UNIVERSITY OF WEST HUNGARY

THESIS OF PHD DISSERTATION

# LANDSCAPE HISTORICAL, PHYTOGEOGRAPHICAL AND COENOLOGICAL SURVEY ON THE RIVERINE ALDER FORESTS OF WESTERN TRANSDANUBIA

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## INTRODUCTION AND AIMS

Riverine alder forests are vegetation units of various composition, which are present in several biogeographical regions of Hungary, in narrow zones in stream valleys of mountainous, hilly and plain areas. Due to the site conditions (developed primarily by streaming water) and the mesoclimatic factors of the habitat (cooler and more humid than the macroclimate), these habitats have special characteristics. Despite their small sizes, their near-natural stands are species rich and possess several montane and swamp forest species. Consequently, these habitats have high conservation value.

No overview of the coenosystematic classification of the alder groves of Western Transdanubia or Hungary has been carried out so far. The coenological relations of the riverine alder forests need clarifications as there are more open issues regarding these habitats. The recognition and distribution of *Carici brizoidis-Alnetum* and *Carici remotae-Fraxinetum* communities is still unclear. In Hungary, no attempt has been made to research the former landuse practices so far, which determined the development, extension and state of the alder groves. It is a relatively known fact that in the past centuries, there were numerous clearings formed in the widening valley bottoms. However, their temporal and spatial distribution and the process of their spontaneous reforestation is insufficiently known.

The research includes the mountainous and hilly areas of Western Transdanubia: the whole areas of Sopron Hills, Kőszeg Hills, Kőszeghegyalja, Vasi-hegyhát small regions, the western part of Felső-Kemeneshát and the northern part of Hetés. My survey discusses the open issues on the riverine alder forests, listed below. The basis of my work is the complex landscape history analysis of the period between the second half of the 18th century and today. Through this I aimed to have a deeper understanding on the origin and history of the riverine alder forests. Regarding Sopron Hills, in the frame of the landscape history analysis I performed the GIS evaluation of different map sources, archive and new aerial photos as well as detailed stand descriptions and map analysis of forestry management plans. In the other research sites an overall study was carried out based only on map sources. In the landscape historical survey I aimed to answer to the following questions:

- What vegetation type covered the valley bottoms (present riverine alder forests) in the past? How these areas were used or cultivated?
- What was the size of the alder groves in the past? Can we follow the increase or decrease of these stands during the previous 230 years? Did these form a stand, if yes, in which areas?
- When and what processes developed the present riverine alder forests? How old are these? Can we consider them 'ancient'?
- How does the forestry management influence the size and state of the alder woods?
- How can we characterize the alder stands of Sopron Hills based on forestry management plan data? What is the areal distribution of the alder forest compartments like?

The other main line of the research was based on field survey. It has the following aims:

- Mapping the distribution and present cover of riverine alder forests as well as detailed survey on their stands in Western Transdanubia.
- Examining the species composition of the stands. Distinguishing distribution patterns to make the florisitic comparision of the landscape units and the evaluation of the differences.
- Survey on the riverine alder forest vegetation. Evaluation of the coenological relations with making and analysing relevés.

## Material and methods used in the landscape history survey

In the landscape history survey I aimed the evaluation of the richest possible sources. For Sopron Hills I worked with the map sections of the First, Second and Third Military Mapping Survey and the corrected version of the Third Military Mapping Survey. I analysed the available topographical, cadastre and forestry maps of the 18th and 19th century, all the forestry management maps (8 series) as well as aerial photo series taken on five occasions in the 20th century. In the other parts of the survey area besides the map sections of the First, Second and Third Military Mapping Survey also cadastre maps of the 19th century, military map of 1953-59 and aerial photos of 2005 were evaluated. Apart from the map sources the remained forestry management data of Sopron Hills were also processed.

The analysis of the map sources and aerial photos were carried out with GIS tools. Analogue maps were transformed into digital form through scanning or taking pictures. The maps and aerial photos with different scales and projection were georeferenced to the Unified National Projection System (Hungarian Grid). For the geometric fitting of each photo I used one-dimensional transformation. To achieve a more exact result, a part of the material was transformed into orthophotos. Based on map sources I made a detailed, quantificated GIS evaluation for Sopron Hills. For the other surveyed areas an overall evaluation was made. During the evaluation of Sopron Hills, I digitized the grassland patches, ploughlands, riparian woods, roads, cultivated lands, coniferous stands and clearcut sites in the potential riverine alder forest areas. In case of Kőszeg Hills and two sample areas of the southern part of Western Transdanubia only grasslands, ploughlands and alder groves were digitalized. I also examined the vegetation types found in the valley bottoms and the extension of the forested and non-forested areas.

During the elaboration of the forestry management plans the following data were collected (of the forest compartments containing black alder): code and area of the forest compartment, ratio of alder as an associate tree species, age and origin. On every date, the actual cover of this species, the weighted average of the stands (with the area) and their distribution based on their age were calculated. In the case of the

forestry management plan data of 1884, 1925, 1953 and 2007, I examined other species and their ratios occurring besides the black alder as well. Based on the forestry management maps the location of the alder compartments and their temporal changes were documented. With the joint analysis of the forestry management plan data and landuse layers the age of the riverine alder forests of Sopron Hills was determined.

**Material and methods used for field studies and evaluation**

To map the distribution of the Western Transdanubian black alder forests and to survey their present state I made field trips to each valley of Sopron Hills and Kőszeg Hills in 2006-2007. In Kőszeghegyalja, Vasi-hegyhát, Felső-Kemeneshát and Hetés only parts of the areas were researched. In the valleys the surveys were carried out at least on two occasions (once in spring and once in summer). The location and extension of the riverine alder forests were mapped. Besides the constant, dominant species of the alder groves, occurrence data of those species which are important from the phytogeographical or vegetation aspects, protected, rare or degradation indicators were also documented. Using the database including 10000 locality data, the point map of 94 species was compiled. Based on similar species distribution patterns, pattern types were elaborated. With the help of these, the floristic relationships of the Western Transdanubian alder woods were characterised.

**Material and methods used in vegetation survey**

For the phytosociological survey 189 coenological relevés were made. I aimed the most complex sampling of the riverine alder forests. The survey was carried out with Braun-Blanquet method, with the use of 400 $m^2$ size, permanent relevés. I examined each relevé at least on two occasions. The coverage of the species was estimated on a percentage scale.

At first, the coenological relevés were analysed by traditional multivariate statistical methods, using SYNTAX program package. To reveal the relationships between the relevés and the separation of groups, hierarchical classification was applied. In the ordination analysis, central and standard principal component analysis was used; for checking the goodness-of-fit of the classification, principal

coordinate analysis was applied. To calculate the distance between the objects Jaccard and Canberra indices were used in all cases. In addition to these, the coenological relevés were analysed also with modified TWINSPAN method, using JUICE program package. The differences between the relevés were calculated also by Jaccard and Sörensen index. I determined the species occurring together within distinct relevé groups with coefficient Φ. For the final relevé groups fidelity, constancy and frequency values of the species were calculated, the diagnostic, constant and dominant species and the differences between all groups were defined. The analyses were carried out in each applied method in more versions, narrowing the data repeatedly. The vegetation of the Western Transdanubian alder woods was evaluated using the groups made in the multivariate analyses, my field experience and the results of the landscape history research.

## Landscape history of riverine alder forests in Western Transdanubia

Based on the landscape and forest history research, in the 1780s (and probably even before) in the whole survey area (except for the narrowest valleys) the present alder grove sites were covered by grasslands, wood hayfields, tall herb communities and rarely mosaics of swamp meadows and tall sedge communities with narrow rows of trees as well as smaller groups of trees.

In Sopron Hills the meadows have almost constant coverage until the beginning of the 20th century; they are present in all wide valleys often stretching to the valley sides. Their area decreased drastically during the 20th century. Although more or less black alder individuals inhabited every streamside of the hills, these groves could have small cover prior to the 20th century. In the broad, flat valley bottoms these were possibly confined to the narrow zones along the streams and at the edges of grasslands. Besides, their few tree rows wide stands were present in the narrower, more steep sided valleys which had permanent forest cover. Due to the short clear-cutting cycles these were mainly coppice forests. After the introduction of modern forestry management planning, the large coniferous plantations temporarily decreased the cover of alder. At the same time, the cessation of grazing caused the spontaneous afforestation of the grasslands in the valley floors. The streamside black alder trees could drop seeds to all sufficiently wet habitats so in that period they occupied a larger area than the potential one. During the 20th century the extension of alder woods changed only slightly in the narrow valleys of Sopron Hills, however, it increased significantly (between the 1960-80s even exponentially) in the broad, flat valley bottoms. The current wide alder groves are originated from the beginning of the 20th century (mainly from its second half). These developed partly with the spontaneous afforestation of the grasslands and partly with the plantation of extensive black alder as well as smaller common ash stands.

In the other parts of the survey site the alder woods could be present with small cover, along streams at the edges of valleys covered by grasslands, in patches of seepage water and at the origin of springs. In Kőszeg Hills the meadows inside the closed forest blocks were covered by continuous forests even by the mid-19th

century. By this time, in the area of Vasi-hegyhát, Felső-Kemeneshát and Kőszeghegyalja, closed forest cover developed in those zones of valleys, which were at considerable distances of villages. In the other parts there were meadows of the same size as earlier (some ten or occasionally 100-200 m wide ones), used as hayfields and/or pastures. Alder groves were present only with small extension even then. From the second half of the 19th century the size of the forests doubled in one hundred years due to the change of landuse practices, e.g. the significant decrease of grazing and meadow management. In the early stage of afforestation the pioneer tree species had a leading role and along streams it was the black alder. Besides spontaneous afforestation the extension of the alder woods was also influenced by the launch of planned forest management. Large alder stands were planted especially in the southern part of Western Transdanubia. In the hilly and foothill areas the actual cover of the groves developed mainly in the 20th century. In the site of riverine alder forests conifers were planted (mainly Norway spruce but in the southern part of Western Transdanubia also Scotch pine).

**Present extension of riverine alder forests in Western Transdanubia**

Alder groves can be found in Sopron Hills along every stream even today. They occur in the area of former grasslands with considerable extension and in narrow valleys in narrow zones, rarely on sides with seepage water. The cover of alder forests is partly limited due to the geomorphology in Kőszeg Hills, as wide, flat valley floors are not extensive here. The steeper valleys can be accompanied long by narrow alder groves only. Besides the abiotic factors, also the former landuse methods and forest management are the reasons why the alder forests have smaller area today. In the upper sections of the valleys these groves have transformed or disappeared in many locations in Kőszeg Hills and some of Sopron Hills. In the narrower valleys with adjacent beech forests the areas of the pioneer alder woods are gradually occupied by the surrounding mesic deciduous forests. The cutting cycle is longer than it was in the past centuries; for this reason the duration of the forest cover on valley sides is longer as well. This is unfavourable for the regeneration of light-tolerant black alder, which leads to the ageing of the riverine alder forests. Similarly, the present extensive secondary stands probably cannot survive under natural circumstances on the long term. Without significant forestry management

activities they begin to transform into mesic deciduous forests and in part into hardwood gallery forests (on the hill edge). The alder groves occupy only the most humid narrow zone by the stream. An alder stand may make the habitat unfavourable for itself as it transpires a lot so dries its habitat, this way it facilitates the succession towards the development of a mesic deciduous forest. This process proceeding in closed forests is illustrated well by the lower, wider section of Hármas Stream, which afforested much earlier than the average.

In the areas of Vasi-hegyhát and Felső-Kemeneshát black alder forests can be found along each stream, however, they rarely follow the water courses all the way long. In the northern part of Hetés, only fragmented natural alder groves remained in the narrow zones of unregulated streams. Partly because of edafic reasons, in the southern part of Western Transdanubia extensive, wide stands were rarely formed by spontaneous succession. Due to climatic conditions and landuse practices, in many locations of the valley bottoms only thin soil covers the gravel layer of the bedrock. In these areas the groundwater can be found only by the roots of trees. As the streams are temporary, the ground water level fluctuates between extremes. These factors don't favour the spread and survival of the black alder, which is a species with high ground water demand. The riverine alder forests are often surrounded by currently cultivated humid hayfields, tall sedge or tall herb vegetation, swamp meadows, wood grasslands (often invaded by *Solidago* spp.). Wider, larger alder stands developed as a result of forest plantation in several sites. These are often dry, weedy and of unfavourable naturalness state. The composition of their herb layer frequently shows that these were meadows in the past.

**Study on the species composition of riverine alder forests**

Apart from climatic and edafic reasons, the vegetation and floristic composition of the alder groves are determined by landuse and forest management practices as well as the surrounding vegetation. Studying the occurrence data of the mapped species, we separated four pattern types, which don't form well-defined patches on the map as the frequency of species changes along the north-south and/or east-west gradients. In the alder stands several montane species occur. Some of these are restricted to the westernmost part of the area (*Noricum*). The localities of most species are concentrated to the western areas and occur with decreasing frequency

towards the east. The species characteristic of tall herb communities and former meadows have less and less localities in the alder groves from the south towards the north. Their distribution pattern is related both to the geomorphological conditions and the landuse practices, and it is typical of the alder stands in the area of former grasslands or specifically humid habitats. At the same time, the distribution frequency of grove or mesic deciduous forest species, which favour nutrient-rich, humic soil, decreases from north to south. Finally, a part of the species of riverine alder forests are present with the same frequency in the alder woods of all landscape units of Western Transdanubia.

*Carex brizoides* is common in all landscape units, generally it is typical of the broader valley sections but rare in other parts. As the foreign literature points out as well, it is often dominant in the herb layer of the alder groves developed in former grasslands and plantations with disturbed soil. In the recently, spontaneously afforested areas its cover is generally less extensive.

**Study on the vegetation of riverine alder forests**

From the aspect of vegetation, the riverine alder forests of Western Transdanubia can be classified into five groups. The alder woods of Sopron and Kőszeg Hills differ significantly from the stands of the southern part. In Sopron Hills the stands of the upper zones of valleys are separated from those of the broad valley bottoms. The border between them is the same as that of the former grasslands. The riverine alder forests can be divided into three groups in Kőszeg Hills and Kőszeghegyalja. Apart from the geomorphological conditions and decreasing alpine-atlantic climatic effect, this is resulted from the different surrounding vegetation.

The alder woods of valleys of upper course character and sites with seepage water can be found in the whole area of Sopron and Kőszeg Hills between 250-550 m a.s.l. These sites had continuous forest cover in the past. The stands of the westernmost part of Kőszeg Hills can be distinguished by their montane species, which indicate that here the influence of the Alps is more definite. The alder groves of narrow valleys can be considered transitions between *Carici remotae-Fraxinetum* and *Aegopodio-Alnetum glutinosae* communities because of the absence of moss layer and high frequency of *Fagetalia* species. The alder forests of the wide valleys

of Sopron and Kőszeg Hills are typical at lower elevations. Due to geomorphological reasons, here, wider groves can form as well. These stands can be found exclusively in the area of former meadows. The fact that they have a species composition partly common with that of the narrow valleys and foothill stands illustrates well the gradual transition between the alder groves. The riverine alder forests of the foothills and hill edges are very similar to those of the wide valleys. These developed in former grasslands, which are surrounded mainly by non-arboreal plant communities and cultivated areas even today. These alder groves are present under closed forest stands and partly planted. Because these stands are farther from the Alps, they are drier and poorer in species. As the adjacent vegetation is different and these forests are frequently plantations, they are weedy more often and their naturalness state is worse. From the coenological aspect, the alder forests of wide valleys and foothills belong to the *Aegopodio-Alnetum glutinosae* community.

The southern part of Western Transdanubia is a lower hilly region. The examined alder groves are situated between 200-300 m a.s.l., in wide valleys typical of the area, mainly along unregulated, often temporary streams cut into the loose bedrock. Even in the middle of the 20th century their sites were occupied by wood hayfields, swamp meadows and tall herb communities. These stands are very different from the alder groves of the northern mountains. They have generally two canopy layers, the lower canopy is well-developed, its characteristic species are *Padus avium* and *Quercus robur*. Several species favouring groves and mesic deciduous forests are considerably rare here. This can be explained by the gravel bedrock and the strongly degraded humic layer. The strong decline of the mesic deciduous forest area due to the clear cutting practices of the past centuries and the shift towards the coniferous species also play major roles. The alder woods are not closed forests but present between meadow communities (of bad condition) and their former places. For this reason the forest species can only slowly colonise these habitats.

The alder groves of worse naturalness state form a different type due to the presence of *Solidago gigantea* and other weed species, which can be partly reasoned by their artificial origin. Here, the mesophyle deciduous and grove species are even more scarce, however, species indicating former swamps and hayfields are more frequent. Of the Hungarian plant communities, the alder woods of the southern part

of Western Transdanubia can be classified into the *Aegopodio-Alnetum glutinosae* association. As the neighbouring countries (also in the Austrian and Slovenian parts adjacent to Vasi-hegyhát) classify these communities into the *Pruno-Fraxinetum* association, we suggest the use of the name *Pruno-Fraxinetum*. The westernmost montane alder woods of Vasi-hegyhát are differentiated similarly to those of the northern hills. These are of very good naturalness state; in their herb layer often montane species appear. The species composition is common with that of the alder stands of narrow valleys of the northern hills and the southern part of Western Transdanubia. The stands of the swampy habitats form more, smaller groups. These are the alder woods of Sopron and Kőszeg Hills with tall sedge communities in the herb layer, which are transitions between the *Aegopodio-Alnetum glutinosae* and *Angelico sylvestris-Alnetum glutinosae* associations. The few relevés made by Sárvíz proved to be typical alder swamp forests. The stands near larger water courses can be classified into the *Paridi quadrifoliae-Alnetum* community.

According to the multivariate analysis, the alder groves dominated by *Carex brizoides* don't form an individual group. The dominance of this species doesn't indicate an individual community but refers to the fact that these are secondary stands. *Carex brizoides* prevails in the alder woods developed in the area of former meadows and plantations with disturbed soil. We can find stands like this in all examined landscape units of Western Transdanubia, in every alder stand typical of wide valleys, irrespectively of their coenological classification. The *Carici brizoidis-Alnetum* community described by HORVAT is a lowland alder forest and in Hungary it was wrongly considered montane. In accordance with the foreign literature, we suggest to omit it from the Hungarian coenological classification.

**NEW SCIENTIFIC RESULTS**

- Based on landscape and forest history research we proved that the area of the riverine alder forests was covered by grasslands which were used as pastures and/or hayfields for centuries. In Western Transdanubia the black alder groves were present with small extension by the end of the 19th century. In the broad, flat valley floors these were probably confined to narrow zones along the streams and at the edges of grasslands. In addition to this, their few tree row wide stands located in the narrower valleys with steep sides as well. The larger, wide alder groves are secondary and relatively young. Most of these developed during the 20th century as a result of spontaneous afforestation or plantation.
- It was confirmed that apart from the abiotic factors, the differences between alder woods are originated from the past and present anthropogenous effects, the various landuse practices and the type of the adjacent vegetation.
- We stated that presently the largest continuous riverine alder forests are situated in Sopron Hills. In Kőszeg Hills these have a less extensive area. On the outer rim of the hills, small transitional stands are characteristic. In the southern part of Western Transdanubia we found alder groves along every surveyed stream, however, there are numerous fragmented stands of low naturalness.
- Based on the survey on species composition we differentiated four pattern types which don't form well-defined patches on the map. In most cases the frequency of the species changes along north-south and/or east-west gradients. The frequency of montane species decreases from west to east. The species typical of the former meadows have less and less localities from south to north. The occurrences of species of groves and mesic deciduous forests (favouring humic soil) decrease from north to south. While other group of *Fagetalia* species is present with the same frequency.
- The vegetation of alder woods was classified into five groups based on the analysis of the coenological relevés with multivariate statistical methods. These were described and their coenological relations were clarified. We stated that the black alder groves of Sopron and Kőszeg Hills strongly differ from the ones of the southern part of Western Transdanubia. In the case of the hills, the stands of the higher zones of the valleys are segregated well from the alder woods of

the broad valley bottoms. The riverine alder forests of foothills, situated under closed forest stands belong also to an individual group. In the southern part of Western Transdanubia, the alder stands form two groups based on their naturalness.

- In the survey of the riverine alder forests of Western Transdanubia the following communities were indicated: *Aegopodio-Alnetum glutinosae, Pruno-Fraxinetum, Paridi quadrifoliae-Alnetum, Angelico sylvestris-Alnetum glutinosae,* transition between *Carici remotae-Fraxinetum* and *Aegopodio-Alnetum glutinosae*, transition between *Carici remotae-Fraxinetum* and *Pruno-Fraxinetum*, transition between *Aegopodio-Alnetum glutinosae* and *Angelico sylvestris-Alnetum glutinosae*.
- We verified that the *Carex brizoides* dominant alder groves don't form a separate group in Western Transdanubia. The dominance of this species doesn't refer to an individual community but to the fact that the alder forests are secondary.
- We proved that the *Carici brizoidis-Alnetum* is wrongly considered a montane community in the Hungarian special literature. Consequently, we suggest its omission from the Hungarian coenological classification. For the riverine alder forests of the southern part of Western Transdanubia community name *Pruno-Fraxinetum* was suggested.

**LIST OF PUBLICATIONS RELATED TO DISSERTATION**

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