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VEGETATION OF MT BADACSONY

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The first vegetation map of Mt Badacsony, a major landmark mount in the Balaton Uplands was made almost 50 years ago, immediately after the closing of the basalt mines and the foundation of the landscape protection area of the region. In that Pál Jakucs demonstrated the advantages of using aerial photographs in vegetation mapping. The present article gives results of the new mapping project of Mt Badacsony, overviews the landscape history of the area, gives detailed and current descriptions of the various types of habitats and vegetation units.

Key words: Balaton Uplands, basalt hill, *Luzulo-Ornetum*, Mt Badacsony, vegetation map

INTRODUCTION

The first vegetation map of Mt Badacsony was made in one of the most intensive periods of the Hungarian vegetation research (Jakucs 1966). Mainly the plateau and the southern margin, is one of the earliest areas that have been mapped by using aerial photographs. The first mapping of Mt Badacsony is important from the point of view of history of science, because that was immediately carried out after the closing of the basalt mines and the foundation of the Badacsony Landscape Protection Area. Since then half a century have passed, with the local landscape changing substantially, and the preparation of a new, detailed, digital vegetation map of a larger area (Badacsony Hill Natura 2000 site) is a timely endeavour.

MATERIAL AND METHODS

Based on landscape geography, Mt Badacsony belongs to the microregion named Badacsony–Gulács group, which is situated in the western part of the Balaton Uplands Region (Marosi and Somogyi 1990). The basalt hills and mountains of the Bakony Region are results of alkali basalt volcanic activity that occurred 3–7 million years ago (Ádám *et al.* 1988, Balogh *et al.* 1994, Budai and Csillag 1999, Harangi 1997). Mt Badacsony, the symbolic element of the landscape near Lake Balaton, is the largest one of the basalt mounts of the Balaton Uplands. Its plateau is bounded by the contour-line of 400 m. Three humps are found on the plateau, the northeastern one is the highest with the

peak of Mt Badacsony (437 m). Geomorphological values (basalt organs, stone sacks) are based on the external features of the basalt rocks showing individual eroded forms and natural debris slopes under them. With huge scars in the body of the eastern and western sides of the mountain, the current morphology is strongly determined by the basalt mining, this activity is seen in form of the huge stone walls, strips and secondary debris slopes. The most important spring is the Klastrom-kút occurring in the northeastern side of Mt Badacsony, more precisely in the forest Köbölkúti-erdő. The spring Kisfaludy-forrás is also famous. Dongókút, being in the side of Tördemic, is a contact spring characterised by small régime and it frequently dries out.

From the aspect of phytogeography, Mt Badacsony belongs to the flora district Balatonicum of the flora region Bakonyicum. As the member of the Badacsony Landscape Protection Area it has been under nature protection since 1965, and it was included in the Balaton Uplands National Park in 1997, then in the Natura 2000 network in 2004.

I have studied the botanical aspects of Mt Badacsony since the middle of the 1990s. During this work I have recorded the xerotherm vegetation types and documented the newly revealed and important elements of the local flora.

The work on a new vegetation map of Mt Badacsony was started in 2008 and lasted until the spring of 2009. I followed the methods and system recommended by the Hungarian Biodiversity Monitoring System ("Á-NÉR"; Kun and Molnár 1999). Sheets of EOTR (= Hungarian Mercator System) at 1:10,000 scale (43-331 and 43-333) were used as base maps. Outlines of the vegetation patches, typical stands and the occurrences of the character species were recorded by Trimble TDS-Recon. The vegetation map was drawn based on an aerial photograph of FÖMI (Institute of Geodesy, Cartography and Remote Sensing, Budapest) taken in 2005. Borders of the changes in the vegetation, as cutting in forests or scrubs, are not seen on the aerial photograph, so they were recorded with the use of the above mentioned GPS device. Naming of the habitat categories follows Fekete *et al.* (1997) and the modified categories (mmÁ-NÉR, ÉIU) and descriptions (Bölöni *et al.* 2003, 2007) have been mainly used according to the newest system.

Names of the coenotaxa mainly follow the nomenclature of Borhidi (2003), but in some cases I used the results and names of other works (Mucina *et al.* 1993, Chytrý 2007). The coenotaxonomic status could not be clearly identified for every category, so in those cases I used the former, provisional names in this paper.

Some categories of Á-NÉR (*e.g.* U6) are not based on the vegetation but instead, on the land-use type and intensity. I suggest that Á-NÉR should be limited to the categorisation of the vegetation, while the categories of the land-use, such as forest, hayfield, pasture, vineyard, orchard, mine, road, should be figured on a separate shape.

HISTORY OF THE BOTANICAL EXPLORATION

Floristical researches

On 15 July 1799 Kitaibel recorded several notable floristical data from Mt Badacsony, including such names as *Actaea spicata*, *Aurinia saxatilis*, *Carpesium cernuum*, *Hippocrepis emerus*, *Hepatica nobilis*, *Lychnis coronaria*, *Physocaulis nodosus*, *Tamus communis*, *Rosa arvensis*, *Vicia sylvatica* (see Gombocz 1945). Data of *Moehringia muscosa* and *Lactuca perennis* are probably erroneous based on the present knowledge about the local flora. There are some locally rare taxa mentioned in the manuscript of Peter Wierzbicki (Bodnár 1957) issued around 1820 about the Badacsony: *Anchusa italica*, *Epilobium angustifolium* [Tomaj], *Geranium divaricatum*, *Gypsophila paniculata* [Tördemic], *Iris sibirica*, *Lythrum virgatum*, *Pimpinella dioica* [Tomaj], *Rosa pumila* (= *gallica*) [Tomaj], *Scorzonera hispanica* [Tomaj], *Smyrnium perfoliatum*, *Tamus communis* [Tomaj]. Based on these species we can see that Wierzbicki, with the name usage of Badacsony, Tomaj and Tördemic, recorded data not only from Mt Badacsony, but from the foothill area and from the grasslands occurring at the shore of Lake Balaton, too. Sigmund (1837) also mentioned some species of interest (*e.g. Limodorum abortivum*, *Smyrnium perfoliatum*) from the area of Szigliget and Badacsony. The work of Simonkai (1876) shows a significant progression in the floristical research of Mt Badacsony. He published 122 vascular taxa, from which the following deserve special notice: *Ventenata dubia* (sub nom. *Avena tenuis*), *Crepis capillaris* (sub nom. *C. virens*), *Galium pumilum* ("on the rocky slopes of the Badacsony") [presumably: *Galium austriacum*], *Polycnemum heuffelii*, *Trigonella monspeliaca*, and *Valerianella coronata*. On Mt Badacsony, Vince Borbás located *Hieracium wiesbaurianum* for the first time (Borbás 1894) and his major work entitled "Flora of Balaton" (Borbás 1900) is a rich source of data in the history of the local floristics; his contribution deserves a more detailed discussion. Borbás recorded 354 vascular plant species from Mt Badacsony and the adjacent shore of Lake Balaton, based both on his own field data and literature sources. [Borbás could have listed more species than 354, but in his monograph he mentioned a number of species with the note of "md." (meaning: grows everywhere); and in some cases the citation of the former data is not there]. Some of Borbás' names are ambiguous anyway (*e.g.* the presence of *Lappula heteracantha*, *Viola collina*) and several names (*e.g. Rubus Kisfaludyanus* Borb.) have no real taxonomic foundation. As we can conclude today, the floristically most important records of his monograph from Mt Badacsony are: *Alyssum desertorum*, *Asplenium septentrionale*, *Erodium ciconium*, *Himantoglossum*, *Lathyrus venetus*, *Ornithogalum sphaerocarpum*, *Potentilla rupestris*, *Rosa zalana*, and *Senecio sylvaticus*. Around

the early 20th century *Orobanche hederae* was found in Hungary for the first time in Mt Badacsony (Mágocsy-Dietz 1914). The occurrence of *Cyclamen purpurascens* Mill. on Mt Badacsony is known based on Mihályfi F., Entz G. ap. Jávorka (1940) ("on the Badacsony, above Rózsakő"). Thereby, the species has been published from the Balaton Uplands for the first time. Ádám Boros made collections on Mt Badacsony six times (22.08.1920, 11.06.1950, 25.06.1955, 29.04.1956, 06.04.1957). Beyond the bryological notes in his hand-written diary (Boros 1973) many new vascular plant records are listed (*e.g. Calamintha sylvatica*, *Geranium molle*, *Vicia dumetorum*). *Clematis vitalba* L. var. *taurina* Bess was published by Zsák (1941). The monograph of Kárpáti (1960), listing several data on *Sorbus* are based on his studies of herbarium specimens: *Sorbus bakonyensis*, *S. danubialis*, *S. domestica* ["Badacsony: Hármasdomb"], *S. pannonica*, *S. pseudodanubialis*, *S. subdanubialis*, although seen from new investigations these are in need of re-examination. Recently, additional new species of floristical importance have been recorded from Mt Badacsony (Bauer 2011, Bauer and Óvári 2003, Bauer *et al.* 2004), and the vegetation mapping project hereby discussed also reveals the presence of previously overlooked species. Some of these are "plants of great merit" from the aspect of nature conservation (*e.g. Allium sphaerocephalon*, *Carex halleriana*, *Mercurialis ovata*, or *Scilla vindobonensis*), while others are "problem plants" as adventive-invasive taxa (*e.g. Amorpha fruticosa*, *Asclepias syriaca*, or *Aster lanceolatus*).

Vegetation researches

Descriptions of the vegetation of Mt Badacsony are present in the early logbooks of Kitaibel (see Gombocz 1945) and in papers of Haberlandt (1861), Borbás (1900) and Borbás and Bernátsky (1907). Soó (1931) introduced beech, hornbeam-oak, pubescent oak forests and scrubs of the Balaton Uplands, based mainly on relevés taken in Mt Badacsony; ha also characterised the vegetation of the basalt rocks and debris slopes of Mt Badacsony; furthermore he denoted the "*Hierochloë hirta* Ass.", "*Hypnum cupressiforme* Ass." and "*Polypodium vulgare* Ass." associations. The description of Soó (1931) about the "*Hierochloë hirta* Ass." stands close to the herb layer of the "*Luzulo-Ornetum*" forests (Jakucs 1966). Soó (1933) also took note of the presence of a subassociation with *Carpinus* of the "*Fraxinetum mixtum: Fraxinus ornus-Acer campestre-Ulmus campestris* association".

The most important stage in the history of vegetation research of Mt Badacsony is the article of Jakucs (1966) providing an aerial photograph-based vegetation map of the plateau and the upper southern margin of the hill. The paper did not give descriptions of the vegetation units, it just mentioned a few

important plant species and used provisional association names. The plateau vegetation was mapped as hornbeam-oak forest (*Querco petraeae-Carpinetum*) with some subunits (*caricetosum pilosae*, *asperuletosum*, *fagosum, smyrniosum*) and mentioning of places degraded by *Pinus nigra* and *Robinia pseudacacia*. In the map of Jakucs the small xerotherm grasslands are present under the name of "cf. *Diplachno-Festucetum sulcatae*". The xerotherm forests of the margins and rocky areas were treated as *Orno-Quercetum pubescentis* and *Ceraso-Quercetum pubescentis* associations. The identification of rock forests occurring on the north- and west-facing plateau margins, on fleet and acidic soil as an individual type named *Luzulo-Ornetum* is an important recognition by Jakucs. He recorded the debris slope forests of ravines as *Aceri pseudoplatani-Tilietum*. In the upper foothills adjacent to the vineyards a narrow zone of Turkey oak forests (*Quercetum petraeae-cerris*) was also drawn by Jakucs.

The manuscript of Debreczy (1988) recorded new grassland associations under the name of "*Lychno viscariae-Festucetum sulcatae*" and "*Lychno-Luzuletum pilosae*" based in part on relevés taken in Mt Badacsony. It is noted here that the presence of some species (*Luzula pilosa*, *Koeleria pyramidata*) contained by the above work are not confirmed by this author's research.

Kovács and Takács (1995) gave an overview about the vegetation of the basalt mounts and hills around Lake Balaton from a conservational point of view. They corrected the map of Jakucs (1966), for example with merging the patches of *Luzulo-Ornetum* and *Ceraso-Quercetum*.

Bauer (2005) published some *Geranio rotundifolii-Sedetum albi* relevés from Mt Badacsony, as well as (in 2008) reported on the research results of the rocky and dry grasslands of the Transdanubian basalt hills, and characterised their most important groups (Bauer 2008).

LAND-USE HISTORY OF THE BADACSONY AREA

The landscape of Mt Badacsony and its surroundings has been under human pressure since the asoic era (Bakay *et al.* 1966). Local remains of Bronze Age and early Metal Age are known. Archaeological remains and sepultures can be found from the Celtic time. The first major landscape modifications are attributed to the Romans, who introduced viniculture in the area (Makay 1913). From the time of the earliest settlements, the villages of present time were found at the same location. In the Middle Ages, besides Lád, Turdemecz and Tomaj, a place named "Köbölkút" was located on the northern slope, but was destroyed by the Turks in the 16th century. Viniculture was also typical in the Middle Ages and has been a growing activity from the 18th century, until it became more intensified at the expense of the areas of natural vegetation cover. Two famous buildings

of the hill, Kisfaludy and Szegedi Róza Houses (Vajkai 1958) were also built at the end of the 18th century. In that time the area of the vineyards was different, from the present coverage. It is seen on the first detailed map of Mt Badacsony, which was prepared for the first military mapping, carried out from 1763 to 1785 at the scale of 1:28,800. That huge project was ordered by Joseph II and the Hungarian part of the mapping was completed between 1782 and 1785. In the corresponding sheet of this map Mt Badacsony is shown as covered mostly by forest, with vineyards just on the lower foothills all around. Vineyards started to spread to the upper levels just in the southern and western slopes. In 1806 Francis I ordered the second military mapping ("Zweite oder Franziszeische Landesaufnahme"). That work was conducted from 1819 to 1869. We can see on the sheet of Mt Badacsony that vineyards covered the piedmont up to the bottom of the rocks; and the roads of the plateau are also seen, these in part may be the ancestors of the present tourist trails. On the margins of the plateau and around the peaks there were grasslands. The third military mapping of the Austro-Hungarian Monarchy was done from 1869 to 1887 at the scale of 1:25,000, but was published at the scale of 1:75,000. On this map the forest cover is more or less similar to the current one. In the area of Kotyor and Köbölkút (and Fekete-bányák) the forests descend to the lower foothill areas, since the exposure of these slopes is not appropriate for vineyards. Furthermore, small forest patches are in some narrow valleys (*e.g.* Péntek-árok). The plateau grasslands were mentioned by Borbás (1900), and he reported on young forests around springs, as near Kisfaludy-forrás and Klastromkút ("... hamar kezdődik a tölgyerdő keveréke, de itt még fiatal s nem nagyon makkol" / "mixed oak forests appear, but here they are too young to produce acorns"). From this one we can conclude that there was an intensive use of the nearest forests. This aspect of the land-use history is very interesting because currently the plateau of Mt Badacsony has a most beautiful and natural-looking forest. The old-growth forests of the plateau were mentioned in Borbás (1900) and we can also find descriptions of the vegetation of the glades ("linea"). Fidei-commissary forests of the plateau were in the property of the Eszterházy family in that time (Kaán 1931). Mágocsy-Dietz (1914) mentioned the presence of beech forests at Mt Badacsony, with this note he was the first to mention this fact.

In the 20th century the landscape structure has significantly changed. Some of the native forests were replaced by planted Black locust (*Robinia*) and Black (Austrian) pine (*Pinus nigra* subsp. *austriaca*), and modified by reforestation/afforestation of deforested areas. Land-use in the vineyards was also changed in the second part of the last century. In part, large-scale and intensive farming with increased use of chemicals, took over traditional agriculture.

Using of the Badacsony area as a bathing resort has become more and more popular in the 20th century, so besides the press-houses more and more cottages and villas were built, occupying higher and higher parts of the slopes with a beautiful view of Lake Balaton area. Old photographs (Cser and Péterffy 2008) show that the rocky plateau-margin was barer than nowadays and the debris slopes were covered by almost continuous forests. In the book of Kaán (1931) there are two photographs taken by Lajos Ambrus showing the scrubby vegetation on the slopes of basalt rocks. Obviously the largest changes in the landscape were caused by the intensive basalt mining, which was stopped in 1963, but it left huge strips and artificial walls on the eastern and western side of Mt Badacsony.

The conservational importance of the natural world of Mt Badacsony has been recognised for a long time, but a real action was only taken several decades later. In his book Kaán (1931), raising issues of how to protect the Hungarian natural environment, put forward Mt Badacsony as an area recommended for protection. At that time the protection of Lake Balaton and Mt Badacsony was also expressed in the Hungarian Parliament in form of an interpellation. Despite all the efforts the Badacsony Landscape Protection Area was not declared a conservation land until 1965.

The aerial photograph published in Jakucs (1966) has great importance in the land-use history of Mt Badacsony. As clearly seen, at that time the debris slopes, occurring below the basalt sacks, formed large, continuous patches. In the last decades however, low debris slope forests and scrubs have grown up on them, concealing some of the former bare slopes. Coverage of the steppe grasslands has also decreased, but it has to be noted that the patches on the vegetation map of Jakucs are larger than in nature simply because of the limitations of the maps's presentment. During the last century significant spontaneous forestation is seen on the rocky slopes of Mt Badacsony. This well-documented area is one of the most spectacular sites of the formation/regeneration of debris slope forests. On the aerial photograph taken in 1966 the mines have bare surfaces, but they subsequently forested. Nowadays, these surfaces are covered by characterless Black pine plantations and secondary oak forests. Different stages of the spontaneous forestation are also observed on debris slopes and grasslands within the former mines.

RESULTS

The natural vegetation of the Badacsony is dominated by Turkey oak-sessile oak forests and mesophilous hornbeam-oak forests. Due to the geomorphological features, edaphic forest and grassland associations, such as debris slope for-

ests, shrub forests, rocky grasslands, and rock chasm grasslands are also characteristic on large parts of the protected area.

The local vegetation is highly heterogeneous from a mapping point of view. Because of the various anthropogenic effects and disturbances the vegetation patches usually can not be identified as exact associations or simple habitat categories. Most of the habitat categories can be named as hybrid units, which are in different successional stages and often affected by invasive species.

Individual categories on the detailed habitat map (BAUER 2009): G3×H3a, I4b, K2, K2×K5, K2×L2a, K2×LY2, K2×RC, K2×S4, L1, L2a×LY2, LY2, LY2×S1, LY2×S4, LY4, M1, OB, OC, P2×LY2, P2×LY2×S1, P2×S6, P2b×OC, P8×S1, RC, RC×K2×S1, RC×K2×S1×S4, RC×L2a×S1×S4, RC×S1, RC×S1×S4×P8, S1, S1×RB, S1×RC, S1×S4, S4, S4×RC, T8, U4. In this paper a simplified habitat map is given (Fig. 1). The figured habitat categories are summed in Table 1, and Table 2 contains the areas of the Natura 2000 habitats.

Characteristics of the habitat types and detected associations

Siliceous open rocky grasslands (Á-NÉR: G3; Natura 2000: 8220): Basalt rocky grasslands and chasm grasslands (*Festuco pallentis-Aurinietum saxatilis* Klika 1941 ex Čeřovský 1949, *Asplenio septentrionali-Melicetum ciliatae* (Soó 1940) Máthé et Kovács 1964) are in all expositions on the basalt walls of Mt Badacsony. Natural stands are typical on the top of the huge rocks called "organ pipes" or "stone sacks". Its parted variant related to the stone walls occurs almost on plumb rock walls. On basalt organs sometimes it is seen under the canopy layer of the debris slope forests. Secondary stands are on rocky walls of former mines closed several decades before. These stands are figured on the map under G3×H3a category.

In the rocky grasslands of Mt Badacsony *Aurinia saxatilis*, *Festuca pallens*, *Hieracium cymosum*, *Lychnis viscaria* and *Seseli osseum* are constant species. Furthermore, *Allium senescens* subsp. *montanum*, *Asplenium septentrionale*, *Campanula rotundifolia*, *Thymus praecox* are most typical in this type of habitat. Characteristic elements in local stands of the association include *Hieracium wiesbaurianum* and *Galium austriacum*. Typical accompanying species are *Acinos arvensis*, *Allium flavum*, *Cardaminopsis arenosa*, *Cerastium pumilum*, *Cotoneaster integerrimus*, *Erysimum diffusum*, *Euphorbia cyparissias*, *Hylotelephium maximum*, *Jovibarba hirta*, *Myosotis ramosissima*, *M. stricta*, *Poa bulbosa*, *Saxifraga tridactylites*, *Sedum album* and *S. sexangulare.* Locally rare species are *Veronica dillenii* and *V. verna*.

Small patches of *Asplenio septentrionali-Melicetum ciliatae* occur on the most exposed, (dry and stony) sides of Mt Badacsony. In these communities, light-

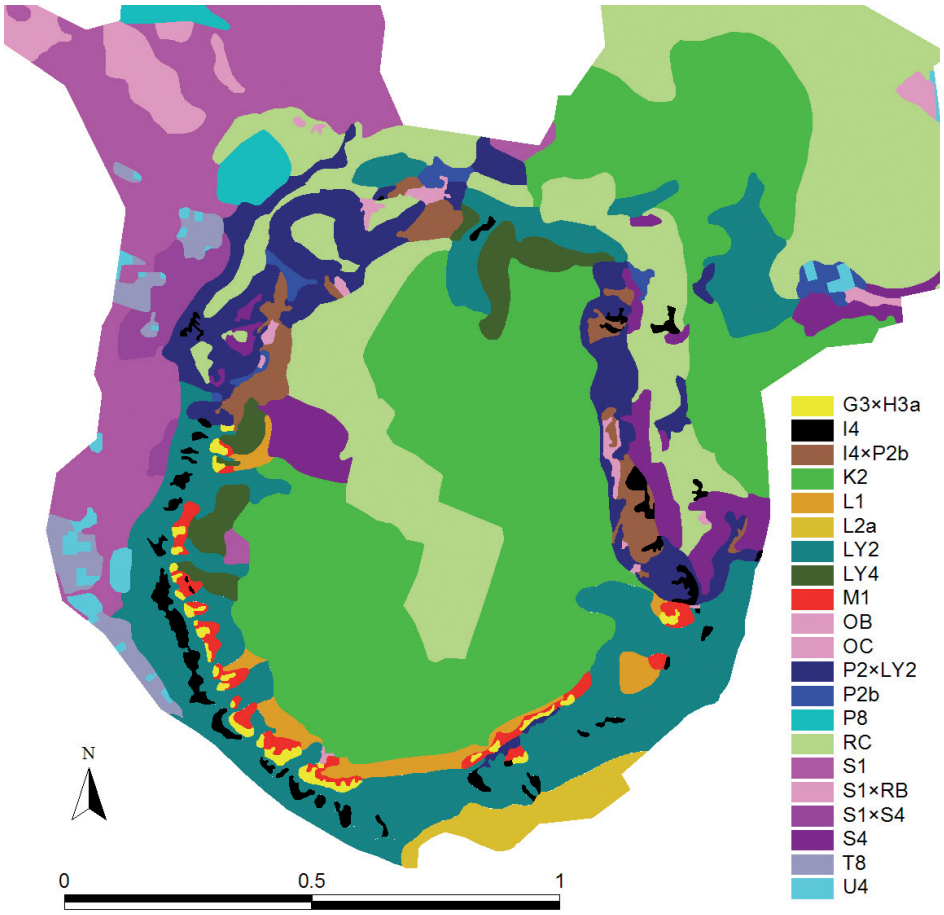

Fig. 1. Vegetation map of Badacsony, with merged Á-NÉR categories. (G3×H3a = Siliceous open rocky grasslands and slope steppes; I4 = Pioneer grasslands on scree slopes; I4×P2b = Pioneer grasslands on scree slopes with scrub; K2 = Oak-hornbeam forests; L1 = Closed thermophilous oak forests (Pannonian woods with *Quercus pubescens*); L2a = Turkey oak forests; LY2 = Mixed forests of scree, rocky slopes; LY4 = Mixed relic oak woodlands on rocks; M1 = Downy oak shrub forests; OB = Secondary humid grasslands; OC = Uncharacteristic dry and semi-dry grasslands; P2×LY2 = Scrubs and woodlands on artificial debris slopes; P2b = Dry scrub vegetation; P8 = Clearcuts; RC = Uncharacteristic hardwood forests and plantations; S1 = *Robinia pseudacacia* stands; S1×RB = Mixed stands of *Robinia* and white poplar; S1×S4 = Mixed stands of *Robinia* and black pine; S4 = Black pine plantations; T8 = Traditional vineyards and orchards; U4 = Yards, premises, wreckage, dumping grounds).

frequent species of basalt rocky grasslands characterised with great drought tolerance are typical, *e.g. Allium flavum*, *Asplenium ceterach* (rare), *A. septentrionale*, *Jovibarba hirta*, *Melica ciliata*, *Poa bulbosa*, *Sedum album*, *Seseli osseum*.

Table 1. Merged habitat categories of the Badacsony Hill Natura 2000 site.

Vegetation types	Á-NÉR	Area (m^2)	Ratio (%)
Open rocky, chasm and steppe grasslands	G3×H3a	13,416	0.53
Pioneer grasslands on scree slopes and walls	I4	29,883	1.20
Pioneer grasslands on scree slopes with scrub	I4×P2b	38,202	1.50
Oak-hornbeam forests	K2	683,982	27.05
Closed thermophilous oak forests	L1	27,672	1.10
Turkey oak forests	L2a	30,829	1.21
Mixed forests of scree, rocky slopes	LY2	305,172	12.06
Mixed relic oak forests on rocks	LY4	42,060	1.67
Downy oak shrub forests	M1	22,707	0.90
Uncharacteristic meadows	OB	6,659	0.26
Uncharacteristic dry grasslands	OC	20,382	0.81
Scrubs and woodlands on artificial debris slopes	P2×LY2	134,263	5.31
Dry scrub vegetation	P2b	19,806	0.78
Clearcuts	P8	27,474	1.09
Uncharacteristic hard wood woodlands and plantation	RC	666,568	26.35
Robinia pseudoacacia plantations	S1	258,908	10.23
Mixed stands of *Robinia* and white poplar	S1×RB	44,644	1.76
Mixed stands of *Robinia* and Black (Austrian) pine	S1×S4	25,554	1.01
Black (Austrian) pine plantations	S4	79,324	3.13
Traditional vineyards and orchards	T8	31,045	1.23
Yards, premises, wreckage, dumping grounds	U4	20,814	0.82
Sum-total		2,529,364	100.00

Table 2. Data of the Natura 2000 habitats on Mt Badacsony.

N2000 code	Name	Area (m^2)	Ratio (%)
6190 and 8220	Rupicolous Pannonian grasslands (Stipo-Festucetalia pallentis) and sub-Pannonian steppic grasslands (= Á-NÉR ~ G3×H3a)	13,416	0.53
91G0	Pannonian woods with *Quercus petraea* and *Carpinus betulus* (K2)	683,982	27.04
9180	Tilio-Acerion forests of slopes, screes and ravines (LY2)	305,172	12.06
91H0	Pannonian woods with *Quercus pubescens* (L1, M1)	50,379	1.99
91M0	Pannonian-Balkan Turkey oak-sessile oak forests (L2a)	30,829	1.22

Slope steppes on stony ground (H3a; 6240): Natural closed dry grasslands are rare and only occur in small fragments on the slopes split by rock exposures yet are important from the aspect of vegetation history, since in spite of their small coverage, they enrich the local flora with several species of interest.

Jakucs (1966) called these patches "cf. *Diplachno-Festucetum sulcatae*". Stands of this association covered larger area on the former map than present, so they presumably shrunk in the last 50 years. These are seen on the current vegetation map under the G3×H3a hybrid-category. In this type of vegetation the rocky grassland component is locally dominant.

Frequent elements of these xerotherm dry grasslands mainly come from the common species of the Transdanubian Mts. Here, the most important grass species are *Elymus hispidus*, *Festuca valesiaca* agg. (*Festuca valesiaca*, and rarely *F. pseudodalmatica*, *F. rupicola*), *Koeleria cristata* agg., *Melica ciliata*, *M. transsilvanica*. Therophytes are frequent (*e.g. Arenaria serpyllifolia*, *Bromus squarrosus*, *Cerastium glutinosum*, *Cruciata pedemontana*, *Lithospermum arvense*, *Myosotis ramosissima*, *Orlaya grandiflora*, *Trifolium arvense*, *Valerianella carinata*, *Vicia hirsuta*, *Viola arvensis*) and chamaephytes are typical in the stands transitional toward the chasm grasslands (*Artemisia campestris*, *Jovibarba hirta*, *Sedum album*, *S. sexangulare*, *Thymus pannonicus*). Additional typical associated species of the local steppe grasslands are: *Acinos arvensis*, *Anthemis tinctoria*, *Asparagus officinalis*, *Dictamnus albus*, *Erysimum diffusum*, *Falcaria vulgaris*, *Filago arvensis*, *Fumaria officinalis*, *Geranium sanguineum*, *Hieracium cymosum*, *Hypericum perforatum*, *Iris variegata*, *Lactuca viminea*, *Lychnis viscaria*, *Medicago minima*, *Muscari neglectum*, *Ornithogalum umbellatum*, *Papaver dubium*, *Poa bulbosa*, *Potentilla argentea* agg., *P. recta*, *Ranunculus illyricus*, *Sanguisorba minor*, *Sedum album*, *S. sexangulare*, *Seseli osseum*, *Stachys recta*, *Stipa capillata*, *Taraxacum erythrospermum*, *Trifolium arvense*, *T. campestre*, and *Vicia grandiflora*. Rare accompanying species in the local stands are *Achillea pannonica*, *Allium sphaerocephalon*, *Potentilla rupestris*, and *Pulsatilla nigricans*.

Pioneer grasslands on rocks and walls (I4): Below the basalt sacks and organs, debris slopes have been formed from different-sized rocks resulting from permanent stone fragmentation. On these periglacial, still changing rocky slopes, debris slope forests develop, but certain parts of the ravines can not be forested. No or just a very few vascular plants can grow on the fragments with large basalt rocks. Such surfaces are covered mainly by lichen associations. The plant association occurring on the margins of the debris slopes and on slopes of small rocks and stones are similar to the disturbed rocky grasslands (*Geranio rotundifolii-Sedetum albi* (Jakucs ex Soó 1973) Bauer 2005) (see Jakucs 1973, Bauer 2005).

Oak-hornbeam forests (K2; 91G0): The zonal forest association of the plateau is the oak-hornbeam forest, but its stands also grow in extrazonal situations

on humid north-facing slopes. Most of the local occurrences of *Carici pilosae-Carpinetum* (Neuhäusl et Neuhäuslova N. 1964) Borhidi 1996 have a rich geophyte aspect, but nudum type also can be found. On parts of the mount characterised by cragged geomorphology, the association forms several transitional types. Stands with transition to debris slope forests are frequent, but types mixed with a few scattered trees of *Robinia pseudacacia* and *Pinus nigra* are also seen. Jakucs (1966) distinguished the following types of *Querco petraeae-Carpinetum*: *caricetosum pilosae*, *asperuletosum*, *quercetosum petraeae*, *smyrniosum,* and *fagosum*. The beech-dominated type is usually treated as a beech association. On the plateau, some mixed oak-hornbeam stands occur, in which the dominance of beech is caused by the certain silvicultural practices. The structure of these stands has not changed since the statement of Jakucs (1966) was written ("fagosum"), but these do not show enough individuality in the herb layer for recognising differences at association level.

Stands with the best natural structure and circumstances are found in old mixed forests of the peak and in the forest Köbölkúti-erdő occurring under the Kőkapu. At present, on several foothill sites that potentially are oak-hornbeam woodland habitats, now *Robinia* woodlands (S1) or derivative forests occur mixed with invasive species (RC, RC×S1, RC×S4 etc.).

The canopy layer of the local oak-hornbeam forests is usually mixed (*Carpinus betulus*, *Quercus petraea*, *Tilia* spp., *Cerasus avium*, *Fraxinus excelsior*, *Ulmus glabra*, *Acer pseudoplatanus*, *Fagus sylvatica*). At some places uncharacteristic tree species are also present with great coverage values (*e.g. Acer campestre*, *Fraxinus ornus*, *Quercus cerris*). The shrub layers of the oak-hornbeam stands show a heterogeneous picture, some of these forests with a dense shrub layer with high coverage, others having no shrub layer. Normally, typical shrub species are *Crataegus oxyacantha*, *Hedera helix*, *Ligustrum vulgare*, *Rhamnus catharticus*, *Staphylea pinnata*; and *Rosa arvensis* is scattered. Presence of *Rubus fruticosus*, *Sambucus nigra* and *Clematis vitalba* is typical on disturbed or degraded stands (RC×K2). In the herb layer of the local oak-hornbeam forests the following species have been recorded: *Ajuga reptans*, *Anemone ranunculoides*, *Arum orientale*, *Brachypodium sylvaticum*, *Campanula rapunculoides*, *C. trachelium*, *Carex digitata*, *C. pilosa*, *C. sylvatica*, *Cephalanthera damasonium*, *Chaerophyllum temulum*, *Chelidonium majus*, *Circaea lutetiana*, *Convallaria majalis*, *Corydalis cava*, *C. pumila*, *C. solida*, *Dactylis polygama*, *Dentaria bulbifera*, *Elymus caninus*, *Epipactis helleborine*, *Euphorbia amygdaloides*, *Fragaria vesca*, *Gagea lutea*, *Galanthus nivalis*, *Galeobdolon montanum*, *Galium odoratum*, *G. sylvaticum*, *Geranium lucidum*, *G. robertianum*, *Geum urbanum*, *Glechoma hirsuta*, *Hepatica nobilis*, *Heracleum sphondylium*, *Lamium maculatum*, *Lapsana communis*, *Lathyrus niger*, *L. vernus*, *Lilium martagon*, *Melica uniflora*, *Mercurialis perennis*, *Myosotis sparsiflora*, *Neottia*

nidus-avis, *Ornithogalum sphaerocarpum*, *Orobanche hederae*, *Parietaria officinalis*, *Physocaulis nodosus*, *Polygonatum latifolium*, *P. multiflorum*, *Polystichum aculeatum*, *Pulmonaria officinalis*, *Ranunculus ficaria*, *Salvia glutinosa*, *Scilla vindobonensis* (Köbölkúti-erdő), *Scutellaria columnae*, *Smyrnium perfoliatum*, *Stachys sylvatica*, *Symphytum tuberosum* subsp. *angustifolium*, *Tamus communis*, *Torilis japonica*, *Urtica dioica*, *Veronica hederifolia* agg., *Vicia dumetorum*, *V. sepium*, *Viola odorata*, and *V. sylvestris*.

The "quercetosum petraeae" stand was reported by Jakucs (1966) from the slopes with a moderate inclination in the southern part of the plateau; it is transitional toward the Turkey oak woodlands. Here, in addition to the species of the oak-hornbeam forests, the following are also typical: *Astragalus glycyphyllos*, *Campanula persicifolia*, *Convallaria majalis*, *Hypericum hirsutum*, *Lactuca quercina*, *L. quercina* var. *sagittata*, *Poa nemoralis*, and *Primula veris*.

Downy oak shrub forests (M1; 91H0): These forests grow on south/southwest-facing steep slopes, escarps, or above huge rocks/walls and noses; their dominant species are *Fraxinus ornus*, *Quercus pubescens*, and *Cerasus mahaleb*. Because of the geomorphological circumstances of Mt Badacsony, they are confined to small fragments. The shrub forests are characterised by poorly growing 5–10 metre-tall trees with restrictions by the extremely dry and stony habitats. The shrub forests are mixed by small dry grassland patches and rocky plant associations. This habitat type greatly differs from the *Luzulo-Ornetum* in species composition, while from the *Orno-Quercetum* in its structural features and in a bit higher contingent of dry grassland species.

Jakucs (1961) listed these shrub forests of Mt Badacsony under the name of *Cotino-Quercetum pubescentis*, based on a sample taken above the Rodostó tourist hostel. Jakucs noted that certain characteristics of the *Genisto-Quercetum* are also recognisable in these stands. Whereas, we note here that the stand was mentioned as *Ceraso-Quercetum pubescentis* in Jakucs (1966).

Permanent species of the canopy layer of the pubescent oak forests of Mt Badacsony are *Cerasus mahaleb*, *Fraxinus ornus*, *Quercus pubescens*, and scattered are *Acer campestre*, *A. platanoides*, *Pyrus pyraster*, *Quercus cerris*, *Q. petraea* and *Tilia cordata*. Presence of the latter species can be attributed to the geomorphological circumstances and closeness of the forest associations of rocky habitats (*Luzulo-Ornetum*, *Mercuriali-Tilietum*). The shrub layer is rich in species. Constant species are *Fraxinus ornus*, *Cerasus mahaleb*, *Rosa canina* agg., and *Hedera helix*. Additional typical shrub species are *Acer campestre*, *Colutea arborescens*, *Cornus mas*, *C. sanguinea*, *Corylus avellana*, *Cotoneaster niger*, *Crataegus monogyna*, *Euonymus verrucosus*, *Ligustrum vulgare*, *Prunus spinosa*, *Rhamnus catharticus*, *Sambucus nigra*, *Sorbus* cf. *danubialis*, *S. torminalis*, *Staphylea pinnata*, *Viburnum lantana*. The herb layer is composed of species with various

habitat requirements. Species richness, especially with regard to the rate of sub-Mediterranean and forest-steppe elements, is less expressed on basalt than in the vicariant shrub forests growing on dolomite bedrock. Based on 10 samples in the local stands, the contingent of the xerotherm, dry oak forest and forest edge species (A) and the number of rocky and dry grassland elements (B) are similar. (A: *Ajuga genevensis*, *Anthemis tinctoria*, *Arabis turrita*, *Aster linosyris*, *Buglossoides purpureo-coerulea*, *Bupleurum falcatum*, *Campanula glomerata*, *C. persicifolia*, *Carex halleriana* (very rare locally), *Dictamnus albus*, *Digitalis grandiflora*, *Erysimum odoratum*, *Euphorbia epithymoides*, *Fragaria viridis*, *Galium glaucum*, *G. mollugo* s. l., *Geranium sanguineum*, *Glechoma hirsuta*, *Hieracium cymosum*, *Hylotelephium maximum*, *Hypericum perforatum*, *Inula ensifolia*, *I. hirta*, *Iris variegata*, *Lactuca viminea*, *Lembotropis nigricans*, *Luzula campestris* agg., *Lychnis viscaria*, *Mercurialis ovata* (rare locally), *Peucedanum cervaria*, *P. oreoselinum*, *Piptatherum virescens*, *Poa nemoralis*, *P. angustifolia*, *Polygonatum latifolium*, *P. odoratum*, *Potentilla heptaphylla*, *P. rupestris* (rare), *Primula veris*, *Pulmonaria mollis* (rare locally), *Securigera varia*, *Silene nutans*, *S. vulgaris*, *Tanacetum corymbosum*, *Trifolium alpestre*, *Verbascum austriacum*, *Veronica chamaedrys*, *Vicia tenuifolia*, *Vincetoxicum hirundinaria*, *Viola hirta*; B: *Acinos arvensis*, *Achillea pannonica*, *Allium flavum*, *A. sphaerocephalon* (rare locally), *Arabidopsis thaliana*, *Aurinia saxatilis*, *Asplenium ceterach*, *A. trichomanes*, *Campanula rotundifolia*, *Cardaminopsis arenosa*, *Centaurea stoebe*, *Chamaecytisus ratisbonensis*, *Elymus hispidus*, *Erysimum diffusum*, *Euphorbia cyparissias*, *Falcaria vulgaris*, *Festuca pallens*, *F. rupicola*, *F. valesiaca*, *Galium austriacum*, *Geranium rotundifolium*, *Holosteum umbellatum*, *Jovibarba hirta*, *Koeleria cristata* agg., *Linaria genistifolia*, *Myosotis ramosissima*, *M. stricta*, *Orlaya grandiflora*, *Ornithogalum umbellatum*, *Papaver dubium*, *Phleum phleoides*, *Poa bulbosa*, *Potentilla arenaria*, *P. argentea*, *P. recta*, *Pulsatilla nigricans* (rare), *Ranunculus illyricus*, *Saxifraga tridactylites*, *Sedum album*, *S. sexangulare*, *Seseli osseum*, *Stachys recta*, *Stipa capillata*, *Teucrium chamaedrys*, *Verbascum lychnitis*, *V. phoeniceum*, *Veronica verna*, *Vicia hirsuta*). Characteristic general and wide-tolerant species: *Alliaria petiolata*, *Anthriscus cerefolium*, *Bromus sterilis*, *B. tectorum*, *Chelidonium majus*, *Dactylis glomerata*, *Fallopia convolvulus*, *Galium aparine*, *Geranium robertianum*, *Geum urbanum*, *Lamium purpureum*, *Ornithogalum umbellatum*, *Physocaulis nodosus*, *Silene latifolia*, *Sisymbrium orientale*, *Veronica hederifolia* agg., *Vicia hirsuta*, *V. grandiflora*, *Viola arvensis*.

Pannonian woods with *Quercus pubescens* (L1; 91H0): Based on the species composition the local stands are close to *Vicio sparsiflorae-Quercetum pubescentis* Zólyomi ex Borhidi et Kevey 1996 (*Orno-Quercetum*) and can be mapped as L1×LY2. Most of the occurrences are transitional toward the adjacent shrub forests and debris slope forests.

In the canopy layer usually *Fraxinus ornus* is dominant, but in some patches *Acer campestre* and *Quercus pubescens* are also frequent. Additional tree species are *Fraxinus excelsior*, *Quercus cerris*, *Tilia cordata*, *Ulmus minor* (L1×LY2). Some stands are mixed with more or less *Robinia*. The shrub layer coverage is high with *Cornus mas*, *C. sanguinea*, *Colutea arborescens*, *Crataegus monogyna*, *Euonymus verrucosus*, *Ligustrum vulgare*, *Lonicera xylosteum*, *Prunus spinosa*, *Rhamnus catharticus*, *Staphylea pinnata*, and *Viburnum lantana*. The herb layer is characterised by nitrofrequent and disturbation-tolerant species (*Alliaria petiolata*, *Anthriscus cerefolium*, *Physocaulis nodosus*, *Smyrnium perfoliatum*) due to high nutrient levels of the soil and heavy erosion. The most important species of the stands are *Arabis turrita*, *Buglossoides purpureo-coerulea*, *Cephalanthera longifolia*, *Corydalis pumila*, *Dictamnus albus*, *Galium mollugo* s. l., *Geranium sanguineum*, *Hieracium cymosum*, *Hylotelephium maximum*, *Inula conyza*, *I. hirta*, *Iris variegata*, *Laser trilobum*, *Peucedanum cervaria*, *Piptatherum virescens*, *Polygonatum latifolium*, *P. odoratum*, *Primula veris*, *Silene nutans*, *Tanacetum corymbosum*, *Trifolium alpestre*, *Vicia pisiformis*, *Vincetoxicum hirundinaria*, *Viola hirta*. Typical in the association, but locally rare species are *Carex halleriana*, *Iris graminea*, *Mercurialis ovata*, and *Pulmonaria mollis*.

Turkey oak forests (L2a; 91M0): The dominant vegetation type of the foothills was probably the Turkey oak woodland. At present, their potential areas are occupied by vineyards up to the bottom of the basalt debris slopes, so that in fact Turkey oak woodlands are mostly lacking from the protected area. The stands of Turkey oak woodland mapped by Jakucs (1966) are still in place, but they mainly show a transitional stage toward the debris slope forests (L2a×LY2). These unique, marginally positioned Turkey oak woodlands grow on surfaces where the bedrock is friable Pannonian sediment with variously sized basalt debris deposits. In these sites special stands occur in which the canopy layer is dominated by old *Quercus petraea* trees, and the soil is covered by basalt debris. Additional common tree species are *Acer campestre*, *Fraxinus ornus*, *Quercus cerris*, *Sorbus torminalis*, and scattered trees of *Robinia pseudacacia* also occur. The shrub layer is mixed: *Acer campestre*, *Cornus mas*, *C. sanguinea*, *Clematis vitalba*, *Crataegus monogyna*, *Euonymus europaeus*, *E. verrucosus*, *Ligustrum vulgare*, *Sambucus nigra*, *Viburnum lantana*. Typical Turkey oak woodlands and dry oak forest species in the herb layer are *Astragalus glycyphyllos*, *Campanula persicifolia*, *Carex divulsa*, *Festuca heterophylla*, *Hypericum hirsutum*, *Lathyrus niger*, *Luzula forsteri*, *Lychnis coronaria*, *L. viscaria*, *Poa nemoralis*, *Tanacetum corymbosum*, *Trifolium medium*, *Vicia cassubica*, *Viola* alba, and *V. odorata*. A robust population of *Tamus communis* thrives in the stands occurring around Rózsakő.

Mixed forests of scree, and rocky slopes (LY2): This frequent association of Mt Badacsony *Aceri pseudoplatani-Tilietum* Jakucs 1966 nom. prov. (~*Mercuriali-*

Tilietum Zólyomi et Jakucs in Zólyomi 1958 s. l.), covering large surfaces on debris slopes of large basalt rocks. Its local occurrences are usually natural, but in a small percentage secondary stands (P2×LY2) mixed with *Robinia* are also found. Already Jakucs (1966) emphasised that the uniqueness of the local debris slope forests' is that they occur in all exposures caused by the special conditions of Mt Badacsony. The rendzina rich in humus can dry out fast on the surface of the debris slopes, but the humidity is preserved in the deeper levels, so the association can grow regardless of the exposure. At the same time, differences in the herb layer of the stands can be observed. The natural types of these stands are typical on the cool, north-facing slopes.

The canopy layer is usually composed of *Acer pseudoplatanus*, *A. campestre*, *Fraxinus excelsior*, *Tilia cordata*, and *T. platyphyllos*. Additional associated trees are *Acer platanoides*, *Carpinus betulus*, *Fagus sylvatica*, *Fraxinus ornus*, *Sorbus torminalis*, *Ulmus glabra*, and *U. minor*. *Tilia argentea* occurs in a regenerating debris slope stand (P2×LY2) in the southern part of the Tomaji-kőbánya (quarry), but that is not regarded spontaneous there. Typical elements of the shrub layer are *Staphylea pinnata* and *Corylus avellana*; other frequent elements are *Cerasus mahaleb*, *Cornus mas*, *C. sanguinea*, *Crataegus oxyacantha*, *Euonymus verrucosus*, *Hedera helix*, *Rhamnus catharticus*, *Rosa arvensis*, *Sambucus nigra* and plants of the species of the canopy layer. Rare shrubs are *Rubus idaeus* and *Hippocrepis emerus* (environs of Kőkapu). The herb layer of the *Tilia* debris slope forests has a full cover in the spring aspect, but otherwise is insignificant on the rocky surfaces. Common species of the early spring aspect are *Corydalis pumila*, *C. solida*, *Mercurialis perennis*, later the nitrofrequent species (*Anthriscus cerefolium*, *Parietaria officinalis*, *Physocaulis nodosus*, *Urtica dioica*) become dominant on the eroded soil. Typical accompanying species are *Ajuga genevensis*, *A. reptans*, *Alliaria petiolata*, *Anthriscus sylvestris*, *Arabis turrita*, *Arum orientale*, *Asplenium adiantum-nigrum, Brachypodium sylvaticum*, *Calamintha sylvatica*, *Cardaminopsis arenosa*, *Carex digitata*, *Chaerophyllum temulum*, *Chelidonium majus*, *Corydalis cava*, *Cystopteris fragilis*, *Dactylis polygama*, *Galanthus nivalis*, *Galium aparine*, *Geranium lucidum*, *G. robertianum*, *Glechoma hirsuta*, *Hepatica nobilis*, *Heracleum sphondylium*, *Hylotelephium maximum*, *Lilium martagon*, *Melittis carpatica*, *Myosotis sparsiflora*, *Ornithogalum sphaerocarpum*, *Orobanche hederae*, *Polygonatum latifolium*, *P. multiflorum*, *Pulmonaria officinalis*, *Ranunculus ficaria*, *Smyrnium perfoliatum*, *Stachys sylvatica*, *Tamus communis*, *Veronica chamaedrys*, and *V. hederifolia* agg.

Without a detailed description, Jakucs (1966) mapped a "species poor" stand of "creek forest" in a deep valley occurring south from the Tomaji-kőbánya (quarry). My recent work did not detect any creek forest species at that site, so did

not confirm the statement made decades ago, concurrently with Kevey (2008), who did not adore the stand identification as a creek forest.

Mixed relic oak forests on rocks (LY4): Under the name of "*Luzulo-Ornetum*" Jakucs (1966) published a new plant association from the north- and northwest-facing, steep, high-crowned slopes of Mt Badacsony. Stands of the association grow on cool, windy sides and steep hillslopes of the plateau-margins, on which the soil is very shallow caused by the erosion. The canopy layer in such sites is not entirely closed, thus often characterised by a similar structure of the shrub forests.

In my opinion the *Luzulo-Ornetum* on basalt, is the vicariant association of *Fago-Ornetum* occurring on dolomite bedrock. Similar to *Fago-Ornetum*, *Luzulo-Ornetum* also has high importance in the phytogeographical and vegetation-historical aspects of Mt Badacsony, mainly in the conservation of relict species. Despite the similar range and structural features, the differences in species composition of the two associations are caused by the differences of habitat capabilities. Dolomite species do not occur in these stands, the association occurring on shallow, acidulating soil can support species of dry and calciphobe oak forest as well as species that have high tolerance to any soil condition. Species composition of these stands has several similarities with the open calciphobe oak forests, but the canopy layer of the latter is species poor, and is strongly dominated by *Quercus petraea*. An important characteristic of "*Luzulo-Ornetum*" stands is that their canopy layer is species rich (Jakucs 1966).

Because of the shallow, leached soils the canopy layer of Mt Badacsony's *Luzulo-Ornetum* is not more than 5–12 m high. In terms of the canopy coverage, it is an open stand with mosaics of rocky grasslands and rocky scrubs, particularly toward the margins. Typical tree species are *Fagus sylvatica*, *Fraxinus ornus*, *Quercus petraea*, *Sorbus torminalis*, but *Cerasus mahaleb*, *Tilia cordata*, *Sorbus bakonyensis*, *Sorbus* cf. *danubialis* (mainly on the margins of the rocks) are also present. On some patches (*e.g.* above the basalt organs of Kőkapu) there was an attempt to make a canopy closure by *Pinus nigra* plantation. These are mainly lacking any real shrub layer, since the occurring shrub specimens are seedlings of trees of the canopy. Normally, typical shrubs include *Cornus mas*, *Viburnum lantana*, and occasionally *Colutea arborescens*, *Cotoneaster niger*.

Character species of the herb layer is *Luzula luzuloides*, but *L. campestris* agg. and *L. forsteri* are also present. Species that help in recognising these stands are *Leucanthemum margaritae*, *Lychnis viscaria*, *Hieracium murorum*, *Hypericum montanum*, *Serratula tinctoria*, *Solidago virga-aurea*, and *Veronica officinalis*. Only a very few nitrofrequent species are present (or are entirely lacking) in the stands. The species richness of the herb layer depends on the coexistence of plants of the dry oak forests, the xerophilous oak forests, the habitats with basalt rocks

and rarely some mesophilous forest species that may or may not concur at these sites. Additionally, typical species of the local stands include *Ajuga genevensis*, *Arabis hirsuta*, *A. turrita*, *Betonica officinalis*, *Campanula persicifolia*, *C. rotundifolia*, *Cardaminopsis arenosa*, *Carex digitata*, *C. montana*, *Clinopodium vulgare*, *Corydalis solida*, *Digitalis grandiflora*, *Euphorbia cyparissias*, *Festuca heterophylla*, *Helictotrichon adsurgens*, *Hepatica nobilis*, *Hieracium cymosum*, *H. sabaudum*, *Hierochloë australis*, *Hypericum hirsutum*, *Inula ensifolia*, *I. hirta*, *Iris variegata*, *Lembotropis nigricans*, *Melampyrum nemorosum*, *Melittis carpatica*, *Peucedanum cervaria*, *P. oreoselinum*, *Platanthera bifolia*, *Poa nemoralis*, *Polygonatum odoratum*, *Primula veris*, *Prunella laciniata*, *Rumex acetosella*, *Seseli osseum*, *Silene nutans*, *Tanacetum corymbosum*, *Trifolium alpestre*, *Veronica chamaedrys*, and on the rocky areas of the forest: *Asplenium septentrionale*, *Aurinia saxatilis, Galium austriacum*, *Hieracium wiesbaurianum*, *Jovibarba hirta*, and *Polypodium interjectum*.

Coenological relevé of one of the most exemplary stands of *Luzulo luzuloidis-Fraxinetum orni* ("*Luzulo-Ornetum*"):

Settlement: Badacsonytomaj. Locality: Badacsony, Kőkapu. Quadrate size: 20 m × 20 m. Bedrock: basalt. Alt. cca. 375 m. Slope: 40–45°. Exp.: N. Date: 30.05.2005. (author: N. Bauer).

Canopy layer A1: *Fagus sylvatica* 30%, *Quercus petraea* 30%, *Fraxinus ornus* 25%, *Pinus nigra* 5%; A2: *Fraxinus ornus* 5%, *Tilia cordata* 5%, *Betula pendula* 3%, *Sorbus* cf. *bakonyensis* 1%.

Shrub layer: *Fraxinus ornus* 5%, *Sorbus* sp. 5%, *Cornus mas* +, *Cotoneaster niger* +, *Euonymus verrucosus* +, *Sorbus torminalis* +, *Viburnum lantana* +.

Herb layer: *Luzula luzuloides* 15%, *Melica uniflora* 10%, *Cardaminopsis arenosa* 5%, *Festuca heterophylla* 5%, *Hierochloë australis* 5%, *Polygonatum odoratum* 5%, *Tanacetum corymbosum* 5%, *Fraxinus ornus* 3%, *Inula hirta* 3%, *Lychnis viscaria* 3%, *Primula veris* 3%, *Trifolium alpestre* 3%, *Hylotelephium maximum* 1%, *Inula ensifolia* 1%, *Luzula campestris* agg. 1%, *Serratula tinctoria* 1%, *Acinos arvensis* +, *Ajuga genevensis* +, *Arabis hirsuta* +, *A. turrita* +, *Aurinia saxatilis* +, *Asplenium trichomanes* +, *Campanula persicifolia* +, *Corydalis solida* +, *Chamaecytisus ratisbonensis* +, *Dactylis polygama* +, *Digitalis grandiflora* +, *Erysimum odoratum* +, *Euphorbia cyparissias* +, *Galium austriacum* +, *G. glaucum* +, *Hepatica nobilis* +, *Hieracium cymosum* +, *H. murorum* +, *Hypericum montanum* +, *Iris variegata* +, *Lembotropis nigricans* +, *Leucanthemum margaritae* +, *Melittis carpatica* +, *Peucedanum oreoselinum* +, *Platanthera bifolia* +, *Polygonatum latifolium* +, *Polypodium vulgare* agg. +, *Seseli osseum* +, *Silene nutans* +, *S. vulgaris* +, *Veronica chamaedrys* +, *V. officinalis* +, *Vincetoxicum hirundinaria* +.

Uncharacteristic dry and semi-dry grasslands (OC): Plant communities growing on deforested areas in the plateau-margins and on secondary surfaces in the stone-mines belong to this category. Dominant grass species are *Agrostis capillaris*, *Bromus inermis*, *B. sterilis*, *Calamagrostis epigeios*, *Elymus hispidus*, *E. repens*, *Festuca valesiaca* agg., *Poa angustifolia*, and locally *Hordeum murinum*. Typical accompanying species of secondary dry grasslands of Mt Badacsony are *Anchusa officinalis*, *Anthoxanthum odoratum*, *Aster linosyris*, *Echium vulgare*,

Erodium cicutarium, *Erophila verna*, *Falcaria vulgaris*, *Festuca rubra*, *Lamium amplexicaule*, *L. purpureum*, *Lathyrus tuberosus*, *Leontodon hispidus*, *Medicago falcata*, *Myosotis ramosissima*, *Papaver dubium*, *Polygonum arenastrum*, *Potentilla argentea* agg., *Sedum sexangulare*, *Vicia angustifolia*, *V. grandiflora*, *V. hirsuta*, *V. lathyroides*, *Viola arvensis*. Locally rare or scattered elements are Chamanerion dodonaei (Tördemici-bánya), *Gagea pratensis*, *Geranium divaricatum* (Ranolder-kereszt and deforested patches of the plateau-margin, Tördemici-bánya), *Lychnis coronaria* (scattered, but mainly in the secondary grasslands and shrubs of the abandoned stone-mines), *Orchis morio* (stone-mines of Tördemic and Tomaj), *Ornithogalum boucheanum*, *O. umbellatum*, *Ranunculus illyricus*.

Secondary humid grasslands (OB): This habitat type is rare in the mapped area. Mowed grassland of a waterwork ground in the margin of the Köbölkúti-erdő and weedy humid grasslands of the former Felsőkolónia belong to this category.

Dry scrub vegetation with *Crataegus* and *Prunus spinosa* (P2b): The unforested areas of the abandoned stone-mines have spontaneously and intensively been colonised by seedlings of native woody plants in the last decades. The secondary shrub and tree vegetation show up markedly on the debris slopes, with two main types on Mt Badacsony.

One is a closed *Pruno spinosae-Crataegetum* stand on plain terrane or slopes occupying various areas on the strips. Common species in these patches are *Acer campestre*, *Crataegus monogyna*, *Juniperus communis*, *Fraxinus ornus*, *Prunus spinosa*, *Rosa canina*, *Rubus fruticosus*. Small *Populus alba*, *P. tremula*, *Salix caprea* shrubs are also present. Locally, invasive species (*e.g. Ailanthus altissima*, *Robinia pseudacacia*) and species escaped from gardens (*e.g. Jasminum fruticans*, *Syringa vulgaris*) also appear in such places.

The second type of the scrub vegetation occurs on transition margins in steep slopes having both natural and artificial vegetation, as waste-piles, stone-mines, or debris slopes. At present these stands can be taken as shrubby vegetation (P2×LY2), but on the long run they may develop into debris slope forests. Characteristic tree species in these areas are *Acer campestre*, *Cerasus mahaleb*, *Cornus mas*, *C. sanguinea*, *Fraxinus ornus*, *Tilia cordata*, and *T. platyphyllos*.

Similar stands can be found on the upper margins of natural debris slopes at the bordering of the basalt rocks. These stands are often strongly overgrown by *Hedera helix* and *Clematis vitalba*. This habitat is marked as "Gebüsch des Schuttrandes" around "Nagyomlás" in Jakucs (1966).

Clearcuts (P8): This habitat type occurs on small patches of Köbölkúti-erdő and Kotyor. Most of the clearcuts is found in *Robinia* plantations or in other plantations mixed with *Robinia*.

Uncharacteristic hard wood woodlands and plantation (RC): This habitat has subtypes on the hill. Usually these are planted homogeneous oak forests in the abandoned stone-mines dominated by *Quercus petraea*, occasionally mixed with *Fraxinus ornus*, *Quercus cerris*, *Tilia cordata*. Shrub and herb layer of the 30–40 year-old closed stands are rudimental and characterised by generalist forest species.

The uncharacteristic forests growing on grounds, which potentially are oak-hornbeam woodland habitats, and can be characterised as young monocultures with a homogeneous structure, were placed into this category.

***Robinia pseudacacia* stands** (S1): The Black locust stands are of artificial origin (*Robinia pseudacacia* plantations), spontaneous occurrences are only found in small patches of the abandoned stone-mines. In the canopy layer of the local *Robinia* stands native species (*Acer campestre*, *Fraxinus ornus*, *Ulmus minor*, *Populus alba*, etc.) can be seen with either spontaneous or non-spontaneous origin (max. 10–20%). A small part of the local *Robinia* stands is spontaneous, occurring in mine-strips and valleys of the vineyards. The shrub layer in this habitat-type is homogeneous, usually dominated by *Rubus fruticosus* agg. or *Sambucus nigra*, with dense *Hedera helix* populations. The herb layer is characterised by generally nitrofrequent elements (*Alliaria petiolata*, *Anthriscus cerefolium*, *Bromus sterilis*, *Chelidonium majus*, *Galium aparine*, *Geranium robertianum*, *Parietaria officinalis*, *Urtica dioica*, *Veronica hederifolia* agg.) and generalist forest species (*Brachypodium sylvaticum*, *Carex divulsa*, *Dactylis glomerata*, *Galeopsis pubescens*, *Geum urbanum*, *Glechoma hirsuta*, *Lamium maculatum*, *Polygonatum latifolium*, *Ranunculus ficaria*, *Viola odorata*). In the spring aspect the presence of *Anemone ranunculoides*, *Corydalis cava*, *C. pumila*, *Hepatica nobilis* is noted. *Myrrhoides nodosa* is also frequent in some *Robinia* stands. Scattered presence of *Arum orientale*, *Carex divulsa*, *Ornithogalum boucheanum*, *O. sphaerocarpum*, *O. umbellatum*, *Orobanche hederae*, *Primula veris*, *Smyrnium perfoliatum*, *Symphytum tuberosum* subsp. *angustifolium*, *Tamus communis*, *Viola alba*, as oak forest species formerly dominated this type of habitat can be mentioned. In the margins and clearings dense populations of *Calamagrostis epigeios*, *Conyza canadensis*, *Erigeron annuus*, *Solidago canadensis*, *S. gigantea* are typical.

***Robinia* woodlands mixed with white poplar** (S1×RB): One patch of this type of vegetation sharply stands out from the *Robinia* plantations on the aerial photograph. It is separated mostly in its structure. Based on the species composition this habitat-type is also dominated by uncharacteristic, nitrofrequent species (*e.g. Chelidonium majus*, *Sambucus nigra*, *Urtica dioica*).

Black pine plantations (S4): *Pinus nigra* plantations were established in very different habitat types of the mount: in place of oak-hornbeam forests, in rocky and scree forests and on secondary surfaces of abandoned stone-mines.

Young, dense, closed stands are lacking the herb layer, but in less dense or mixed stands it is formed by species from the high-tolerant species of the adjacent forests.

Traditional vineyards and orchards (T8): Most of the local vineyards were planted on the foothills in habitats originally occupied by Turkey oak and Pubescent oak forests. The vineyard areas have been established mainly in small blocks. Cellars also exist, but the number of the weekend houses and gardens are on the rise. Here, using pesticides and chemical fertilisers is a common practice, so the occurrence of the rare weed species related to viniculture is limited; some of the previously known "vineyard weeds" may not be there anymore. Some species occur in a few restricted blocks, examples include *Allium oleraceum*, *Eragrostis cilianensis*, *Filago arvensis*, *Gagea arvensis*, *Tordylium maximum*, and *Urtica urens*. The weed vegetation of the vineyards, balks and road margins is formed by the following common and general species: *Amaranthus retroflexus*, *Apera spica-venti*, *Aristolochia clematitis*, *Artemisia vulgaris*, *Ballota nigra*, *Berteroa incana*, *Bromus inermis*, *Buglossoides arvensis*, *Camelina microcarpa*, *Capsella bursa-pastoris*, *Cardaria* draba, *Chenopodium album*, *Chondrilla juncea*, *Cirsium arvense*, *Convolvulus arvensis*, *Cynoglossum officinale*, *Descurainia sophia*, *Digitaria sanguinalis*, *Diplotaxis muralis*, *Elymus repens*, *Erodium cicutarium*, *Euphorbia cyparissias*, *E. esula*, *E. helioscopia*, *Fumaria officinalis*, *F. schleicheri*, *F. vaillanti*, *Geranium pusillum*, *G. rotundifolium*, *Holosteum umbellatum*, *Lactuca serriola*, *Lamium amplexicaule*, *L. purpureum*, *Lathyrus tuberosus*, *Lavathera thuringiaca*, *Libanotis pyrenaica*, *Malva sylvestris*, *Medicago sativa*, *M. lupulina*, *M.* × *varia*, *Melampyrum barbatum*, *Mercurialis annua*, *Muscari comosum*, *Ornithogalum boucheanum*, *O. umbellatum*, *Papaver rhoeas*, *Poa annua*, *P. compressa*, *Portulaca oleracea*, *Ranunculus polyanthemos*, *Sambucus ebulus*, *Senecio vulgaris*, *Setaria pumila*, *Solanum nigrum*, *Sonchus oleraceus*, *Stellaria media*, *Taraxacum officinale*, *Torilis arvensis*, *Tragopogon orientalis*, *Trifolium arvense*, *Tussilago farfara*, *Veronica hederifolia* agg., *V. polita*, *Vicia grandiflora*, *V. hirsuta*, *V. tenuifolia*, *V. villosa*, *Viola arvensis*, etc. Some species are escaped from gardens, exemplified by *Euphorbia lathyris*, *Geranium macrorhizum*, *Iris germanica*, *Muscari armeniacum*, *Narcissus* spp., *Sedum rupestre*, *Vinca major*, and are frequently seen in balks and abandoned vineyards.

Occurrences of weedy associations of vineyards, as *Stellario mediae-Mercurialietum annuae* Ubrizsy 1967, *Convolvulo-Portulacetum* Ubrizsy 1949, *Echinochloo-Setarietum pumilae* Felföldy 1942 corr. Mucina 1993 are typical in this habitat.

Some of the vineyards are abandoned (Desisted vineyards and orchards, O12), in which weeds, at some places invasive ones, are dominant; also, development of secondary scrub is observed. Typical species here include *Ambrosia*

artemisiifolia, *Calamagrostis epigeios*, *Humulus lupulus*, *Lycium barbarum*, *Sambucus ebulus*, *Solidago canadensis*, *S. gigantea*, and invasive species, such as *Ailanthus altissima*, *Amorpha fruticosa*, *Asclepias syriaca*, *Robinia pseudacacia*, are becoming a growing problem in all parts of the vineyards.

Yards, premises, wreckage, dumping grounds (U4): Rickety buildings of former Felsőkolónia, Rodostó tourist house, cellars and some formerly wooded and currently disturbed vineyards belong to this category.

Additional typical, but unmapped habitat categories

Open vegetation of shaded rocks (I3): This rocky vegetation occurring in forests and shaded, north-facing rocks can be identified as the association of *Hypno-Polypodietum* (Jurko et Peciar 1963) Simon 1971). Soó (1931) defined these stands as *Hypno-Sedetum*, but he did not give a detailed description. Common species of Mt Badacsony habitats are *Cardaminopsis arenosa*, *Asplenium trichomanes*, *Aurinia saxatilis*, *Chelidonium majus*, *Geranium robertianum*, *Hylotelephium* maximum, *Moehringia trinervia*, and *Polypodium interjectum*. This vegetation type appears on the old walls of former mines and debris slopes of hump-yards. Rare accompanying species are *Asplenium adiantum-nigrum*, *Dryopteris carthusiana* (Tomaji-bánya), *Polystichum aculeatum*. They are usually parts of the LY2 and P2b×LY2 habitats.

Trampled weedy vegetation (O13): This type can not be figured at the published scale, for its tiny area.

Intensively cultivated vineyards and orchards (T7): Within the Natura 2000 territory of Mt Badacsony, intensive vineyards and orchards are absent, but the low-altitude foothill areas are mainly covered by this habitat type. Intensive vineyards occur on the ascending lower slopes, on the once-potential habitats of Turkey oak woodlands.

Open mines, mine dumps (U5, U6): Basalt mining of Mt Badacsony was finished in 1963. Smaller parts of the mine dumps have been spontaneously forested by secondary vegetation, but above the abandoned mine areas plantations were established. Based on these facts the former mine areas have been mapped as secondary vegetation types (*e.g.* OC, P2b, RC, S4), and not as U5/U6.

Adventive and invasive species of the studied area

Acer negundo L. – the species spreads extensively on the shores of Lake Balaton, while on Mt Badacsony it only occurs scattered in the shrubbery of Felsőkolónia, below the section of "Bujdosók lépcsője" (stairs) and the electric track of Köbölkúti-erdő.

Ailanthus altissima (Mill.) Swingle – spreads on the margins and clearings of Kotyor and Köbölkúti-erdő, along the electric tracks, in abandoned stone-mines.

Ambrosia artemisiifolia L. – widely spreads along roads, in vineyards and waste areas.

Amorpha fruticosa L. – Badacsonytomaj, occurring in shrubbery under the Tomaji-bánya (mine), around Felsőkolónia, and along roads and tracks toward to the settlement, in scrubs under the power-lines.

Asclepias syriaca L. – scattered in abandoned vineyards and neglected road margins.

Aster lanceolatus agg. – in the weedy grasslands and shrubbery of Felsőkolónia.

Broussonetia papyrifera (L.) Vent. – Badacsonytördemic, in scrubs of empty grounds.

Fallopia × *bohemica* (Chrtek et Chrtková) J. Bailey – Badacsonytomaj, around neglected buildings of Felsőkolónia.

Helianthus tuberosus agg. – in the margin of Köbölkúti-erdő.

Impatiens parviflora DC. – scattered in the forest of the plateau.

Mahonia aquifolium (Pursh) Nutt. – in *Robinia* plantations and in other secondary forest patches.

Phytolacca americana L. – scattered in some forest-edges and along tourist trails, in small groups above Badacsonytördemic in the margins of Köbölkúti-erdő.

Robinia pseudacacia L. – its planted stands are included in the mapped area, but it spreads spontaneously with patches of various size in abandoned mine dumps, in clearings, in disturbed forest segments.

Solidago canadensis L. – scattered in forest-edges, neglected grounds, road-margins.

Solidago gigantea Ait. – its small groups in road-margins, forest-edges, in clearings of Kotyor and Köbölkúti-erdő.

Besides the vegetation mapping of Mt Badacsony, the author has been working on the sampling of the dry grasslands of the Bakony region, the shrub forests of the Transdanubian basalt hills and also the *Luzulo-Ornetum* stands recognised by P. Jakucs, but so far not published in detail. Results of these studies will be published in future articles.

* * *

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