

University of Pécs
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**Historical, phytogeographical and coenological
investigations on the forests of the Sopron Hills**

PhD. Thesis

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Pécs

2010

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I. BACKGROUND AND RESEARCH AIMS

The surroundings of Sopron city and Sopron Hills have long been a priority target of botanical research in Hungary. From the compilation of the „Flora Semproniensis” (1739-1740), considered the first Flora in Hungary, until the first third of the 20th century studies concentrated on the flora; however, the phytosociology unfolding in the 1930s led to the beginning of investigations of the hills’ vegetation. The research of forest vegetation and forest associations was carried out in various stages; yet the papers published in different periods have one thing in common: they deal almost exclusively with the Hungarian part of the hills divided by the Austrian-Hungarian border. On the Austrian side no coenological analysis was carried out in the forests, due mainly to the peripheral state of this range within Austria.

Sopron Hills are a promising site for a vegetation scientist for two reasons. On the one hand this area, part of the eastern ranges of the Alpine region, can be considered transitional from the geological, climatological and phytogeographical point of view. The other important aspect is the secondary nature of the hills’ forest vegetation; as a result of the significant impact of the last two and a half thousand years of civilization (especially forest utilization in the Middle Ages and the coniferisation starting from the mid-19th century) the forests and their sites have been strongly transformed.

In my dissertation I focused on the forest vegetation of these relatively well researched, but in some details still poorly explored region, and I tried to decipher the principles of the forest vegetation while „forgetting” about the state border (as an artificial line). In my studies I applied a complex approach; besides the basic coenological analysis of the forests I also put a strong emphasis on the analysis of historical data, exploring the ecological context and on tracing the existing phytogeographical connections towards the Alps. The aims of my investigations can be summarized as follows:

- An overview of the forest history of the Sopron Hills (changes in forest cover, tree species composition, herb layer patterns), exploring the effects of the centuries / millennia of human activities on forest habitat types.
- An analysis of the issue of nativity of the conifers (spruce, fir, scots pine, black pine, larch), widely used in the region in the last 150 years of forest management, and the sweet chestnut cultivated for a long time.
- The detection, analysis and evaluation of the changes in the vegetation, that have taken place since the 1950s, with particular regard to the acidophilous forests emerging as a result of soil degradation.
- An overview of the general classification problems concerning acidophilous forests and the phytogeographical-coenological analysis of such forests occurring in the hills.
- A detailed coenological and phytogeographical analysis of the poorly known or unknown forest associations (beech and alder forests, dry oak woods) of the area.
- An investigation of the issue of the secondary nature of alder floodplain forests and their classification; an analysis of the questions of montane ash-alder floodplain forests.
- The detailed description of the forest associations of the Sopron Hills, and constructing a map of their potential natural vegetation.

II. STUDY AREA

Sopron Hills are a medium-height north-eastern subrange of the Alpine mountain range, reaching furthest into the Carpathian Basin together with the Kőszeg Mountains. To the west it is separated by the Szikrai Saddle (Sieggrabner Sattel) from the adjacent, nearly north-south running Rosalia Mountains (Rosaliengebirge). Its area is approximately 185 km² (nearly two thirds of it belongs to Austria).

The main ridge of the hills is of west-east direction, its highest point is the Brenntenriegel (606 m) falling within the territory of Austria; east from it the height of the main ridge is gradually reduced. The stepped surface was formed by the fragmentation of the former denudation plane; the recent geomorphology is characterized with wide and flattened ridges and moderately steep slopes. The valleys are usually deeply cut (in the eastern part sometimes almost gorge-like) formations. The surface hydrography is defined by a network of small-flow streams; runoff is channelled in 3 directions by these streams to the three receiving rivers (Wulka, Ikva and Répce).

Concerning the area's geology, the formations of two geological epochs play a major role: in the eastern part of the hills an island-like extrusion of a Paleozoic (praeperm) crystalline slate block (consisting of muscovite-gneiss, mica slate, quartzite and leucophyllite) can be observed while the western part is covered with Miocene (Ottangian and Karpatian) sandy, gravelly and clayey sediments. In addition, smaller areas are covered with Badenian clay and sand and some patches (mainly in the southern, south-eastern part) with Leitha limestone and calcareous sand.

On the crystalline slates mostly acidic non-podzolic brown forest soils developed, which dry out easily. On the Miocene sands, clays and gravels lessivated brown forest soils or pseudogley brown forest soils can be found, characterized by a favourable water regime (podzolic brown forest soils are relatively rare). The Leitha limestone surfaces carry shallow rendzinas while sand surfaces dry rusty brown forests soils. The typical soil types of valley bottoms are colluvial and alluvial forest soils.

The climate of the region is basically cool with high precipitation, however, in west-east direction a definite macroclimatic gradient can be observed. While the eastern hill front is warmer and dryer, the western, inner area is much cooler and has higher precipitation. The mean annual temperature varies between 8-9 °C, and the annual precipitation usually between 650-850 mm. Given the geographical location, the climate variables are mostly characteristic of a sub-Atlantic climate effect; no definite sub-Mediterranean effect can be detected.

From the phytogeographical point of view the Sopron Hills are situated in the border region of the Alpine (*Alpicum*) and the Pannonian (*Pannonicum*) floristic provinces. The xerothermic (sub-continental and sub-Mediterranean) species of the Pannonian region still penetrate the vegetation of the northern, eastern and southern rim while in the inner (western) valleys montane species appear as an evidence of the phytogeographical impact of the Alps. The dominant forest associations of the two areas also differ: the former is dominated by oak woods while the latter by beech forests.

In the hills mesophilous and acidophilous deciduous forests are dominant, but due to the plantation of conifers on both the Austrian and the Hungarian side, there are significant areas of secondary coniferous stands.

III. METHODS

A) Analysis of forest history data

From the development of the first settlements to the 18th century, I have made estimates on the changes in forest area and their locations based on indirect evidence (archaeological data, diplomas, etc.). A more precise evaluation was possible for the period starting from the end of the 18th century: I examined the changes of forest cover for 4 periods (1784, 1840, 1951 and 2005) with the help of military and forestry maps, aerial photos and satellite imagery. I created the forest masks with ArcView 3.1 and ArcGIS 9.1 software. I also interpreted the changes presented on the maps verbally.

I summarized the changes in the tree species composition of the forests until the 19th century also based on indirect information, while for some parts of the region (especially the forests formerly owned by the city of Sopron) I could rely on some available descriptions, reports and forest history studies. From the end of the 19th century the forest inventories and management plans of the former municipal forests (approx. 4000 ha) were available for a total of 8 dates (1885, 1925, 1953, 1963, 1973, 1984, 1994, 2004); these formed the basis of a detailed analysis (reflecting the areal changes of tree species).

Concerning changes in the herb layer of the forests I only touched on the most important processes (those that could be deduced from the existing written records and the current state). The description of the state at the turn of the millennium is based on my own field data collection. The comparison of the forest history background and the forest habitats (classified according to the General National Habitat Classification System) playing a role in the present vegetation is based on a thorough field campaign.

B) An evaluation of nativity issues

In the course of the examination of nativity issues I focused on those coniferous species (*Abies alba*, *Larix decidua*, *Picea abies*, *Pinus nigra*, *Pinus sylvestris*) which have the limit of their natural distribution range in the region and were also intensively cultivated over the past one and a half century (and are therefore hard to judge). Besides these I also examined the sweet chestnut (*Castanea sativa*), cultivated for a long time in the region. I have reviewed the relevant vegetation historical and phytogeographical literature, studied the „overlap” between the geographical features of hills and the ecological needs of the above-mentioned tree species and processed the available historical data (palynological and anthracological evidence, forest management plans, etc.). As a conclusion of the verbal evaluation I expressed my opinion on the question of nativity (occurrence within the natural distribution range) for each examined species.

C) An evaluation of the changes in the herb layer of the forests

The analysis of changes in the spatial patterns of the herb layer occurring since the mid-20th century was performed for the Hungarian part of the hills, in a study area of 545 ha (Váris–Tövissüveg). In 1997 I re-mapped the area originally surveyed by István Csapody in 1959, with a resolution of 1:10.000. The comparison of the two maps was carried out following digital pre-processing by visualizing the areal distribution of the different dominance-types with the help of both tabular and map display.

For 119 sample areas surveyed by Csapody in 1959 I also performed the analysis of the compositional changes having taken place in the herb layer of the forests. The repeated survey of those 56 plots that proved suitable for re-assessment was carried out with the previously used classical A-D scale, without the inclusion of the moss layer, mainly in 1997. The analysis only included the data of the herb layer; in the course of the work I converted the A-D values of the vascular taxa present to percentage values. For the multivariate analysis of the compositional changes I used the SYN-TAX 2000 software package. The distribution of Borhidi's relative ecological indicator values and social behaviour types was calculated as weighted sum based on cover values of individual species.

D) The phytogeographical and coenological analysis of the forests

The phytogeographical and coenological analysis of the forests of Sopron Hills was carried out in four separate groups (acidophilous forests, beech, oak and alder woods). For each group I summarized the most important conclusions of the detailed field visits concerning the history, habitat and coenology and in the case of some issues (classification problems of acidophilous forests, montane beech forests, xerothermic oak woods, ash-alder floodplain forests, etc.) I also provided a wider phytogeographical overview. For the phytogeographical analysis I prepared point maps of some species of mesophilous deciduous forests and dry oak woods (a total of 26 vascular plant species) displaying their occurrences in the area (mainly on the basis of my own data).

Within the four groups my own coenological relevés and others from the literature (according to the Braun-Blanquet method, using 400 m² plots) served as a basis of the detailed coenological analysis. In the case of the acidophilous forests analysis was based on 76 relevés (37 of which are my own), while for the beech forests I used 64 relevés (30 own), for the oak forests 112 (40 own) and for the alder woods 36 (30 own). Data analysis was carried out with the TWINSpan method, based on reciprocal averaging (correspondence analysis), using the 7.0 version of the JUICE software package. I chose the level of pseudospecies as 3 (0, 5, 25%), I ran the analysis with the maximum number of divisions (6) and interpreted the resulting classification according to the level of the divisions.

For the finalized groups of relevés (calculating the fidelity values according to the Φ -coefficient) I determined the diagnostic species related to the acidophilous forests, beech, oak and alder woods. I compiled the table of synthetic data (fidelity, constancy) with $\Phi = 0.30$ using Fischer's exact test ($P < 0.05$, $P < 0.001$). I interpreted the analysis results, and carried out the matching of the vegetation types resulting from the classification with the coenological units.

E) Description of the forest associations, creating a potential vegetation map

The detailed description of the forest associations was prepared as the conclusion of the phytogeographical-coenological analysis, in a uniform structure (occurrence and site, structure and species composition, syndynamics and naturalness, syntaxonomy and nomenclature, phytogeographical relationships), with critical comments on the precedent (published after 1945) Hungarian and Austrian literature.

Besides the description of the forest associations the summary of the thesis results appears on the map displaying the potential natural vegetation (according to the approach of Tüxen) of the Sopron Hills. In the course of editing this map the pattern of those units had to be drawn, which are defined as primary formations, are described as associations in their own right and can be considered climax associations (indirectly encompassing pioneer and transitional associations as well). The task was performed on the basis of numerous field visits in the entire area, primarily relying on the present stands and the site-vegetation relationships observed during the work (while of course eliminating the phenomena of anthropogenic origin), invoking the observed analogies. The map has a scale of 1:25.000, so the smallest unit plotted is 25 m in diameter (1 mm on the map). As an exception, the alder floodplain forests accompanying the streams are presented if they reach a minimum of 10 m width of the alluvial plain.

IV. RESULTS

A) The forest history of the Sopron Hills

- The first human-induced deforestation of the hills began from the subboreal period and starting from the early Iron Age (from 700 BC) human impacts resulting in major forest area losses can be detected on the foothills. After the Hungarian conquest period, in the 12th-13th century, another wave of deforestation occurred, also in the foothill areas. From the 18th century the presence of clearings (meadows) along the streams are recorded while the settlements in the central area evolved from the beginning of the 19th century.
- According to historical maps, at the end of the 18th century 59.7 % of the area was forested which was reduced moderately until the middle of the 20th century (56.1 %). From the 1950s the spontaneous reforestation of former meadows and vineyards, as well as smaller afforestations resulted in an increase of forest area, and at the turn of the millennium 61.0 % was reached.
- Concerning changes in the tree species composition before the 18th century, besides the vegetation historical evidence we can draw conclusions based on the extent and nature of contemporary human impacts. In the 1700s coniferous species were only sporadically present; from the 1850s, however, an extensive coniferisation began (following the Austrian-Czech example), and its effect is still noticeable in the vegetation of the area.
- Changes in the tree species composition over the past one and a half century are reflected in the data series available for the period between 1885-2004 for the former municipal forests of Sopron city (approx. 4000 ha) in the eastern part of the hills. Plantations increased the areal proportion of coniferous species (*Abies alba*, *Picea abies*, *Larix decidua*, *Pinus nigra*, *Pinus sylvestris*) to over 50 % of the region in a hundred years. At the same time, the area of the pioneer tree species (*Betula pendula*, *Populus tremula*, *Salix caprea*) as well as *Carpinus betulus* (considered a weed, to be removed), quite common in the forests degraded in the Middle Ages, decreased drastically. Until the 1970s the territory occupied by *Fagus sylvatica* and *Quercus petraea* did not change significantly. As a consequence of the conifers' decline, which intensified from the 1980s, a strong decrease (more than 600 ha) in the area of *Picea abies* occurred while *Quercus petraea* showed small, *Fagus sylvatica* and *Larix decidua* a spectacular growth.

- Of the changes that took place in the herb layer of the forests the (secondary) expansion of acidophilous species, some xerothermic (*Quercetalia pubescentis-petraeae*) elements and species of clearings, justified by the dramatic effects of common forest use, can be emphasized, along with the spreading of non-native elements from the 20th century.
- As a result of centuries / millennia of human impact the foothill areas are largely deforested, covered with secondary habitat types (arable lands, grasslands, vineyards, etc). Of the secondary habitats of closed forest block *Pinus sylvestris* and *Pinus nigra* forests (S4), other stands with non-native coniferous trees (S5) and uncharacteristic forests mixed with non-native tree species (RD) occur in most areas, while of the natural forest habitat types the sessile oak-hornbeam forests (K2), beech forests (K5) acidophilous oak-hornbeam forests (K7b) and closed acidophilous oak forests (L4a) are present in larger areas.

B) Nativity issues

- Since the classification of the tree species having the limit of their natural distribution range in the Sopron Hills as spontaneous or synanthrope significantly influences the evaluation of the forest vegetation, in order to provide a proper description it is absolutely necessary to form an opinion on the issues of nativity, despite the involved uncertainties.
- In my thesis I considered those of the examined tree species native, which (1) find the ecological conditions suitable to their needs in the hills, (2) at the sites suitable for them don't have to face competing tree species, which would drive them out in the long run, (3) are present in the area as a result of natural processes (regardless of direct and indirect human impact).
- Based on the above principles, of the examined conifers I accepted the nativity of *Abies alba* in beech forests showing montane characteristics, and that of *Pinus sylvestris* in the open-canopy acidophilous forests, but discarded this possibility in the case of *Picea abies*, *Larix decidua* and *Pinus nigra*. *Castanea sativa* proved controversial; however, as a temporary solution, I considered it a native species in this study.

C) Changes in the forests' herb layer

- In the study area between Váris and Tövissüveg (on bedrock of crystalline slate) in four decades (between 1959 and 1997) a remarkable transformation took place in the herb layer of the forests. Based on the areal changes of the herb layer types the most important successional direction is the transformation of types dominated by acidophilous species (*Quercetalia robori-petraeae*) into types determined by non-acidophilous (primarily *Quercetalia Fagetea*) species. In a 442.3 ha part of the area, which proved suitable for comparison, the total area of the *Calluna vulgaris*, *Deschampsia flexuosa*, *Luzula luzuloides*, *Vaccinium myrtillus* types was 238.0 hectares in 1959 (53.8 %), while this value decreased to 94.3 ha in 1997 (21.3 %). Besides these changes it is necessary to emphasize the expansion of the *Melica uniflora* dominance type in stands where canopy closure has been decreased as a result of forestry operations: its area increased from 139.8 ha (31.6 %) to 242.4 ha (54.8 %).

- Concerning the compositional changes of the herb layer types, preliminary studies showed a reduction in the role of the acidophilous elements (*Quercetea roboreticae*), and indicated a spread of *Melica uniflora* in the stands rich in light. The 6 types of transitions specified by more detailed analysis showed a finer-scale pattern of change in the rearrangement of herb layer types. Of the 6 types of transitions, 2 showed the retreat of acidophilous elements to different extents while 2 other types described the expansion of the heliophile *Melica uniflora*.
- The most apparent feature of the herb layer changes observed in the Váris–Tövissüveg study area is the spectacular areal decrease of the dominance types characterized by acidophilous plant species. The decline of the species living on extremely acidic substrates can be explained by the regeneration of the upper (humus) soil layer. The bare or raw humus surface of soils become common as a result of centuries-long forest management practices and the coniferisation, but after the partial decline of the conifers, leaf litter from the deciduous tree species and the relatively undisturbed processes of base replenishment caused regeneration processes to intensify in the last 50 years.
- As a result of the supposed soil regeneration (1) the Calluna-Betula heaths have disappeared and transformed into acidophilous oak or oak-hornbeam forests; (2) the area of acidophilous oak forests decreased, their stands evolved into oak-hornbeam forests with an acidophilous character, or mesophilic oak-hornbeam forests (with species characteristic of base-poor soils); (3) there was a dramatic decrease in the area of oak-hornbeam forests with an acidophilous character; (4) the acidophilous beech forests declined, the valley-floor stands transforming into submontane beech forests on base-poor soils.
- The spectacular retreat of acidophilous forests within half a century verifies the secondary nature of most of these stands. This statement is especially true for oak-hornbeam forests with an acidophilous character; in the case of this type its unclear relations to topography, its transitional coenological character and the stands so dramatically changing within a few decades make questionable the actual independence of this forest association.

D) The phytogeographical and coenological analysis of the forests

- The analysis of the area's acidophilous deciduous forests (dominated by acidophilous species in the herb layer) carried out on the basis of 76 coenological relevés has resulted in 3 types. The markedly acidophilous oak forests (incl. markedly acidophilous beech forest relevés) are related to extremely acidic sites, while the mainly secondary stands of sessile oak-hornbeam and beech forests with an acidophilous character (characterized with the co-occurrence of *Quercetea roboreticae*, *Quercus-Fagetum* and *Fagetalia* species), are usually found on moderately acidified (due to anthropogenic effects) soils.
- Based on the analysis results it can be stated that in classifying acidophilous forests, both in the oak-hornbeam and beech submontane region the same scheme should be followed: the markedly acidophilous forests should be described as independent associations, while the stands with a transitional character should be considered a *luzuletosum* subassociation of the mesophilous (zonal) forests of base-poor soils.

- The analysis of beech (*Fagus sylvatica*) dominated forests, based on 64 coenological relevés has resulted in four coenological units. The markedly acidophilous beech forests (rarely) appearing on crystalline slate and extremely acidic soils, the mesophilous (submontane) beech forests associated with base-poor soils and the calcareous beech forests of the Leitha limestones (only appearing next to Neckenmarkt) can be described as independent associations. Beech forests with an acidophilous character should be identified as the *luzuletosum* subassociation of the mesophilous (submontane) beech forests partly due to their transitional coenological character and partly because of the secondary, regenerating stands.
- The beech forests of the inner (western) parts of the Sopron Hills showing montane characteristics cannot be considered true montane forests. Although the environmental conditions in certain places reach the threshold values for low montane beech (annual precipitation above 800 mm, annual mean temperature below 8 °C), most vascular plants of montane character and the mosses of the spruce zone cannot be found outside the alder floodplain forests. The montane character of even the areas with the most favourable mesoclimatic conditions is only shown by the most likely natural occurrences of *Abies alba*, the strong decline of *Carpinus betulus*, the expansion of *Acer pseudoplatanus*, the increasing importance of the *Festuca drymeja* dominance type and the sporadic appearance of *Equisetum sylvaticum*, *Gentiana asclepiadea* and *Petasites albus*. The presence of real montane beech forests cannot be verified by numerical analysis and the orographic characteristics of the region do not confirm it either.
- The potential territory of beech-dominated forests and the quality of geological substrate show a strong correlation; the block of beech forests in the western part of the hills, standing on the Ottnangian-Karpathian gravelly-clayey sediments suddenly breaks up on the crystalline slate (east of the Görbehalom–Gruberkreutz–Neckenmarkt line) and ends abruptly on the Badenian clay covering the north-western area (Bannmaisriegel, Rohrbacher Wald). The shifts in the former case can be explained with the unfavourable water regime of the soils on the crystalline slate (amplifying the effects of the west-east climatic gradient), while in the latter case (in addition to the effect of the Wulka Basin) the heavy soils do not favour the presence of beech.
- The analysis of the oak (mainly *Quercus petraea* agg.) dominated forests was carried out on the basis of 112 coenological relevés and as a result 5 coenological units were distinguished. Out of these the markedly acidophilous oak forests characteristic of the extremely acidic sites (on crystalline slate and gravel sediments), the mesophilous oak-hornbeam forests of the base-poor soils, and the 2 types of Turkey oak-sessile oak forests appearing on acidic substrate and Leitha limestones (present in fragments on the north-west and south-eastern edge of the hills) can be identified as independent associations.
- The sessile oak-hornbeam forests with acidophilous characteristics cannot be considered independent associations due to a transitional coenological character, the lack of diagnostic species and the secondary, dynamically regenerating stands. These forests can be described as the *luzuletosum* subassociation of mesophilous oak-hornbeam forests. Based on these findings the independence of the association earlier described in the Hungarian coenotaxonomical system under the name *Luzulo-Carpinetum* SOÓ ex CSAPODY 1964 can be ruled out.

- Besides the oak forest types distinguished by numerical analysis, the presence of a sixth type of oak-dominated forest can be shown, even though only fragments of it exist: the pedunculate oak-hornbeam forests of the foothills and valley bottoms. Their former stands were mainly found in the lower sections of the valleys (on the widening valley bottoms) running towards the Sopron Basin and the southern-southeastern foothill between Lackenbach and Harka.
- In the *Quercus petraea* agg. dominated forests of the hill rim *Quercetalia pubescentis-petraeae* elements (*Anthericum ramosum*, *Berberis vulgaris*, *Buglossoides coeruleum-purpurea*, *Carex Michelin*, *Euonymus verrucosa*, *Cornus mas*, *Ligustrum vulgare*, *Peucedanum oreoselinum*, *Quercus pubescens*, *Sorbus torminalis*, *Teucrium chamaedrys*, *Trifolium alpestre*, *Viburnum lanthanum*, *Vincetoxicum hirundinaria*, etc.), occur partly in highly exposed sites (ridges, peaks) (primary occurrences), and partly in rides, forest edges, on road sides. The concentrations of occurrences („xerothermic flora islands”) appear primarily in the north-western and the eastern-southeastern part of the hills. In the former case they can be considered the remnants of the xerothermic vegetation of the boreal period while in the latter case the results of „swarming” following cuttings.
- The analysis of alder (*Alnus glutinosa*) dominated forests based on 36 phytosociological relevés indicated the presence of three alder wood types (which can be considered independent associations). Of these, at the upper and middle sections of streams, in sites with seepage water, mixed ash-alder floodplain forests with montane species can be found. The type mixed with hornbeam, rich in species of mesophilous deciduous forests, is characteristic of the middle and lower stream sections. The third type of alder wood, showing a transitional tendency towards alder swamps occurs in similar locations, but in sites with stagnant water.
- Most of the alder woods of the Sopron Hills are secondary stands, which emerged with the spontaneous reforestation of former clearings after 1950. These forests still preserve some scattered meadow elements in their herb layer (*Colchicum autumnale*, *Lychnis flos-cuculi*, *Ranunculus acris*, etc.), but as the successional processes progress their species composition is gradually transformed.
- The alder stands dominated by *Carex brizoides* are all the results of the reforestation of meadows. The independence of this type could not be verified with numeric analysis (the relevés are usually classified as one of the above-mentioned 3 types), therefore the presence of the association *Carici brizoidis-Alnetum* I. HORVAT 1938 em. OBERD. 1953 in the area (and thus in Hungary) can be ruled out. The alder woods of the upper stream sections can, however, be identified as ash-alder floodplain forests (*Carici remotae-Fraxinetum* KOCH ex FABER 1926) of which the occurrence in Hungary had earlier been the subject of debate.
- Ash-alder floodplain forests are a pool of the montane plant species of Sopron Hills. *Pleurospermum austriacum* once lived on the edge of an upper-section type alder wood but *Anthriscus nitida*, *Doronicum austriacum*, *Equisetum sylvaticum*, *Gentiana asclepiadea*, *Lysimachia nemorum*, *Petasites albus*, can also be found partly or entirely in such forests as well as certain bryophytes of the spruce zone (e.g. *Lepidozia reptans*, *Nowellia curvifolia*, *Riccardia palmates*, *Tetraphis pellucida*).

E) Forest associations and potential natural vegetation of the Sopron Hills

- On the basis of phytogeographical-coenological analysis, the presence of 11 forest associations could be detected in the Sopron Hills. The forest associations distinguished on the 1:25.000-scale potential natural vegetation map of the area (with an indication of their area proportion) are the following: *Angelico sylvestris-Alnetum glutinosae* BORHIDI in BORHIDI & KEVEY 1996 (0.2 %), *Carici remotae-Fraxinetum* KOCH ex FABER 1926 (0.9 %), *Aegopodio-Alnetum glutinosae* V. KÁRPÁTI & I. KÁRPÁTI & JURKO ex ŠOMŠÁK 1961 (1.8 %), *Circaeo-Carpinetum* BORHIDI 2003 em. KEVEY 2006 (8.9 %), *Galio sylvatici-Carpinetum* OBERD. 1957 (45.0 %), *Melampyro-Fagetum* OBERD. 1957 (+), *Veratro nigri-Fagetum* ZUKRIGL 1999 (+), *Galio odorati-Fagetum* SOUGNEZ & THILL 1959 (41.0 %), *Fraxino orno-Quercetum cerridis* KEVEY – SONNEVEND in KEVEY 2008 (0,3 %), *Sorbo torminalis-Quercetum* SVOBODA ex BLAŽKOVÁ 1962 (0.2 %), *Luzulo-Quercetum petraeae* HILITZER 1932 (1.7 %).
- The conclusions of the analysis highlight some nomenclatural and syntaxonomical problems. On the basis of these, the relationship of the associations *Aegopodio-Alnetum glutinosae*, described in Hungary, and *Pruno-Fraxinetum*, marked from Austria, should be further studied based on records from a larger area. Because of the removal of *Carici brizoidis-Alnetum* from the Hungarian syntaxonomical system those alder floodplain forests of the Northern Mountain Range, which show montane characteristics, should be subject to further analysis. The calcareous beech forests of the Eastern Alps (in this study temporarily named *Veratro nigri-Fagetum*) need nomenclatural correction, and finally the classification of Turkey oak-sessile oak forests in Hungary, so far only done on a geographical basis, is also ripe for revision.

V. THE MOST IMPORTANT NEW SCIENTIFIC RESULTS

- Processing the historical background of the forest cover, the confirmation of the nativity of *Abies alba* and *Pinus sylvestris*, the rejection of the spontaneity of *Picea abies*.
- Exploring the regeneration processes of secondary acidophilous forests and the development of a new classification system for acidophilous forests (with particular regard to the interpretation of acidophilous-mesophilous types of a temporary character).
- Clarifying the spatial distribution of certain plant species (montane, xerothermic and alder wood species) crucial for the phytogeographical evaluation of the hills.
- Excluding the possibility of the occurrence of montane (low montane) beech forests; demonstrating the presence of submontane calcareous beech forests.
- The differentiation and mapping of Turkey oak-sessile oak forests based on the type of bedrock in the Sopron Hills.
- The interpretation of the sessile oak-hornbeam forests displaying acidophilous characteristics as subassociations; the rejection of the independence of the association *Luzulo-Carpinetum* SOÓ ex CSAPODY 1964.
- Verifying the secondary nature of the alder stands dominated by *Carex brizoides* (*Carici brizoidis-Alnetum*), as well as demonstrating the presence of montane ash-alder floodplain forests (*Carici remotae-Fraxinetum*) in Hungary.
- A detailed description of the forest associations present in Sopron Hills and developing the map of its potential natural vegetation.

VI. LIST OF PUBLICATIONS

Publications related to the dissertation

- SZMORAD F.** (2010): Fürtös bodza (*Sambucus racemosa* L.). – *Tilia* **15**: (megjelenés alatt)
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