et al. 1993
TDC. *Cynosurion cristati* Tüxen 1947
TDC01. *Lolio perennis-Cynosuretum cristati* Tüxen 1937
TDC02. *Anthoxantho odorati-Agrostietum tenuis* Sillinger 1933
TDD. *Molinion caeruleae* Koch 1926
TDD01. *Molinietum caeruleae* Koch 1926
TDE. *Deschampsion cespitosae* Horvatić 1930
TDE02. *Holcetum lanati* Issler 1934
TDE04. *Cnidio dubii-Deschampsietum cespitosae* Passarge 1960
TDF. *Calthion palustris* Tüxen 1937
TDF02. *Cirsietum rivularis* Nowiński 1927

TE. *Calluno-Ulicetea* Br.-Bl. et Tüxen ex Klika et Hadač 1944
Nardus grasslands and heathlands
TEA. *Nardion strictae* Br.-Bl. 1926
TEA01. *Festuco supinae-Nardetum strictae* Šmarda 1950
TEA02. *Thesio alpini-Nardetum strictae* Jeník et al. 1980
TEC. *Violion caninae* Schwickerath 1944
TEC01. *Festuco capillatae-Nardetum strictae* Klika et Šmarda 1944
TEC02. *Campanulo rotundifoliae-Dianthetum deltoidis* Balátová-Tuláčková 1980
TEE. *Euphorbio cyparissiae-Callunion vulgaris* Schubert ex Passarge in Scamoni 1963
TEE01. *Euphorbio cyparissiae-Callunetum vulgaris* Schubert 1960
TEF. *Genisto pilosae-Vaccinion* Br.-Bl. 1926
TEF02. *Calamagrostio arundinaceae-Vaccinietum myrtilli* Sýkora 1972
TEF03. *Festuco supinae-Vaccinietum myrtilli* Šmarda 1950

TF. *Koelerio-Corynephoretea* Klika in Klika et Novák 1941
Pioneer vegetation of sandy and shallow soils
TFE. *Arabidopsion thalianae* Passarge 1964
TFE01. *Festuco-Veronicetum dillenii* Oberdorfer 1957
TFF. *Alysso alyssoidis-Sedion* Oberdorfer et Müller in Müller 1961
TFF01. *Cerastietum* Oberdorfer et Müller in Müller 1961

TH. *Festuco-Brometea* Br.-Bl. et Tüxen ex Soó 1947
Dry grasslands
THA. *Alysso-Festucion pallentis* Moravec in Holub et al. 1967
THA01. *Festuco pallentis-Aurinietum saxatilis* Klika ex Čeřovský 1949 corr. Gutermann et Mucina 1993
THB. *Bromo pannonici-Festucion pallentis* Zólyomi 1966
THB01. *Poo badensis-Festucetum pallentis* Klika 1931 corr. Zólyomi 1966
THC. *Diantho lumnitzeri-Seslerion* (Soó 1971) Chytrý et Mucina in Mucina et al. 1993
THC02. *Minuartio setaceae-Seslerietum caeruleae* Klika 1931
THC03. *Saxifrago paniculatae-Seslerietum caeruleae* Klika 1941
THD. *Festucion valesiacae* Klika 1931
THD01. *Festuco valesiacae-Stipetum capillatae* Sillinger 1930
THD04. *Koelerio macranthae-Stipetum joannis* Kolbek 1978
THD06. *Astragalo exscapi-Crambetum tatariae* Klika 1939
THE. *Cirsio-Brachypodion pinnati* Hadač et Klika ex Klika 1951
THE03. *Polygalo majoris-Brachypodietum pinnati* Wagner 1941
THF. *Bromion erecti* Koch 1926
THF01. *Carlino acaulis-Brometum erecti* Oberdorfer 1957
THF02. *Brachypodio pinnati-Molinietum arundinaceae* Klika 1939

THG. *Koelerio-Phleion phleoidis* Korneck 1974
THG01. *Potentillo heptaphyllae-Festucetum rupicolae* (Klika 1951) Toman 1970
THH. *Geranion sanguinei* Tüxen in Müller 1962
THH02. *Geranio sanguinei-Dictamnetum albi* Wendelberger ex Müller 1962
THI. *Trifolion medii* Müller 1962

XB. *Stellarietea mediae* Tüxen et al. ex von Rochow 1951
Annual vegetation of arable land and ruderal habitats
XBA. *Caucalidion* von Rochow 1951

XC. *Artemisietea vulgaris* Lohmeyer et al. ex von Rochow 1951
Xerophilous ruderal vegetation with biennial and perennial species
XCB. *Dauco carotae-Melilotion* Görs ex Rostański et Gutte 1971
XCC. *Convolvulo arvensis-Elytrigion repentis* Görs 1966

XD. *Galio-Urticetea* Passarge ex Kopecký 1969
Nitrophilous perennial vegetation of wet to mesic habitats
XDA. *Senecionion fluviatilis* Tüxen ex Moor 1958

SA. *Asplenietea trichomanis* (Br.-Bl. in Meier et Br.-Bl. 1934) Oberdorfer 1977
Vegetation of rocks, walls and stable screes
SAB. *Asplenion cuneifolii* Br.-Bl. ex Eggler 1955
SAB02. *Notholaeno marantae-Sempervivetum hirti* Br.-Bl. 1961

VA. *Lemnetea* de Bolós et Masclans 1955
Vegetation of free floating aquatic plants
VAA. *Lemnion minoris* de Bolós et Masclans 1955
VAA02. *Lemnetum minoris* von Soó 1927
VAC. *Hydrocharition morsus-ranae* (Passarge 1964) Westhoff et den Held 1969
VAC03. *Ceratophylletum demersi* Corillion 1957

VB. *Potametea* Klika in Klika et Novák 1941
Vegetation of aquatic plants rooted in the bottom
VBA. *Nymphaeion albae* Oberdorfer 1957
VBA01. *Nymphaeo albae-Nupharetum luteae* Nowiński 1927
VBA07. *Potamo natantis-Polygonetum natantis* Knapp et Stoffers 1962
VBB. *Potamion* Miljan 1933
VBC. *Batrachion fluitantis* Neuhäusl 1959
VBD. *Ranunculion aquatilis* Passarge 1964

VD. *Littorelletea uniflorae* Br.-Bl. et Tüxen ex Westhoff et al. 1946
Vegetation of oligotrophic water bodies
VDB. *Eleocharition acicularis* Pietsch ex Dierßen 1975
VDB03. *Limosello aquaticae-Eleocharitetum acicularis* Wendelberger-Zelinka 1952

MA. *Isoëto-Nano-Juncetea* Br.-Bl. et Tüxen ex Br.-Bl. et al. 1952
Vegetation of annual wetland herbs
MAA. *Eleocharition ovatae* Philippi 1968
MAA02. *Cyperetum micheliani* Horvatić 1931
MAC. *Verbenion supinae* Slavnić 1951

MB. *Bidentetea tripartitae* Tüxen et al. ex von Rochow 1951
Vegetation of annual nitrophilous wetland herbs
MBA. *Bidention tripartitae* Nordhagen ex Klika et Hadač 1944
MBA01. *Rumici maritimi-Ranunculetum scelerati* Oberdorfer 1957
MBA04. *Polygono brittingeri-Chenopodietum rubri* Lohmeyer 1950

MC. *Phragmito-Magno-Caricetea* Klika in Klika et Novák 1941
Marsh vegetation
MCA. *Phragmition australis* Koch 1926
MCA04. *Phragmitetum australis* Savič 1926
MCA05. *Glycerietum maximae* Nowiński 1930 corr. Šumberová et al. in Chytrý 2011
MCA06. *Glycerio-Sparganietum neglecti* Koch 1926
MCC. *Eleocharito palustris-Sagittarion sagittifoliae* Passarge 1964
MCD. *Phalaridion arundinaceae* Kopecký 1961
MCD01. *Rorippo-Phalaridetum arundinaceae* Kopecký 1961
MCD02. *Caricetum buekii* Hejný et Kopecký in Kopecký et Hejný 1965
MCE. *Glycerio-Sparganion* Br.-Bl. et Sissingh in Boer 1942
MCE05. *Leersietum oryzoidis* Eggler 1933
MCG. *Magno-Caricion elatae* Koch 1926
MCG02. *Equiseto fluviatilis-Caricetum rostratae* Zumpfe 1929
MCG07. *Carici elatae-Calamagrostietum canescentis* Jílek 1958
MCH. *Magno-Caricion gracilis* Géhu 1961
MCH03. *Caricetum gracilis* Savič 1926
MCH05. *Caricetum distichae* Nowiński 1927
MCH06. *Caricetum ripariae* Máthé et Kovács 1959

RA. *Montio-Cardaminetea* Br.-Bl. et Tüxen ex Klika et Hadač 1944
Vegetation of springs
RAA. *Caricion remotae* Kästner 1941
RAA01. *Caricetum remotae* Kästner 1941
RAA02. *Cardamino-Chrysosplenietum alternifolii* Maas 1959
RAD. *Swertio perennis-Dichodontion palustris* Hadač 1983
RAD01. *Crepido paludosae-Philonotidetum seriatae* Hadač et Váňa 1972
RAD02. *Swertietum perennis* Zlatník 1928
RAD03. *Cardaminetum opicii* Szafer et al. 1923

RB. *Scheuchzerio palustris-Caricetea nigrae* Tüxen 1937
Vegetation of fens, transitional mires and bog hollows
RBA. *Caricion davallianae* Klika 1934
RBA02. *Carici flavae-Cratoneuretum filicini* Kovács et Felföldy 1960
RBB. *Sphagno warnstorfii-Tomentypnion nitentis* Dahl 1956
RBB03. *Menyantho trifoliatae-Sphagnetum teretis* Warén 1926
RBC. *Caricion canescenti-nigrae* Nordhagen 1937
RBC04. *Bartsio alpinae-Caricetum nigrae* Bartsch et Bartsch 1940
RBD. *Sphagno-Caricion canescentis* Passarge (1964) 1978
RBD01. *Sphagno recurvi-Caricetum rostratae* Steffen 1931
RBD04. *Polytricho communis-Molinietum caeruleae* Hadač et Váňa 1967
RBE. *Sphagnion cuspidati* Krajina 1933
RBE01. *Drepanoclado fluitantis-Caricetum limosae* (Kästner et Flössner 1933) Krisai 1972

RC. *Oxycocco-Sphagnetea* Br.-Bl. et Tüxen ex Westhoff et al. 1946
Bog vegetation
RCA. *Sphagnion magellanici* Kästner et Flössner 1933
RCA01. *Eriophoro vaginati-Sphagnetum recurvi* Hueck 1925
RCA02. *Andromedo polifoliae-Sphagnetum magellanici* Bogdanovskaja-Gienev 1928
RCA05. *Ledo palustris-Pinetum uncinatae* Klika ex Šmarda 1948

KA. *Salicetea purpureae* Moor 1958
Riparian willow scrub and willow-poplar forests
KAC. *Salicion albae* de Soó 1951
KAC01. *Salicetum albae* Issler 1926
KAC02. *Salicetum fragilis* Passarge 1957

KB. *Rhamno-Prunetea* Rivas Goday et Borja Carbonell ex Tüxen 1962
Mesic and xeric scrub and *Robinia* groves
KBA. *Prunion fruticosae* Tüxen 1952
KBA01. *Prunetum fruticosae* Dziubałtowski 1926
KBB. *Berberidion vulgaris* Br.-Bl. et Tüxen 1952
KBB01. *Junipero communis-Cotoneasteretum integerrimi* Hofmann 1958
KBB02. *Violo hirtae-Cornetum maris* Hilbig et Klotz in Rauschert 1990

KC. *Roso pendulinae-Pinetea mugo* Theurillat in Theurillat et al. 1995
Subalpine krummholz vegetation
KCA. *Pinion mugo* Pawłowski et al. 1928
KCA01. *Dryopterido dilatatae-Pinetum mugo* Unar in Unar et al. 1985

LA. *Alnetea glutinosae* Br.-Bl. et Tüxen ex Westhoff et al. 1946
Alder and willow carrs
LAA. *Alnion glutinosae* Malcuit 1929
LAB. *Salicion cinereae* Müller et Görs ex Passarge 1961
LAB01. *Salicetum auritae* Jonas 1935

LB. *Carpino-Fagetea* Jakucs ex Passarge 1968
Mesic and wet deciduous broad-leaved forests
LBA. *Alnion incanae* Pawłowski et al. 1928
LBA02. *Piceo abietis-Alnetum glutinosae* Mráz 1959
LBA03. *Carici remotae-Fraxinetum excelsioris* Koch ex Faber 1936
LBA04. *Stellario nemorum-Alnetum glutinosae* Lohmeyer 1957
LBA07. *Fraxino pannonicae-Ulmetum glabrae* Aszód 1935 corr. Soó 1963
LBB. *Carpinion betuli* Issler 1931
LBB01. *Galio sylvatici-Carpinetum betuli* Oberdorfer 1957
LBB03. *Carici pilosae-Carpinetum betuli* Neuhäusl et Neuhäuslová-Novotná 1964
LBB04. *Primulo veris-Carpinetum betuli* Neuhäusl et Neuhäuslová in Neuhäuslová-Novotná 1964
LBC. *Fagion sylvaticae* Luquet 1926
LBC01. *Galio odorati-Fagetum sylvaticae* Sougnez et Thill 1959
LBC02. *Mercuriali perennis-Fagetum sylvaticae* Scamoni 1935
LBC03. *Carici pilosae-Fagetum sylvaticae* Oberdorfer 1957
LBC04. *Athyrio distentifolii-Fagetum sylvaticae* Willner 2002
LBC05. *Galio rotundifolii-Abietetum albae* Wraber 1959
LBD. *Sorbo-Fagion sylvaticae* Hofmann in Passarge 1968
LBD01. *Cephalanthero damasonii-Fagetum sylvaticae* Oberdorfer 1957
LBE. *Luzulo-Fagion sylvaticae* Lohmeyer et Tüxen in Tüxen 1954
LBE01. *Luzulo luzuloidis-Fagetum sylvaticae* Meusel 1937
LBE02. *Calamagrostio villosae-Fagetum sylvaticae* Mikyška 1972
LBF. *Tilio platyphylli-Acerion* Klika 1955
LBF01. *Aceri-Tilietum* Faber 1936
LBF02. *Mercuriali perennis-Fraxinetum excelsioris* (Klika 1942) Husová in Moravec et al. 1982
LBF03. *Arunco dioici-Aceretum pseudoplatani* Moor 1952
LBF04. *Seslerio albicantis-Tilietum cordatae* Chytrý et Sádlo 1998

LC. *Quercetea pubescentis* Doing Kraft ex Scamoni et Passarge 1959
Thermophilous oak forests
LCA. *Quercion pubescenti-petraeae* Br.-Bl. 1932
LCA01. *Lathyro collini-Quercetum pubescentis* Klika 1932 corr. Roleček in Chytrý 2013
LCA02. *Lithospermo purpurocaerulei-Quercetum pubescentis* Michalko 1957
LCA03. *Euphorbio-Quercetum* Knapp ex Hübl 1959
LCB. *Aceri tatarici-Quercion* Zólyomi 1957
LCB01. *Quercetum pubescenti-roboris* (Zólyomi 1957) Michalko et Džatko 1965
LCB02. *Carici fritschii-Quercetum roboris* Chytrý et Horák 1997

LCC. *Quercion petraeae* Issler 1931
LCC01. *Sorbo torminalis-Quercetum* Svoboda ex Blažková 1962
LCC02. *Genisto pilosae-Quercetum petraeae* Zólyomi et al. ex Soó 1963
LCC03. *Melico pictae-Quercetum roboris* (Mikyška 1944) Klika 1957

LD. *Quercetea robori-petraeae* Br.-Bl. et Tüxen ex Oberdorfer 1957
Acidophilous oak forests
LDA. *Quercion roboris* Malcuit 1929
LDA01. *Luzulo luzuloidis-Quercetum petraeae* Hilitzer 1932
LDA02. *Viscario vulgaris-Quercetum petraeae* Stöcker 1965
LDA03. *Vaccinio vitis-idaeae-Quercetum roboris* Oberdorfer 1957
LDA04. *Holco mollis-Quercetum roboris* Scamoni 1935

LF. *Vaccinio-Piceetea* Br.-Bl. in Br.-Bl. et al. 1939
Boreo-continental coniferous forests
LFB. *Dicrano-Pinion sylvestris* (Libbert 1933) Matuszkiewicz 1962
LFB02. *Vaccinio myrtilli-Pinetum sylvestris* Juraszek 1928
LFB03. *Hieracio pallidi-Pinetum sylvestris* Stöcker 1965
LFC. *Piceion abietis* Pawłowski et al. 1928
LFC01. *Calamagrostio villosae-Piceetum abietis* Schlüter 1966
LFC03. *Equiseto sylvatici-Piceetum abietis* Šmarda 1950
LFC04. *Soldanello montanae-Piceetum abietis* Volk in Br.-Bl. et al. 1939
LFD. *Vaccinio uliginosi-Pinion sylvestris* Passarge 1968
LFD01. *Vaccinio uliginosi-Betuletum pubescentis* Libbert 1933
LFD02. *Vaccinio uliginosi-Pinetum sylvestris* de Kleist 1929
LFD03. *Vaccinio-Pinetum montanae* Oberdorfer 1934

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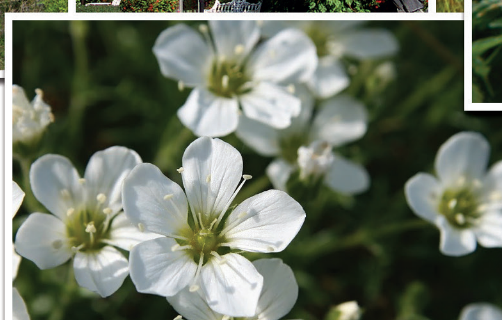

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