

THE ASSOCIATION OF SPREADING ELM AND NARROW-LEAVED ASH (*FRAXINO-ULMETUM LAEVIS* SLAV. 1952) IN FLOODPLAIN FORESTS OF THE PODRAVINA AND PODUNAVLJE

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Izveček

Asociacija *Fraxino-Ulmetum laevis* je gozdna združba trdih listavcev, ki uspeva na najvišjih rastiščih poplavnih območij vzdolž velikih rek jugovzhodne Evrope. Prvič jo je opisal Slavnić leta 1952 v Vojvodini. Prejšnje raziskave so potrdile pojavljanje teh sestojev v Baranji na Hrvaškem, dolvodno ob Donavi do Iloka, fragmentarno razviti so v območju Podravske Slatine in vzdolž reke Save v območju Spačve. Rezultati sinekološko-vegetacijskih raziskav so nakazali obstoj te združbe na celotnem območju Podravine in Podonavja, večinoma na peščenih aluvijih in na oglejenih tleh. Floristična sestava asociacije *Fraxino-Ulmetum* je prikazana na podlagi 19 relativno heterogenih fitocenoloških popisov iz Podravine in Podonavja. Rezultat multivariatne analize in klasične sintetske analize teh popisov sta dve varianti. Prva, suha, se pojavlja v zgornjem in srednjem toku Drave. Imenujmo jo varianta *Prunus padus*. Druga, vlažnejša, se pojavlja ob Donavi in jo poimenujemo *typicum*. Znotraj zadnje se pojavljajo razlike v popisnem gradivu iz Baranje in z otokov Donave v vzhodni Hrvaški, ki so rezultat različnih hidrološko-pedoloških razmer. Gozdovi bresta in jesena so bili v prejšnjih časih dobro razviti, čeprav le fragmentarno in na manjših površinah. Danes se njihova površina veča zaradi bolj suhih razmer, nerednega in kratkotrajnejšega poplavljanja. Sestoji nimajo večje gospodarske vrednosti, a jih je potrebno z vidika biološke diverzitete, ekološke stabilnosti in splošnih koristi ohraniti v čim večji meri.

Abstract

The association *Fraxino-Ulmetum laevis* is a forest community of hard broadleaves occupying the highest positions in floodplain areas along large rivers of south-eastern Europe. It was described for the first time in Vojvodina by Slavnić in 1952. According to earlier research, this community is developed in Baranja in Croatia, then downstream of the river Danube up to Ilok, fragmentarily in the area of the Podravska Slatina forests, and along the river Sava in the Spačva area. The results of synecological-vegetation research indicated the existence of this community over entire Podravina and Podunavlje, mostly on sandy alluvium and on the eugley hypogley soil type. The floral composition of the association *Fraxino-Ulmetum* is shown on the basis of 19 relatively heterogeneous phytocoenological relevés from the Podravina and Podunavlje. The results of multivariate analysis and the results obtained by classical synthetic analysis of these relevés revealed the existence of two variants. The first, drier, is linked to the river Drava and the upper and central part of its course. It is labelled as the variant *Prunus padus*. The second, more humid, is linked to the Danube, and is labelled as the variant *typicum*. Within the latter, there are certain differences between the relevés from Baranja and those from the Danube islands in eastern Croatia, which are the result of different hydrological-pedological conditions. The forest of spreading elm and narrow-leaved ash was formerly relatively well represented, albeit fragmentarily and over small areas. Today, it is expanding again because drier conditions, infrequent and shorter-lasting floods favour its development. The community does not have any significant commercial value, but from the aspect of biological diversity, ecological stability and general benefits it is highly valuable and should be preserved wherever possible.

Ključne besede: asociacija *Fraxino-Ulmetum laevis*, poplavni gozdovi, Podravina, Podunavlje, sinekološko-vegetacijske raziskave, variante

Key words: association *Fraxino-Ulmetum laevis*, floodplain forests, Podravina, Podunavlje, synecological-vegetational research, variants

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1. INTRODUCTION

The association *Fraxino-Ulmetum laevis* is a forest community inhabiting the highest positions of floodplain areas along large rivers, and was described for the first time in Vojvodina by Slavnić (1952). According to Slavnić, this community forms the first belt of hardwood riparian forests, which, starting from the water, continues directly on poplar forests, and is made up of pedunculate oak, narrow-leaved ash and spreading elm. Unlike willow and poplar forests, this community usually occurs on older alluvium of higher positions. The alluvium of a finer composition is usually clayey in its upper layer, has a clearly delineated forest horizon of varying depths and is mostly carbonate. It is important to stress that the community occurs on river banks along "live" water and not in swamps along bogged backwaters, where mollic gleysol is formed. Slavnić also points out that this community displays a significant floristic affiliation with the Slavonian forest of pedunculate oak; however, these are two separate systematic units.

In his floral study of riparian forests of Baranja, Jovanović (1965) also mentions stands like these and thus confirms Slavnić's observations. In terms of site humidity, he discriminates a large number of variants, depending on the prevalence of narrow-leaved ash or pedunculate oak.

Antić & al. (1969) also find this community in the area of Baranja and roughly distinguish three sub-associations, a more humid *typicum* prov., a transitional *alnetosum* prov. and a drier *quercetosum* prov.

According to research to date, in Croatia this community is developed downstream the river Danube up to Ilok (Rauš 1976 1992, Mayer 2000), and fragmentarily in the area of the Slatina Podravian forests (Vukelić, Baričević & Perković 1999), as well as along the river Sava in the Spačva area (Rauš 1975). All these authors point out that these are smaller areas on micro-elevations in the floodplain region of large Croatian rivers, in areas occasionally covered by short-lasting floods, and on the highest positions of the Danube islands. They also quote that the community covers older and more developed alluvial soils at higher positions, on which some individual pedogenetic processes can be perceived. They are usually well aerated carbonate sandy clayey soils well supplied with nutrients. Floods are more frequent here.

All these authors also stress that the community occurs fragmentarily and that it used to cover

much larger areas in Podunavlje, Posavina and Podravina, and that it is a rarity of riparian forests.

These data testify to the outstanding natural-scientific importance of this community being the best developed form of vegetation in a floodplain area. This is further corroborated by its rare status and poor exploration, as well as by considerable past and current changes in the floodplain ecosystem of Croatia and even more so in Europe. This paper is aimed at giving a detailed description of this community in the Croatian Podravina and Podunavlje. The description of its synecology, synchronology, systematics and syndynamics will be based on our own current studies using classical phytocoenological methods and modern statistical methods.

2. METHODS

Forest vegetation was investigated according to the principles of the Zürich-Montpellier school, on the basis of analysing 19 relevés. The scientific names of plants were coordinated with Ehrendorfer (1973).

All phytocoenological records were entered in the TURBOVEG database (Hennekens 1995). The data were then transferred into a common table in Excel. The Braun-Blanquet (1928) scale for abundance and cover estimation was transformed in the van der Maarel (1979) ordinal scale, providing a matrix for entering the multivariate analysis.

Numerical analysis was done with the SYN-TAX 2000 programme package (Podani 1994), which is used for multivariate analyses in taxonomy and synecology.

Two methods of multivariate statistical analysis were used in this work:

1. Cluster analysis
2. Multidimensional scaling

The results of the hierarchical cluster methods used in the work are presented in the dendrogram form. The work included the following agglomerative methods, which are the most frequently used cluster methods in biology: Single linkage (Nearest neighbour) method, Complete linkage (Farthest neighbour) method and Average linkage method (UPGMA and WPGMA) (Pielou 1984).

The similarity ratio (van der Maarel index) was used as a similarity measure.

Multidimensional scaling is a method which helps the analyst to determine relative relationships among objects in space. There is a large number of

these methods, of which the Principal coordinate analysis (PCoA), described by Gower, 1966, was used for this work.

3. RESEARCH AREA

Synecological-vegetational research into the community *Fraxino-Ulmetum laevis* was conducted in the area of Podravina and Podunavlje. In Podravina, research was done in the Podrava forests near Varaždin (5 relevés – from the boundary with Slovenia to the mouth of the river Mura into the Drava), Podrava forests near Slatina and Donji Miholjac (5 relevés), whereas in the area of Podunavlje in Baranja research included forests of Zmajevac – Šarkanj, Siga, Ulmaci and Zlatna Greda (5 relevés). The area from Aljmaš to Ilok is represented with 4 relevés by Đ. Rauš from 1976 – see Figure 1.

According to Köppen's classification, the climate of the studied area is categorised as "Cfbwx", which denotes a temperate warm rainy climate in

which precipitation is uniformly distributed over the year. However, it should be pointed out that the eastern part of the studied area differs by a higher annual mean air temperature (meteorological station Đurđevac 10.3 °C, Osijek and Gradište 11.2 °C) and relatively smaller precipitation quantity (Đurđevac 843.5 mm, Gradište 675.8 mm, Osijek 626.1 mm annually). The data refer to the period from 1981 to 1999.

The geological substrate is predominantly made up of pebbles, sands, clays and loams. They consist of loose material originating in the Pleistocene as a product of sedimentation of the Pannonian Sea and the action of rivers. It is mainly characterised by high heterogeneity in the horizontal and vertical sense. Genetically, this heterogeneous material is overlaid by a younger alluvial layer consisting of clay, loam, mud and powdery materials. The studied area of Baranja is located on a loess terrace of the Erdut plateau, on alluvial deposits of finely-grained loam, with varying participation of differently-sized sand particles and colloidal clay particles.

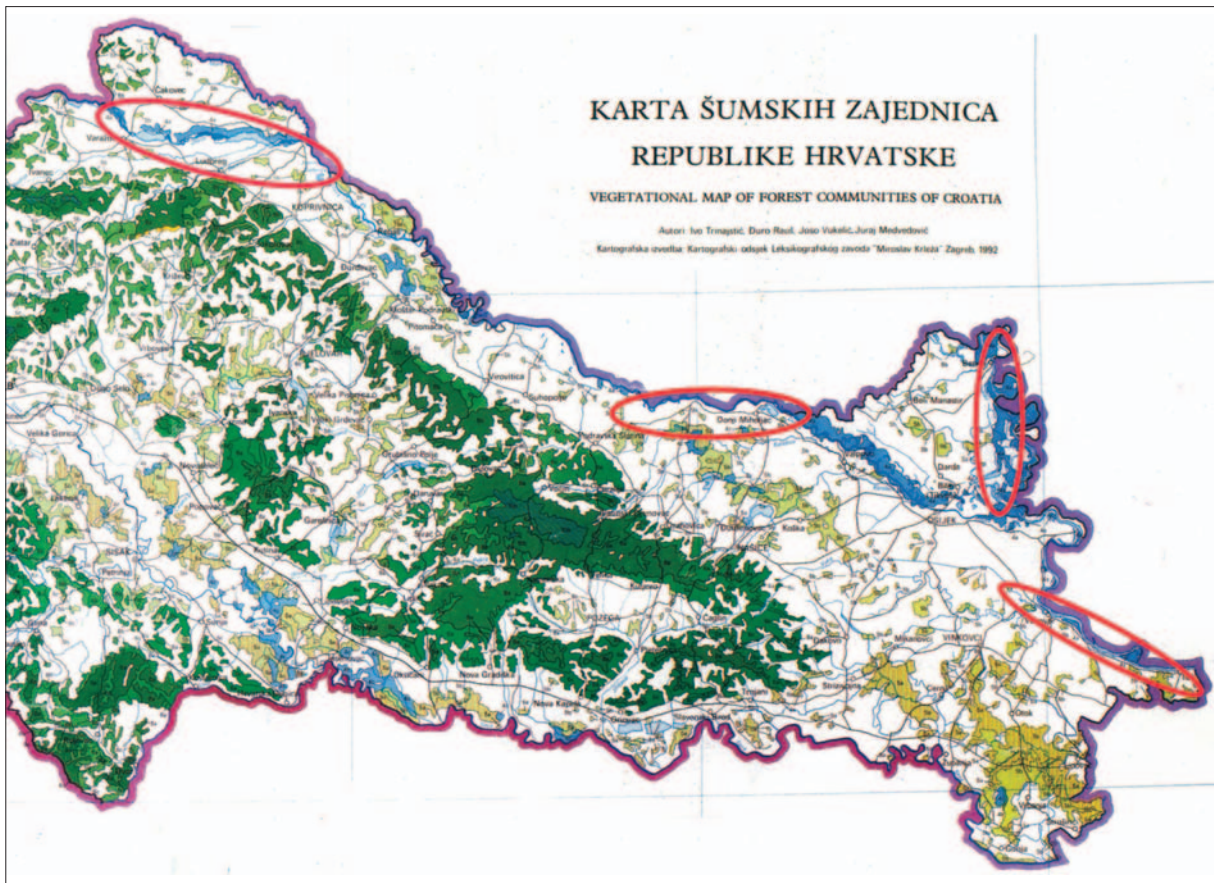


Figure 1: Area of phytocoenological survey of the community *Fraxino-Ulmetum laevis*
 Slika 1: Območje fitocenoloških raziskav asociacije *Fraxino-Ulmetum laevis*

Flood water is the most important ecological factor related to the occurrence and development of riparian forests. Thus, due to the high fall of the river Drava and the resulting speed of its water, the water level rises rapidly and the water floods its surroundings, taking away and bringing in a number of particles. Consequently, the stands along the Drava are characterised by pebbles and sands, while those along the slower and more sedate Danube by mud material.

All the regions are exposed to constant and periodical flooding. Such conditions result in the development of special soil types – hydromorphous alluvial soils. The association *Fraxino-Ulmetum laevis* develops on two types of alluvial carbonate soils: poorly developed moderately gleyic soils and developed, deep gleyic soils.

4. RESULTS AND DISCUSSION

Compared to earlier insights, the results of this research have shown the existence of the association *Fraxino-Ulmetum laevis* along the entire Podravina and Podunavlje regions. Very beautiful and rich stands were studied near Varaždin close to the Slovenian border, a little smaller at the mouth of the Mura into the Drava at Legrad, in Podrava forests of Slatina and Miholjac and especially in Baranja in the Šarkanj region in the north-easternmost part of Croatia (Figure 1). These are smaller areas on micro-elevations in the floodplain region, over terrain which is flooded occasionally for short periods. In the majority of these localities, the community was either described for the first time or new insights on the community were gained.

Detailed pedological research in ten localities in the area of forest offices Batina and Tikveš in Baranja showed that the community develops on sandy alluvium, on the eugley hypogley soil type. The depth of the soil is 100–130 cm, its structure ranges from finely-grained sandy loam to powdery clayey loam. The soil reaction is neutral to weakly basic (pH ranges from 6.7 to 7.8). The humus content in the humus accumulative horizon ranges from 6.1 to 11 % at 20 cm deep. An exception is compartment 15 b, a locality in the area of Šarkanj, forest office Batina, where the community develops on humofluvisol without any detected gleying processes. Due to ecological conditions in this area, abundant organic production and an elevated position, the humus content in the humus-accumulative horizon is also high and comes to about 25 %.

The floral composition of the association *Fraxino-Ulmetum* is presented on the basis of 19 relatively heterogeneous relevés. This is primarily the result of the differences in the floral composition of individual areas and possibly some differences at the time of survey, or changes in water relations that had taken place in the meantime. As shown by the synthetic Table 1, the floral composition of the association in the studied area is distinctly characterised by a permanent presence of characteristic species of the association in all the three layers – spreading elm (*Ulmus laevis*), and the trees of narrow-leaved ash (*Fraxinus angustifolia*) and pedunculate oak (*Quercus robur*). The very dense tree layer that covers the soil almost completely is represented by other species of riparian areas, except for distinctly pioneering ones such as, for example, purple willow and almond-leaved willow. The shrub layer is sporadically also very dense with an average coverage of over 50 %. Along with species from the tree layer, it is characterised by *Cornus sanguinea*, *Viburnum opulus*, *Acer tataricum*, and in Podunavlje also by *Crataegus pentagyna* and the neophytes *Fraxinus americana* and *Acer negundo*. The ground layer is characterised by the species *Ulmus laevis*, *Carex remota*, *Festuca gigantea*, *Polygonum hidropiper*, *Rubus caesius*, *Urtica dioica*, *Glechoma hederacea* and *Solidago serotina*.

The results of classical synthetic analysis and multivariate statistical analysis using the Syn-Tax 2000 programme have shown that all relevés belong to the same association, but also that bringing together similar relevés shows two larger groups and four smaller groups of records.

Very similar results were obtained with multivariate analysis with all the applied methods, which also coincide with the already described results obtained from classical synthetic analysis of phytocoenological relevés. The constrictions of space here do not allow us to present more than one example of cluster analysis – complete link (Figure 2) and one example of ordinal analysis – the Principal coordinate analysis (PCoA) (Figure 3).

Based on the floral composition of associated relevés in each group, the participation degree of individual species by layers, and the characteristic and differentiating nature of species with a higher participation degree, two variants of this community were identified: a drier one and a more humid one.

It is clear from the synthetic table (Table 1) and the diagrams (Figure 2 and 3) that the former is linked to the upper and central course of the river

Table 1: Floral composition of the association *Fraxino-Ulmetum laevis* and differences among individual variants
Tabela 1: Floristična sestava asocijacije *Fraxino-Ulmetum laevis* in razlike med posameznimi variantami

Association: Variant: Area: Source:	<i>Fraxino-Ulmetum laevis</i> Slav. 1952																		
	<i>Prunus padus</i>										<i>Typicum</i>								
	Varaždin					Slatina					Baranja				Dunav				
	Vukelić & Baričević 2003										Rauš (1976)								
Number of record:	10	11	12	13	14	15	16	17	18	19	5	6	7	8	9	1	2	3	4
Relevé area (m ²)											400								
Cover tree layer (%):	50	80	80	90	80	80	80	40	60	60	80	70	70	90	80	90	80	90	100
Cover shrub layer (%):	70	80	70	80	90	80	70	80	80	70	80	60	70	80	60	15	5	5	5
Cover herb layer (%):	70	80	90	80	100	60	100	90	80	60	40	50	70	60	70	90	90	100	50

Characteristic and distinguishing species of the association and alliance *Alno-Quercion roboris*:

<i>Fraxinus angustifolia</i>	A	1	2	2	1	3	4	5	.	.	.	2	2	.	.	.	+	2	.	.
<i>Quercus robur</i>	.	1	.	.	1	1	+	3	4	3	4	4	4	5	5	+	2	1	2	
<i>Ulmus laevis</i>	1	3	3	4	3	2	.	.	.	+	2	1	+	1	.	2	1	1	3	
<i>Ulmus minor</i>	.	1	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.
<i>Ulmus laevis</i>	B	1	1	.	2	+	1	1	.	.	2	1	2	3	1	1	+	+	+	
<i>Fraxinus angustifolia</i>	.	1	.	2	2	.	.	.	.	.	.	1	.	.	.	+	.	.	.
<i>Viburnum opulus</i>	+	.	.	+	+	.	.	.	.	.	1	+	1	+	.	.	.	.	1
<i>Ulmus minor</i>	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	+
<i>Quercus robur</i>	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+
<i>Ulmus laevis</i>	C	.	.	.	+	1	.	.	.	1	+	.	.	+	+	+	.	.	.	
<i>Carex remota</i>	.	.	.	.	.	1	1	.	.	.	2	2	.	+	.	1	+	+	+
<i>Festuca gigantea</i>	.	.	.	+	.	.	+	.	.	.	.	.	.	+	+	1	.	.	.
<i>Fraxinus angustifolia</i>	.	.	.	+	+	.	+	.	.	.	+	1	.	.	1	.	.	.	.
<i>Rumex sanguineus</i>	.	.	.	.	.	.	.	.	.	1	+	.	+	+	.	.	+	.	.
<i>Scrophularia alata</i>	.	.	.	.	.	+	.	.	.	1	.	.	.	.	.	+	.	.	.
<i>Quercus robur</i>	.	.	.	.	.	.	+	.	.	.	+	+	+	.	.	.	.	.	.
<i>Impatiens noli-tangere</i>	.	.	.	.	.	.	.	1	1	.	+	.	.	1	.	.	.	.	.
<i>Solanum dulcamara</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	+	+	.	.
<i>Viburnum opulus</i>	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
<i>Ulmus minor</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
<i>Lycopus europaeus</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
<i>Cardamine dentata</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.

Distinguishing species of the variants:

<i>Prunus padus</i>	A	2	1	2	+	1	.	+	.	.	.	.	.	.	.	.	.	.	.
<i>Prunus padus</i>	B	.	2	1	1	2	.	+	.	.	.	.	.	.	.	.	.	.	.
<i>Lonicera caprifolium</i>	.	+	2	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Aegopodium podagraria</i>	C	3	3	2	3	3	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Lamium orvala</i>	.	2	+	3	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Pulmonaria officinalis</i>	.	2	2	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Allium ursinum</i>	.	3	+	+	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Stachys sylvatica</i>	.	+	+	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Asarum europaeum</i>	.	+	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Lonicera caprifolium</i>	.	.	.	+	+	2	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Dryopteris filix-mas</i>	.	+	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Prunus padus</i>	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Sambucus nigra</i>	B	2	.	2	2	2	2	2	2	2	.	.	.	.	.	.	.	.	.
<i>Crataegus monogyna</i>	.	.	1	.	.	1	1	+	1	+	.	.	.	.	.	.	.	.	.
<i>Ligustrum vulgare</i>	.	+	3	+	2	2	1	+	2	.	.	.	.	.	.	.	.	.	.
<i>Humulus lupulus</i>	.	1	.	2	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
<i>Euonymus europaea</i>	.	.	.	1	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.

Number of record:		10	11	12	13	14	15	16	17	18	19	5	6	7	8	9	1	2	3	4
<i>Brachypodium sylvaticum</i>	C	+	+	.	+	+	.	1	1	1	.	.	.	.	.	.	.	.	.	.
<i>Paris quadrifolia</i>		2	1	2	1	1	2	1	.	.	.	.	.	.	.	.	.	.	.	.
<i>Ranunculus ficaria</i>		1	.	.	.	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.
<i>Clematis vitalba</i>		.	.	+	+	+	2	+	.	.	.	.	.	.	.	.	.	.	.	.
<i>Humulus lupulus</i>		.	+	+	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Carex sylvatica</i>		1	.	.	.	+	.	+	1	.	.	.	+	.	.	.	.	.	.	.
<i>Cerastium sylvaticum</i>		+	.	.	.	.	1	+	+	3	.	.	.	.	.	.	.	.	.	.
<i>Sambucus nigra</i>		.	.	.	.	.	.	.	1	+	1	.	.	.	.	.	.	.	.	.
<i>Morus alba</i> A		.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	+	1	.
<i>Fraxinus americana</i>		.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
<i>Morus alba</i> B		.	.	.	.	.	.	.	.	.	.	+	1	+	+	1	.	+	.	+
<i>Fraxinus americana</i>		.	.	.	.	.	.	.	.	.	.	1	1	1	1	+	.	.	.	+
<i>Polygonum hydropiper</i>	C	.	.	.	.	.	.	+	.	.	.	+	.	+	+	1	.	+	.	.
<i>Oxalis stricta</i>		.	.	.	.	.	+	.	.	.	.	+	.	+	+	.	.	.	+	.
<i>Leucium aestivum</i>		.	.	.	.	.	.	.	.	.	.	1	.	1	1	+	.	.	+	.
<i>Stachys palustris</i>		.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	+	.
<i>Ranunculus repens</i>		.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	+	.
<i>Crepis paludosa</i>		.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	+	+	.
<i>Lysimachia nummularia</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.
<i>Galium palustre</i>		.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	+	.	.
<i>Potentilla reptans</i>		.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	.
<i>Lysimachia vulgaris</i>		.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.
<i>Mentha aquatica</i>		.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	+
<i>Scutellaria galericulata</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.
<i>Fraxinus americana</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
<i>Morus alba</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
<i>Acer tataricum</i> A		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
<i>Acer tataricum</i>	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
<i>Poa trivialis</i>	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	+
<i>Calamagrostis epigeios</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.
<i>Acer tataricum</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Characteristic species of the order <i>Fagetalia</i> and class <i>Quercu-Fagetea</i>:																				
<i>Acer campestre</i>	A	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Acer campestre</i>	B	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	+
<i>Crataegus laevigata</i>		.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Urtica dioica</i>	C	.	.	.	.	+	.	2	3	2	2	1	1	+	.	3	.	.	.	+
<i>Circea lutetiana</i>		1	.	1	+	+	3	3	3	1	1	+	+	.	.	+	.	.	.	.
<i>Symphytum tuberosum</i>		.	2	1	1	1	.	.	.	.	.	.	+	1	1	.	.	.	.	.
<i>Geum urbanum</i>		.	+	.	.	.	.	+	+	.	.	+	.	.	.	.	.	.	.	.
<i>Lamiastrum galeobdolon</i>		1	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+
<i>Arum maculatum</i>		.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Vinca minor</i>		.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Neottia nidus-avis</i>		.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Sanicula europaea</i>		.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Acer campestre</i>		.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Other species of wet and flooded sites:																				
<i>Iris pseudacorus</i>	C	.	.	+	.	+	+	.	.	.	.	.	+	1	+	.	+	+	.	.
<i>Euphorbia palustris</i>		.	.	.	.	+	.	.	.	.	.	.	.	1	+	.	.	.	.	.
<i>Cirsium palustre</i>		+	.	.	.	+	.	.	.	.	.	.	.	+	.	+	.	.	.	.
<i>Carex elata</i>		.	.	.	.	.	+	.	1	.	.	+	.	.	.	.	.	.	.	.
<i>Lythrum salicaria</i>		.	.	.	.	.	.	.	.	1	.	.	.	+	+	+	.	.	.	.
<i>Glyceria fluitans</i>		.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
<i>Deschampsia cespitosa</i>		.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Myosotis palustris</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
<i>Caltha palustris</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.

Number of record:		10	11	12	13	14	15	16	17	18	19	5	6	7	8	9	1	2	3	4
Other species:																				
<i>Populus nigra</i>	A	2	1	1	.	2	1	.	.	.	.	.	.	.	.	.	2	.	1	.
<i>Populus alba</i>		.	2	2	2	1	.	.	.	.	.	.	.	.	.	.	1	.	2	.
<i>Alnus incana</i>		2	.	+	.	.	.	.	.	+	+	+	.	.	.	.	+	.	.	.
<i>Salix alba</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
<i>Acer negundo</i>		.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
<i>Robinia pseudoacacia</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Cornus sanguinea</i>	B	3	2	3	2	3	4	4	3	2	3	4	3	3	.	2	+	+	.	+
<i>Crataegus pentagyna</i>		.	.	.	.	+	1	+	1	2	2	.	.	.	.	1	+	+	2	.
<i>Acer negundo</i>		.	.	.	.	+	.	.	.	+	.	.	+	+	.	.	+	+	.	.
<i>Rubus caesius</i>		.	.	.	.	.	2	.	.	.	.	4	3	4	2	3	.	.	.	.
<i>Robinia pseudoacacia</i>		.	.	.	.	.	.	.	.	.	+	2	.	.	.	.	+	.	.	.
<i>Populus alba</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	+	.
<i>Crataegus nigra</i>		.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.
<i>Populus nigra</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
<i>Rosa sp.</i>		.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.
<i>Alnus incana</i>		.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
<i>Vitis sylvestris</i>		.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Celtis australis</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
<i>Rhamnus cathartica</i>		.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Rubus caesius</i>	C	3	3	3	2	1	.	2	2	+	2	3	3	2	3	1	2	2	2	1
<i>Glechoma hederacea</i>		+	.	.	.	1	.	+	2	3	.	.	.	.	.	2	.	1	1	+
<i>Solidago serotina</i>		.	1	+	.	1	+	.	1	.	.	+	1	1	+	2	+	.	.	.
<i>Symphytum officinale</i>		.	+	.	.	.	1	+	+	+	.	.	.	.	.	2	+	+	.	.
<i>Galium aparine</i>		1	.	1	+	+	1	2	2	2	.	.	.	.	+	.	1	.	.	.
<i>Cornus sanguinea</i>		1	.	+	.	.	.	.	+	+	2	1	.	.	.	.	.	.	.	.
<i>Agrostis alba</i>		.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	+	+	1	.
<i>Galeopsis speciosa</i>		.	.	.	.	.	+	.	.	1	.	.	.	.	.	.	+	.	.	.
<i>Calystegia sepium</i>		.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	+	.	.	.
<i>Populus alba</i>		.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
<i>Bidens tripartita</i>		.	.	.	.	.	.	.	.	.	.	.	.	+	2	+	.	.	.	.
<i>Prunella vulgaris</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.
<i>Stenactis annua</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.
<i>Parietaria officinalis</i>		2	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Leucium vernum</i>		.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Physalis alkekengi</i>		.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.
<i>Torilis japonica</i>		.	.	.	.	.	.	.	1	+	+	.	.	.	.	.	.	.	.	.
<i>Erigeron annuus</i>		.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	+	.	.
<i>Acer negundo</i>		.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.
<i>Rumex hydrolapathum</i>		.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	.	.	.	.
<i>Phragmites communis</i>		.	.	.	.	.	.	.	.	.	.	.	.	2	+	.	.	.	.	.
<i>Galeopsis tetrahit</i>		.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.
<i>Chelidonium majus</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
<i>Vitis sylvestris</i>		.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Impatiens parviflora</i>		.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
<i>Phalaris arundinacea</i>		.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
<i>Robinia pseudoacacia</i>		.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
<i>Viola odorata</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
<i>Erigeron canadensis</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
<i>Euphorbia salicifolia</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
<i>Plantago media</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
<i>Trifolium repens</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
<i>Carex hirta</i>		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
<i>Ligustrum vulgare</i>		.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Alliaria petiolata</i>		.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
<i>Equisetum hyemale</i>		.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
<i>Alnus incana</i>		.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
<i>Lapsana communis</i>		.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

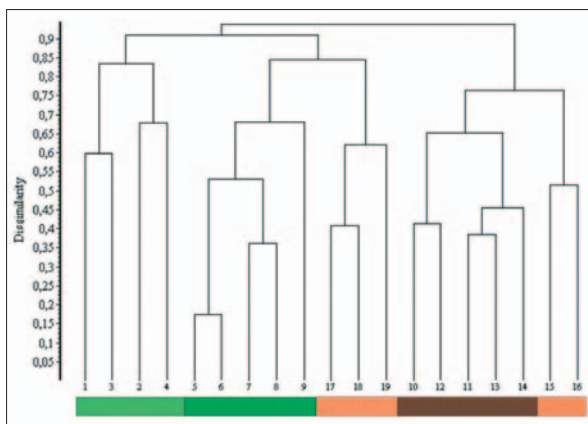


Figure 2: Dendrogram constructed with cluster analysis – complete link

Slika 2: Dendrogram, klasifikacija s popolnim povezovanjem

Key to the Figures 2 and 3:

- dark green colour – *Fraxino-Ulmetum laevis typicum* (Baranja)
- light green colour – *Fraxino-Ulmetum laevis typicum* (the Danube to Ilok)
- dark brown colour – *Fraxino-Ulmetum laevis* var. *P. padus* (Varaždin)
- light brown colour – *Fraxino-Ulmetum laevis* var. *P. padus* (Slatina)

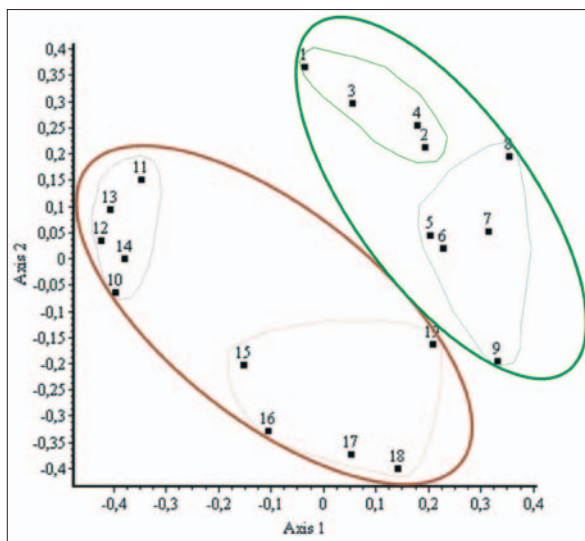


Figure 3: Ordinal diagram constructed with multidimensional scaling – PCoA

Slika 3: Ordinacijski diagram, metoda glavnih komponent (PCoA)



Figure 4: Characteristic appearance of the association of spreading elm and narrow-leaved ash in the area of Podravina forests near Varaždin (Photo: D. Baričević)

Slika 4: Značilen videz asociacije dolgopecljatega bresta in ostroplodnega jesena v Podravini v bližini Varaždina (Foto: D. Baričević)

Drava. It is labelled as the variant *Prunus padus* and is characterised by the species *Prunus padus*, *Lonicera caprifolium*, *Aegopodium podagraria*, *Lamium orvala*, *Pulmonaria officinalis*, *Allium ursinum*, *Brachypodium sylvaticum* and others.

The latter is linked to the river Danube and less to the lower part of the river Sava flow, and is labelled as a variant *typicum* and characterised by the species *Morus alba*, *Polygonum hydropiper*, *Oxalis stricta*, *Lysimachia nummularia*, *Leucium aestivum* and others. There are certain differences within this community between the relevés from Baranja and the Danube islands from Aljmaš to Ilok as opposed to Posavina (Rauš 1975), but the stands in Posavina should be studied in more detail and compared with humid forests of pedunculate oak.

These differences are expected and are primarily the result of conditions in which the community occurs. Thus, for example, the stands along the river Drava are characterised by pebbles and sands, those along the Danube by mud materials, while those along the Sava by redeposited swampy

loess. Additionally, three hydropower stations with their retentions have been built in the upper flow of the river Drava (from the boundary with Slovenia), which has had a very strong impact on water relations. Since water management is oriented primarily to the needs of energy production, there is no more regular flooding; instead, there are floods only several times in a decade. In contrast, the conditions in the area along the river Danube are much more natural; however, a dam was built there which has changed water and other site conditions.

Riparian forests largely depend on the dynamics, height and length of stagnating flood waters, but throughout history man and his ameliorative activities have irrevocably changed the landscape and the vegetation structure of the area. The first and foremost consequence of the erection of a dam in Baranja was an abrupt separation of the vegetation from the usual ecological conditions. Man has also influenced the floral picture of the Baranja region by introducing exotic tree species



Figure 5: Appearance of the variant *typicum* in the Šarkanj area in Baranja (Photo: D. Baričević)
Slika 5: Varianta *typicum* v Baranji, v območju Šarkanja (Foto: D. Baričević)

such as *Acer negundo* – ash-leaved maple, *Morus alba* – white mulberry, *Fraxinus americana* – white ash, which have adapted very well to the newly created changed conditions.

It should be pointed out that this community represents the final terminal stage in the development of the vegetation of floodplain regions, in the same way in which the forest of pedunculate oak and common hornbeam (*Carpino betuli-Quercetum roboris*) represents the final terminal stage in the lowland area outside the reach of direct floods.

Systematically, the community belongs to the alliance *Alno-Quercion roboris* Ht. 1937 (1938), order *Alnetalia glutinosae* Tx. 1937 and class *Alnetea glutinosae* Br.-Bl. Et Tx. 1943.

Slavnić was among the first to point to its affiliation with the forest of pedunculate oak and *Genista elata* (*Genista elatae-Quercetum roboris*), but he also stressed considerable differences in the conditions of its occurrence and floral composition. Thus, similar stands to the community of spreading elm and oak (*Quercus roboris-Ulmetum laevis* Issler 1926) were described in Slovenia (Marinček & Seliškar 1984), but according to initial research, there are also significant differences; consequently, to accurately compare and identify these communities it is necessary to make further detailed investigations.

5. CONCLUSIONS

Based on research results, the following conclusions may be drawn:

1. Research results indicated the occurrence of the community *Fraxino-Ulmetum laevis* along the entire Podravina and Podunavlje regions. Very beautiful and rich stands were investigated at Varaždin near the Slovenian border, the slightly smaller ones at the mouth of the Mura into the Drava at Legrad, in the forests of Slatina and Miholjac Podravina and especially in Baranja in the Šarkanj area in the north-easternmost part of Croatia. In the majority of these localities the community was either described for the first time or the existing knowledge on the community was expanded.

2. Detailed pedological research in the Baranja area showed that the community develops mostly on sandy alluvium, on the eugley hypogley soil type.

3. The floral composition of the phytocoenosis *Fraxino-Ulmetum* is represented on the basis of 19 relevés. They are relatively heterogeneous, which is primarily the result of the floral compositions in in-

dividual areas and probably of different periods in which the survey was done, or the changes in water relations that had taken place in the meantime.

4. The results of multivariate analysis from all methods used showed very similar results, which also coincide with the already described results obtained with a classical synthetic analysis of phytocoenological relevés.

5. Based on the floral composition of associated relevés in each group, the participation degree of given species per layers, and a characteristic and differentiating nature of species with a higher participation degree, two variants of this community were established: a drier one and a more humid one.

6. The first is linked to the river Drava and its upper and central flow. It was labelled as the variant *Prunus padus* and is characterised by the species *Prunus padus*, *Lonicera caprifolium*, *Aegopodium podagraria*, *Lamium orvala*, *Pulmonaria officinalis*, *Allium ursinum*, *Brachypodium sylvaticum* and others.

7. The second is linked to the river Danube and less to the lower flow of the river Sava. It is labelled as the variant *typicum* and is characterised by the species *Morus alba*, *Polygonum hydropiper*, *Oxallis stricta*, *Lysimachia nummularia*, *Leucoium aestivum* and others.

8. Systematically, the association belongs to the alliance *Alno-Quercion roboris* Ht. 1937 (1938), order *Alnetalia glutinosae* Tx. 1937 and class *Alnetea glutinosae* Br.-Bl. et Tx. 1943.

9. Slavnić was among the first to point to its affiliation with the association *Genista elatae-Quercetum roboris*, but he also stresses considerable differences in the conditions of its occurrence and floral composition. Stands similar to the association *Quercus roboris-Ulmetum laevis* Issler 1926 were also described in Slovenia (Marinček & Seliškar 1984), initial research showed some significant differences. In order to compare and define these communities more accurately, it is necessary to do further detailed research.

10. The association *Fraxino-Ulmetum laevis* used to be widespread, albeit fragmentarily and over small areas. However, as these highest parts were always interesting for agricultural production in the first place, the areas covered with this community decreased. Today, it is expanding again because drier conditions, less frequent and shorter-lasting floods favour its growth.

11. From a natural-scientific aspect, the community is very important as the best developed form of vegetation in the floodplain region. This is further supported by its rare status, insufficient

exploration and range regression, as well as by considerable past and present changes taking place in floodplain ecosystems of Croatia and Europe.

12. The community does not have any considerable economic value, but in terms of biological diversity, ecological stability and general benefits it is highly valuable and should be preserved wherever possible.

6. POVZETEK

Asociacija dolgopecljatega bresta in ostroplodnega jesena (*Fraxino-Ulmetum laevis* Slav. 1952) v nižinskih poplavnih gozdovih Podravine in Podonavja

Asociacija *Fraxino-Ulmetum laevis* je gozdna združba, ki se razvije na najvišjih rastiščih na poplavnih območjih ob rekah in jo je opisal Slavnić (1952) v Vojvodini. Na podlagi dosedanjih raziskav, je bila združba ugotovljena na naslednjih lokalitetah na Hrvaškem, in sicer: v Baranji (Jovanović 1965, Antić & al. 1969), dolvodno ob Donavi do Iloka (Rauš 1976, 1992, Mayer 2000), fragmentarno v Podravske gozdovih na območju Slatine (Vukelić, Baričević & Perković 1999), kakor tudi ob reki Savi na območju Spačve (Rauš 1975).

Rezultati so pokazali, da se asociacija *Fraxino-Ulmetum laevis* pojavlja na celotnem območju Podravine in Podonavja. Dobro razvite sestoje smo raziskal pri Varaždinu, blizu slovenske meje, nekoliko manjše pri izlivu Mure v Dravo pri Legardu, v gozdovih pri Slatini in Miholjcu v Podravini in posebno v Baranji na območju Šarkanj v najbolj severovzhodnem delu Hrvaške. Večina teh lokalitet je bila prvič popisana ali pa smo razširili že obstoječe vedenje o njih.

Podrobna pedološke raziskave v Baranji so pokazale, da se združba razvije predvsem na peščenih naplavinah, na evglej hipoglej tipu.

Floristična sestava asociacije *Fraxino-Ulmetum laevis* je prikazana na osnovi 19 popisov. Rezultati vseh uporabljenih multivariatnih analiz kažejo zelo podobne rezultate kot klasične sintetske analize fitocenoloških popisov.

Na podlagi floristične zgradbe popisov, ki jih uvrščamo v dve skupini, smo na podlagi stalnosti rastlinski vrst po plasteh ter značilnih in razlikovalnih vrst, ki imajo večjo stalnost, opredelili dve varianti: suho in vlažno.

Prva, bolj suha, se pojavlja v zgornjem in osrednjem delu toka reke Drave. Varianto smo poimenovali smo jo po vrsti *Prunus padus* in jo označujejo

vrste: *Prunus padus*, *Lonicera caprifolium*, *Aegopodium podagraria*, *Lamium orvala*, *Pulmonaria officinalis*, *Allium ursinum*, *Brachypodium sylvaticum* in še nekatere.

Druga varianta, ki je bolj vlažna, se pojavlja ob reki Donavi in redkeje ob spodnjem toku reke Save. Poimenovali smo jo *typicum* in jo označujejo vrste: *Morus alba*, *Polygonum hydropiper*, *Oxallis stricta*, *Lysimachia nummularia*, *Leucoium aestivum* in še nekatere.

Slavnić je med prvimi pokazal na povezanost asociacije z asociacijo *Genisto elatae-Quercetum roboris*, toda poudaril je očitne razlike v rastiščnih razmerah in floristični zgradbi. Podobne sestoje kot je asociacija *Quercus roboris-Ulmetum laevis* Issler 1926 so bili opisani v Sloveniji (Marinček & Seliškar 1984), vendar začetne raziskave kažejo očitne razlike. Da bi lahko primerjali in opredelili te združbe, bodo potrebne nadaljnje podrobne raziskave.

Asociacija *Fraxino-Ulmetum laevis* je bila nekdaj bolj razširjena, čeprav fragmentirano na majhnih površinah. Danes pa se ponovno širi, zaradi bolj suhih rastiščnih razmer: manj pogostoh in krajših poplav.

Združba nima večje ekonomske vrednosti, vendar je zelo pomembna zaradi biotske raznovrstnosti, ekološke stabilnosti in splošnih koristi. Tako jo je potrebno ohraniti, kjer je to le mogoče.

7. REFERENCES

- Antić, M., Jovanović, B., Jović, N., Munkačević, V. & Nikolandić, S. (1969): Fitocenološka – pedološka istraživanja u plavnom području Baranje. *Jelen* 8: 99–112.
- Braun-Blanquet, J. 1928: Pflanzensociologie. Grundzüge der Vegetationskunde. Biologische Studienbücher 7, Berlin.
- Ehrendorfer, F. 1973: Liste der Gefäßpflanzen Mitteleuropas. G. Fischer Verlag, Stuttgart, 318 pp.
- Hennekens, S. M. 1995: TURBO(VEG). Software package for input, processing and presentation of phytocoenological data. User's guide. Instituut voor Bos en Natuur. Wageningen and Unit of Vegetation Science, University of Lancaster, Lancaster.
- Gower, J. C. 1966: Some distance properties of latent root and vector methods used in multivariate analysis. *Biometrika* 53: 325–338.
- Jovanović, B. (1965): Biljni svet – osnovne karakteristike autohtone flore i vegetacije Beljskog lovno-šumskog područja. *Jelen* 3: 61–81.

- Marinček, L. & Seliškar, A. (1984): Rastlinske združbe ob Muri. Manuscript. Biološki inštitut Jovana Hadžija, 22 pp.
- Mayer, Ž. (2000): Ritske šume hrvatskog Podunavlja i njihova prirodna obnova. Specijalistički rad, Šumarski fakultet Sveuč. u Zagrebu, 56 pp.
- Pielou, E. C. 1984: Interpretation of ecological data. Primer of ordination and classification. Wiley Interscience, New York.
- Podani, J. 1994: Multivariate data analysis in ecology and systematics. A methodological guide to the SYN-TAX 5.0 package, SPB, Amsterdam.
- Rauš, Đ. (1975): Šumska vegetacija "Vorlanda" na lijevoj obali Save između Orljave i Bosuta. JAZU, Posebna izdanja, knj. II: 111–128.
- Rauš, Đ. (1976): Vegetacija ritskih šuma dijela Podunavlja od Aljmaša do Iloka. Glas. šum. pokuse 19: 5–75.
- Rauš, Đ. & Matić, S. (1990): Vegetacijska i uzgojna istraživanja u GJ "Vukovarske dunavske ade" PJ šumarije Vukovar. Šumarski list 114 (1–2): 5–44.
- Rauš, Đ. (1992): Vegetacija ritskih šuma uz rijeku Dravu od Varaždina do Osijeka s težištem na Varaždinske podravske šume. Glas. šum. pokuse 28: 245–256.
- Slavnić, Ž. (1952): Nizinske šume Vojvodine. Zbornik Matice Srpske sv. 2: 2–38.
- Van der Maarel, E. 1979: Transforming of cover-abundance values in phytosociology and its effect on community similarity. Vegetatio 39: 97–114.
- Vukelić, J., Baričević, D. & Perković, Z. (1999): Vegetacijske i druge značajke zaštićenog dijela "Slatinskih podravskih šuma". Šumarski list 123 (7–8): 287–299.

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