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FLORISTIC DIVERSITY OF POSAVINA'S FLOODPLAIN FORESTS IN SERBIA AND THEIR WIDER GEOGRAPHICAL CONTEXT

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Abstract

In order to detect floristic divergence of analysed stands we applied TWINSPAN classification and ordinary Correspondence Analysis. Both analyses have shown an almost identical result of floristic composition, where 114 studied samples were grouped into seven association groups at the third twinspan classification level. These seven groups, successively from the most humid to most dry, comprising two large groups of plant associations, completely corresponding to two alliances: Forest of Pedunculate Oak and Alder and Forest of Pedunculate Oak and Hornbeam. SIMPER procedure have shown tahat within the first 20.51% of cumulative contribution, the floristic divegence among the studied forest stands includes 13 taxa: *Carpinus betulus.*, *Fraxinus angustifolia*, *Quercus cerris*, *Amorpha fruticosa*, *Convallaria majalis*, *Crataegus oxyacantha*, *Quercus robur*, *Lysimachia nummularia*, *Tamus communis*, *Galium aparine*, *Rubus caesius*, *Ulmus carpinifolia* and *Ajuga reptans*. ANOSIM analysis were used to determine the degree of floristic discontinuity. It was largest between forest of Pedunculate Oak, Hornbeam and Turkey Oak and forest of Pedunculate Oak and Ash (statistics R = 0.8824 ($p<0.001$)). The lowest floristic dissimilarity was between the forest of Pedunculate Oak, Hornbeam and Turkey Oak and forest of Pedunculate Oak, Hornbeam and Turkey Oak with Lindens, where R = 0.2009 ($p<0.01$). Posavina floodplain forests in Serbia generally show good agreement with analogous communities in neighbouring countries in the Balkan peninsula and Central Europe.

Introduction

Flood forests are biologically diverse associations appearing at the points of contact between the aquatic and the terrestrial environmental conditions, in valleys of lowland rivers and river channels, where the main ecological factors are lower altitude, distance from the river and frequency and duration of inundation with flood water (Sperduto & Nichols, 2004) in which the water table is usually at or near the surface, and the land is covered periodically or at least occasionally with shallow water (Paal *et al*., 2007). Forest associations of this type are distributed on banks of freshwater basins and in marsh and swamp areas throughout the Palearctic. They are particularly well-represented in valleys of large rivers in lowland and hillsides, in forest, steppe, forest-steppe, cold desert and semi-desert areas of Eurasia (Davies & Moss, 2002).

These forests have very specific ecological conditions in the temperate zone (Klimo & Hager, 2001) and are usually characterized by a combination of high species diversity, density and productivity (Mitch & Gosselink, 1983). They can be treated as azonal since they are strongly influenced by soil features and climate has only a minor influence (Breckle, 2002).

Floodplain forests have a multiple role in the landscape, since they are important from ecological, biological, environmental and economic points of view (Horner *et al*., 2010). These forests tend to be a mosaic of species-rich vegetation communities due to environmental heterogeneity caused by their position in the landscape, the intensity and frequency of flooding (Ward *et al*.,1999).

Altought they show rich biological and ecological diversity, the floodplain forests in Europe are less biodiverse than those of America and Asia, due to the effects of the last glaciation (Schnitzler *et al*., 2005). The coverage of floodplain forests in Europe has decreased (Glaeser & Volk, 2009) and for that reason are ranked as endangered biotopes (Machar, 2008). Historically, natural floodplain forests have been fragmented and heavely impacted by watercourse regulations, timber harvesting and other human activities (Nillson, 1992; Prax *et al*., 2008; Štirba *et al*., 2008). Therefore, the remaining stands are a part of European natural heritage and belong to the habitats of great importance for nature protection on the European scale.

According to Tuckner & Standford (2002) and Turner *et al*., (2004), various processes of human activities made the floodplain forests more important in terms of ecosystem conservation than in terms of wood stock production. There is consequently a need to investigate these ecosystems and define their function, and it was thus highlighted that the number of studies should increase (Wenger *et al*., 1990). As a result of this awareness, many studies of floodplain forests have been prepared, elaborating biodiversity, function and their importance (Drescher, 2007; Willner, 2007; Wallnöfer, 2009; Baričević *et al*., 2009).

The most important international documents that define floodplian forests as priority habitats are Habitat Directive (EEC/92/43 1992) and Bern Convention (1979).The Habitat Directive, which represents the legal framework for program NATURA 2000, includes these forests in Serbia in codes 91E0, 91F0 and 9160, while the Bern Convention, which is the foundation for program EMERALD Network, includes these forests in codes 44.1, 44.914, 44.2, 44.43, 41.2. Within the territory of Serbia, floodplain forests develop on banks of watercourse basins and in various parts of alluvial plains, under a greater or smaller influence of underground and flood water.Depending on influence of underground and surface water and age of associations, the floodplain forests in Serbia develop on various types of hydromorphic or automorphic soils (Lakušić *et al*., 2005).

As in the region of Posavina the floodplain forests are still very well represented and there are some very old and relatively well-preserved stands. The goals of this paper were: 1. to determine and reassess their basic floristic composition. Also, we go one step ahead, 2. to determine degree of floristic divergence among the forest groups and at the same time, tried to place these forests within a broader scale of Balkans and Central Europe. As floodplain forests in Europe are fragile and increasingly threatened by anthropogenous pressure, there is a growing need for an increasing degree of placing the stands of these associations under a special conservation regime, thence these research provides a basis for nature protection and for the sustainable management of forest in floodplain area of Posavina.

Material and Methods

Study area: The area of Posavina is situated between 18°59’45’’ and 20º21'30" of Eastern longitude and between 44º37'53" and 45º11'37" of Northern latitude (the study area including the forest associations of most of Forest Area “Klenak”, marked on the map – Fig. 1). The absolute altitude decreases from west toward east. The terrain is slightly undulating with terraces and depressions, which are filled with atmospheric and river water when water level of river Sava exceeds 500 cm (Jurišić *et al*., 2011). In the forest complexes at greater distances from River Sava, where the impact of river water is minor or absent, the relief of the terrain is characterized by larger leveled or slightly undulating surfaces with scarce, wide shallow depressions. The greatest area covered with these forests is situated close to river Sava, where the soils are alluvial in origin and of varying ages, from very young to old alluviums upon which various types of soil are based. (Jović & Knežević, 1986).

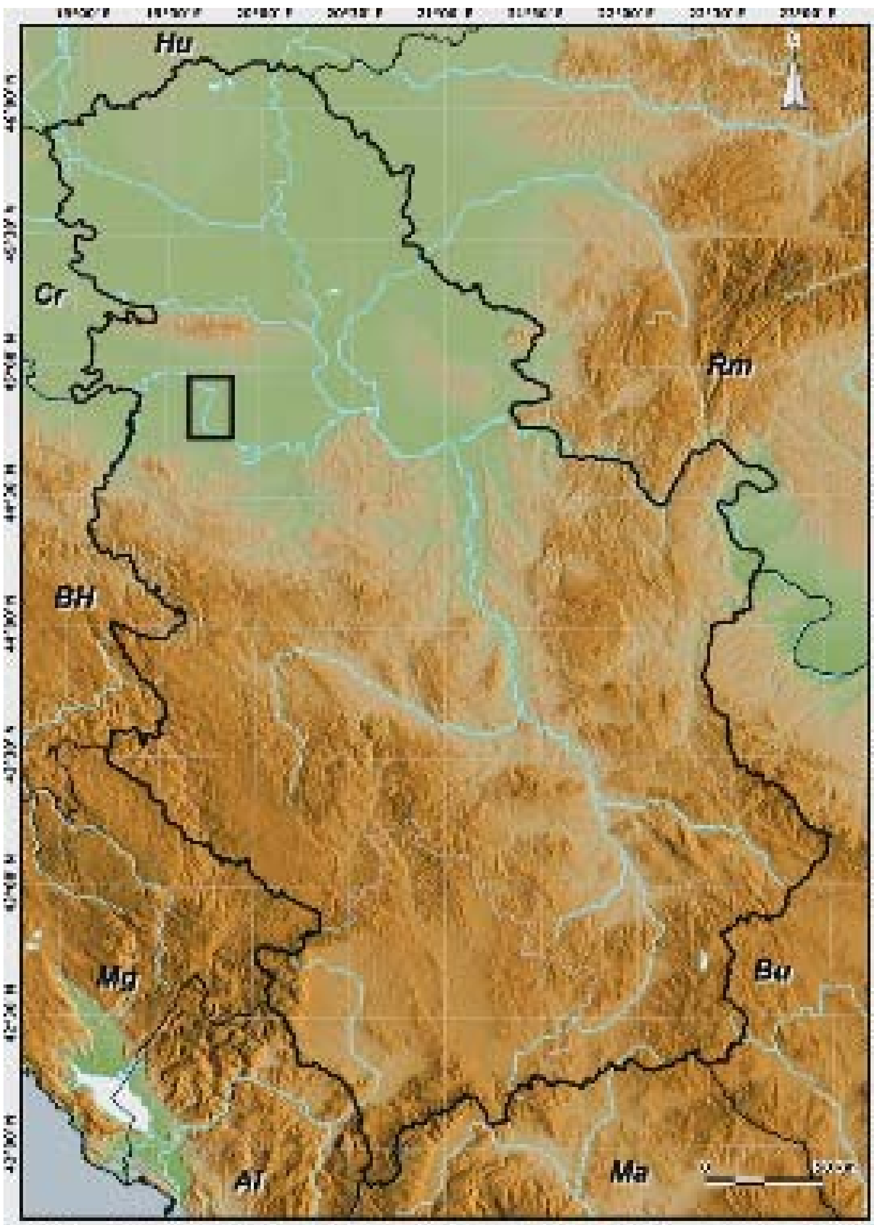

Fig. 1. UTM map of Serbia with the indicated projection of the study area in Posavina.

Data sampling: The studies commenced in spring 2008 and lasted until October 2011. Method of random samples was used to determine 114 plots (stands) where floristic studies were done. Each plot was square in shape, with 20 x 20 m (400 m^2). A list of recorded species of vascular flora was made for each studied area, including the values of abundance and cover according to Braun-Blanquet methodology (Braun-Blanquet, 1964). Nomenclature and taxonomy are in agreement with the Flora Europaea (Flora Europaea Database) and Flora SR Srbije (Sarić, 1992).

Numerical analysis: In order to detect basic floristic differentiation of analyzed stands we applied TWINSPAN classification. The Braun-Blanquet's combined abundance-cover scale is alpha-numeric, and this prevents numeric data processing. Therefore we transformed the combined abundance-cover values into a (1-9) completely numeric scale that was proposed by Westhoff & Van der Maarel (1973). This matrix was then subjected to divisive clustering - Two Way Indicator Species Analysis (TWINSPAN) (Hill 1979), using WinTWINS version 2.3 (Hill & Šmilauer, 2005).Additionally we applied two ordination methods.The first, Detrended Correspodence Analysis (DCA) (Hill & Gauch, 1980) was used to determine the length gradient for the floristic species data.As the gradient for the first DCA axes was 3.214, indicating that the unimodal ordination method were suitable for the analysis, thus Correspodence analysis (CA) was chosen for the further ordination analysis (Lepš & Šmilauer, 2003). The ordination methods and visualization of CA results were carried out using the CANOCO and CanoDraw programs (ter Braak & Šmilauer, 2002).

Analysis of Similarities (One-Way ANOSIM) (Clarke, 1993), is a non-parametric test, applied in order to evaluate the significant differences that could happen in the species composition among TWINPAN groups. The One-Way ANOSIM statistic R is based on the difference of mean ranks between groups rB and within groups rW. R = rB - rW / (N (N-1) / 4)**,** where N – number of samples. In addition, we used the SIMPER (Similarity percentages) procedure (Clarke, 1993) for assessing which taxa are primarily responsible for an observed difference between groups of samples gained in the TWINSPAN analysis, also separated in the CA ordination plot. The results include the average dissimilarity, contribution % (average dissimilarity / SD (average dissimilarity)) for each individual taxon and cumulative contribution of all included taxa, as well as the overall average multi-group dissimilarity among all compared groups or some individual pairs of these groups that may be analyzed, according to the Bray-Curtis distance. The analysis included all present taxa in all three forest strata. ANOSIM and SIMPER analysis was realized with multivariate analysis software PAST version 2.10. (Hammer *et al*., 2001).

Results and Discussion

Classification of forest stands: A TWINSPAN indicator species analysis was performed on 114 samples in the area of Posavina. The results are shown in (Fig. 2) as an annotated dendrogram in which the indicator species at each division are given up to the third division. Eigenvalues and sample sizes are shown for each division. The first division produces a Group 0 (with 56 plots) which is indicated by a cluster of species characteristic for alliance of Pedunculate Oak and Hornbeam The indicator species of this group are: *Quercus cerris* from the third cut level and *Carpinus betulus* from the first cut level. The opposite group in this division, Group 1 (with 58 plots), which is indicated by a cluster of species characteristic for alliance of Pedunculate Oak and Alder has 5 indicator species: *Fraxinus angustifolia* and *Amorpha fruticosa* both from the third cut level and *Carex vulgaris*, *Mentha aquatica* and *Rumex hydrolapathum* from the first cut level. However it is shown that the TWINSPAN classification of the investigated plots cutting at the third cut level shows 7 groups that may be interpreted as 7 forest associations. The TWINSPAN and CA results were mostly similar on this third cut level and the forest groups classified by TWINSPAN were actually confirmed by CA analysis.

These forest stands are well characterized by the presence of diagnostic species groups indicated by the numerical analysis. The floristic differences between these groups may be summarized as follows: The division group 00 (with 50 plots) leads to: Group 000 (with 45 plots) and Group 001 (with 5 plots). Group 000 indicated by indicator species: *Quercus robur* and *Ulmus carpinifolia* at level 3 and *Rubus caesius* and *Convolaria majalis* at level 1, a Group 001 with *Quercus cerris* at level 1 and *Tilia parvifolia* at level 2. Group 01 (with 6 plots) was already separated at the second classification cut level. As the set value of minimal size of division group is 7, it was not divided in the third cut level, and as a homogeneous floristic unit it was separated and also supported by CA analysis. The indicator species of this group are *Carpinus betulus* and *Quercus robur* at level 1 and *Brachipodium sylvaticum* at level 2.

The division group 10 (with 23 plots) leads to: Group 100 (with 8 plots) and Group 101 (with 15 plots). Group 100 indicated by indicator species: *Quercus robur* at level 2 and *Carex remota* at level 1, a Group 101 with *Carpinus betulus* at level 3 and *Fraxinus angustifolia* and *Ajuga reptans* at level 1. The division group 11 (with 35 plots) leads to: Group 110 (with 10 plots) with indicator species *Quercus robur* at level 4 and *Acer campestre* at level 1, as well as Group 111 (with 25 plots) with indicator species *Fraxinus angustifolia* at level 7, *Amorpha fruticosa* at level 3 and *Roripa amphibia* at level 2. The eigenvalue for this division – 0.552 – is particularly strong.

Ordination based on the separated TWINSPAN forest groups: The correspondent analysis (CA) has shown that in floristic sense the flooded forests of Posavina are clearly differentiated into two large association groups, matching the TWINSPAN groups and completely corresponding to the two alliances: (0) Forest of Pedunculate Oak and Hornbeam (*Carpinion betuli ilyrico moesiacum* Horv.56) occupying the left side of the correspondent space and (1) Forest of Pedunculate Oak and Alder (*Alno-Quercion roboris* Horv.37) distributed in the right side of the same ordinance space (Fig. 3).

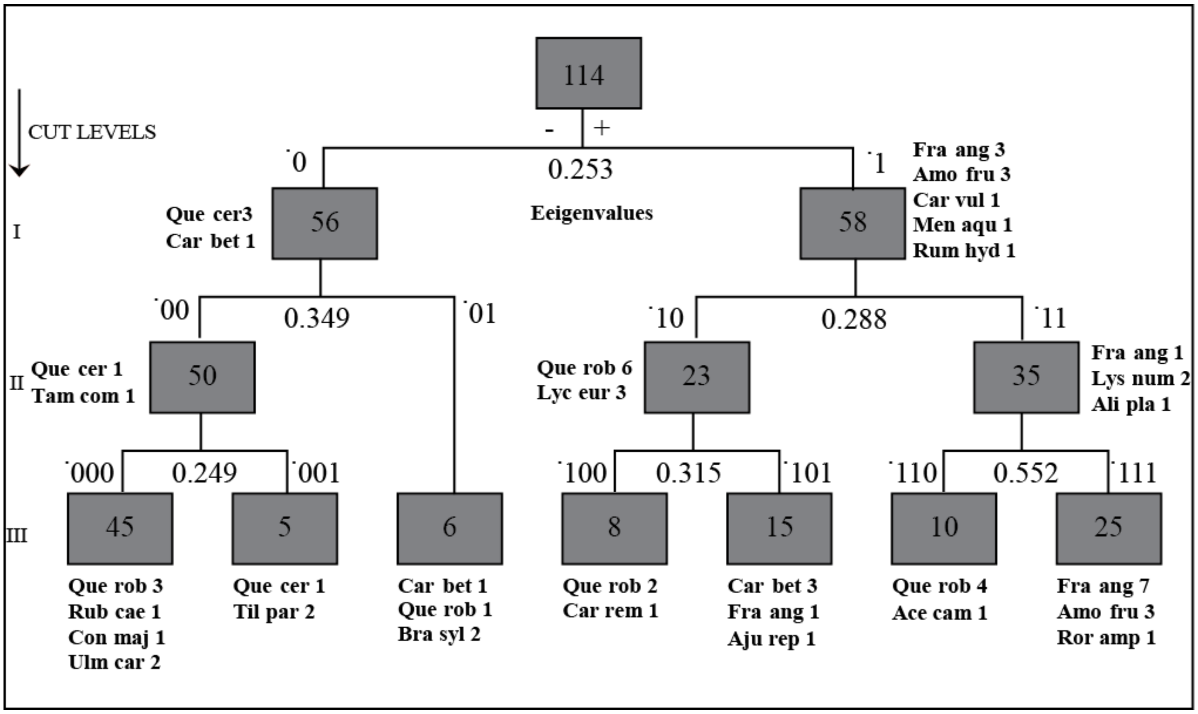

Fig. 2. TWINSPAN classification dendrogram for the investigated floodplain forests in Posavina.
(For each division level eigenvalues and indiacor species are shown; the TWINSPAN groups are in detail (full name) represented to results)
Legend: indicator species (full name): Que cer-*Quercus cerris*, Car bet-*Carpinus betulus*, Fra ang-*Fraxinus angustifolia*, Amo fru-*Amorpha fruticosa*, Car vul- *Carex vulpina*, Men aqu-*Mentha aquatica*, Rum hyd-*Rumex hydrolapathum*, Tam com-*Tamus communis*, Que rob-*Quercus robur*, Lyc eur-*Lycopus europaeus*, Lys num-*Lysimachia nummularia*, Ali pla-*Alisma plantago aquatica*, Rub cae-*Rubus caesius*, Con maj-*Convollaria majalis*, Ulm car-*Ulmus carpinifolia*, Til par-*Tilia parvifloia*, Bra syl-*Brachypodium sylvaticum*, Car rem-*Carex remota*, Aju rep-*Ajuga reptans*, Ace cam-*Acer campestre*, Ror amp-*Rorippa amphibia*

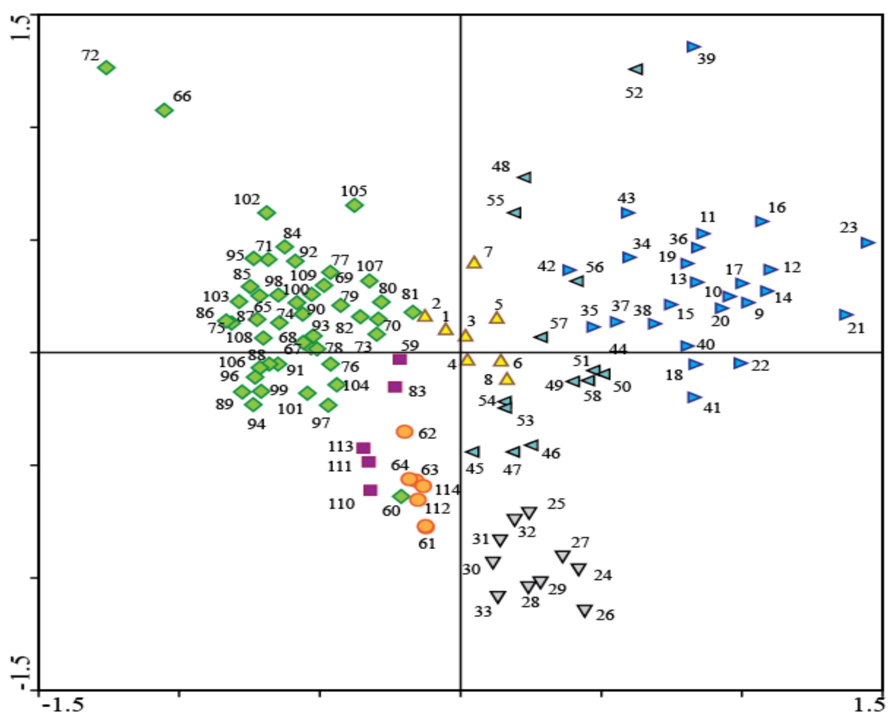

Fig. 3. Correspodence analysis based on the seven TWINSPAN groups (Ordination of 114 samples along the first two CA axes, which express 10.21 % of the total variance). These groups are in detail represented to results: diamond (000), square (001), circle (01), up-triangle (100), left- triangle (101), down-triangle (110) and right- triangle (111).

The CA analysis performed at level of seven TWINSPAN groups has shown that there is only a single pronounced floristic unit (110) which corresponds: Forest of Pedunculate Oak and Hornbeam with Field Maple and Tatar Maple (*Fraxino-Quercetum roboris aceretosum* Jov.et Tom 1980). The remaining six groups of ecological units form one heterogeneous assemblage that indicates a pronounced transitional character in floristic composition of these stands. Within this heterogeneous assemblage there is a relatively clear but very thin line, which separates the remaining TWINSPAN groups corresponding to the following forest associations: (100) - Forest of Pedunculate Oak (*Genisto elata – Quercetum roboris* Horv.37), (101) Forest of Pedunculate Oak, Hornbeam and Ash (*Carpino-Fraxino -Quercetum roboris* Miš.et Broz, 62), (111) Forest of Pedunculate Oak and Ash (*Fraxino-Quercetum roboris* Jov.51) in relation to groups (01) Forest of Pedunculate Oak and Hornbeam (*Carpino-Quercetum roboris* (Vuk.56) Jov.67), (000) Forest of Pedunculate Oak, Hornbeam and Turkey Oak (*Carpino-Quercetum robori-cerris* Jov.67), (001) Forest of Pedunculate Oak, Hornbeam and Turkey Oak with Lindens (*Tilio-Carpino-Quercetum robori-cerris* Jov.79). This divergence of floristic composition among these seven TWINSPAN groups indicates presence of two sets of completely different environmental habitat conditions, which are in floristic sense correspondent with the more hygrophilous forests belonging to group (1 - Forest of Pedunculate Oak and Alder) versus the more meso-xerophilous forests of group (0 - Forest of Pedunculate Oak and Hornbeam).

The forest groups determined by this study as belonging to alliance of Pedunculate Oak and Alder are characterized by greater participation and vitality of hygrophilous species of trees, shrubs and ground vegetation than in the forest types separated into the alliance of Pedunculate Oak and Hornbeam. However, due to high humidity the stratum of bush vegetation almost does not appear at all, while the ground level flora is dominated by hygrophytes. Most stands have monodominant character, so depending on type of forest there is always a single completely dominant hygrophilous species. The occurrence of bi-dominant forests in this alliance is much lower in the studied area. In contrast to the previously mentioned decisively hygrophilous types of forests there are some forests of Pedunculate Oak and Hornbeam with the greatest recorded presence of mesophilous and meso-xerophilous species. Particularly indicative is presence of Hornbeam (*Carpinus betulus* L.) and Turkey Oak (*Quercus cerris* L.) which appear as dominant species in numerous stands at studied localities. These forests are also characterized by a better developed bush stratum and richer stratum of herbaceous plants. The tree stratum, as a rule, includes a larger number of tree species, and in the driest conditions the stands have an almost oligodominant character. The exception is a smaller number of studied associations where the oligodominant character is completely lost and hornbeam remains as the single dominant species. It is assumed that these differences are a result of the flooding regime, which has an identifiable impact on the floristic composition of the communities and abundance of trees (Turner *et al*., 2004).

Within the studied forest stands there were 248 recorded taxa at species and subspecies level. The greatest recorded species richness was in forest of Pedunculate Oak, Hornbeam and Turkey Oak (212 taxa), while the least number of taxa was present in the forest of Pedunculate Oak and Hornbeam (71 taxa) – (Table 1).

Results of the analysis of forests differenciation via ANOSIM: According to the floristic composition the studied forest stands were clearly separated into seven statistically significantly separate groups. The R statistic of the performed ANOSIM analysis has proven existence of divergence in floristic composition within the compared TWINSPAN groups at different levels of statistical significance (Table 1). The lowest recorded difference in floristic composition is between groups 000 and 001 for R = 0.2009 while the largest is between groups 000 and 111 for R = 0.8824.

Global $R_{ANOSIM} = 0.7233$ ($p = 0.0001$) also indicates a high level of floristic divergence during the simultaneous comparison of all seven TWINSPAN groups. While the value of $R > 0.75$ induces great differentiation among the compared groups, all the lower recorded values indicate medium or even lower degree of floristic divergence, clearly supporting the idea on presence of a completely transitory character of floristic matrix among these forest groups. The results of these analyses have shown that although there is a floristic discontinuity within the separate forest groups within both alliances, there is still no complete floristic divergence of forest stands (associations) between them.

Table 1. Results of ANOSIM analysis (One-way ANOSIM - pairwise test) of floristic composition, extracted by TWINSPAN into seven forest groups , with statistics of R and p values.

Groups	100	101	110	111	01	000	No
100	0						94
101	0.2922 **	0					151
110	0.5175 ***	0.3241***	0				183
111	0.6005 ***	0.3387***	0.2758**	0			196
01	0.7418 ***	0.4865***	0.6936***	0.6021***	0		71
000	0.8002***	0.6585***	0.8524***	**0.8824***	0.2189**	0	212
001	0.8517***	0.5646***	0.7442***	0.7993***	0.2307*	**0.2009***	105

(Level of significance: * p<005, ** p<0.01, *** p<0.001)

SIMPER procedure: The SIMPER analysis has shown the following relationships: Within the first 50% of cumulative contribution, the dissimilarity of flora of these seven groups includes 51 out of the total of 248 taxa, according to the order given in (Table 2). Within just the first 20.51% of cumulative contribution, the floristic dissimilarity among the studied taxa includes 13 taxa, mostly diagnostic species such as: *Fraxinus angustifolia*, *Amorpha fruticosa, Ajuga reptans* and *Lysimachia nummularia* (the left side of the classification diagram) and *Carpinus betulus*, *Quercus cerris*, *Tamus communis*, *Rubus caesius*, *Convallaria majalis* and *Ulmus carpinifolia* (the right side of the classification diagram), representing globally more hygrophilous vs. mesophilous habitats, respectively, as well as those under the constant influence of inundation vs. those without any influence of flood or stagnant surface water for the greatest part of the year.

The overall multi group average dissimilarity between all 7 compared forest types is 80.45%. This percentage also indicates a very high level of dissimilarity in floristic composition of individual plant types. The SIMPER analysis has shown that two groups (000 and 001), although with a high degree of homogenization, are actually the most similar, with overall average dissimilarity between these two groups of only 68.42 %. This dissimilarity is significantly greater (even from the total average for all groups), between the groups 000 and 111, which are also at diametrically opposite positions in the ordination correspondent space, with the value of 84.32%. Between these two groups, there are four species with abundance and cover value of already slightly more than 10% of cumulative contribution to total dissimilarity (the parentheses include two numbers: individual contribution (%) and cumulative contribution), in the following order: *Fraxinus angustifolia* (3.83%, 3.83%), *Carpinus betulus* (3.14%, 6.97%) *Quercus cerris* (2.63%, 9.60%) and *Amorpha fruticosa* (1.75%, 11.35%). The main dissimilarity between groups 000 and 001 pertains to the first six species with 10.14% of cumulative contribution: *Quercus cerris* (1.92%, 1.92%), *Ajuga reptans* (1.79%, 3.71%), *Tilia cordata* (1.71%, 5.42%), *Lysimachia nummularia* (1.66%, 7.08%), *Quercus robur* (1.57%, 8.65%) and *Tilia platyphyllos* (1.49%, 10.14%).

Floodplain forests of Posavina in a wider geographical context

Inventory of floras by plant taxonomists is a common practice throughout the world to have information about plants. A flora is a compiled checklist of plant species growing in any geographic area.Through this practice, valuable data is recorded which could be used as reference for future studies (Badshah *et al.,* 2013). The flora includes the number of species, while vegetation refers to their distribution and number of individuals and size of each of the relative importance (Ali, 2008). The distribution pattern of plant species diversity is synthetic reflection of all kinds of ecological gradients and patterns of biodiversity along environmental gradients is one of the basic isses in biodiversity research (Kratochwil, 1999; Sarwar & Qaiser, 2012).

If the forest associations studied in Posavina are compared to other regions in Balkans and Europe, many associations will be identical or very similar.

Quercus robur – *Fraxinus angustifolia* dominated forests (***Fraxino-Quercetum roboris*** Jov.51) are found on alluvial plain. This vegetation is to some extent azonal and its composition is therefore similar to that in other South European regions (Brullo & Spamponato, 1999; Pavlov & Dimitrov 2002; Vukelić & Baričević, 2004). The same association exists in special nature reserve Zasavica, as an important wetland in Serbia (Čavlović *et al*., 2012), while the similar association *Q. robur* - *Fraxinus angustifolia* subsp. *oxycarpa* was recorded in northwestern Thrace in Turkey, on nutrient-rich humid sites (Kavgaci *et al.*, 2010).

However, in Posavina area, in the smaller number of associations studied in this research, the dominant species was *F. angustifolia* while *Q. robur* is only co-dominant or completely missing. Instead its place in structure of this association is taken by *Alnus glutinosa*. *Alnus glutinosa-Fraxinus angustifolia* dominated forest is located in the most humid part of Posavina area dominated by *F. angustifolia*, but sites that are in depressions and flooded or even submerged throughout the year are dominated by *A.glutinosa*, which thrives best in such conditions (Kramer *et al.,* 2008; Douda *et al.,* 2009). Such associations in Posavina are remnants of former association with much wider distribution, which may be found in Central and Eastern Europe under the name *Leucojo-Frxinetum angustifolia* Glavač 1959. *alnetosum* Glavač 1959. Similar stands appear also in the Greek and Turkish parts of Thrace (Kavgaci *et al*., 2011). These forests are mixed with the swampy forest of the class *Alnetea glutinosae* and some authors classify them within this class (Glavač, 1959; Baričević, 1998; Brullo & Spampinato, 1999).

According to Baričević *et al*., 2009 identical monodominant forest of Pedunculate Oak *Genisto elata-Quercetum roboris* Horv.37 and Forest of Pedunculate Oak and Hornbeam *Carpino-Quercetum roboris* (Anic 1959) *emend* were also recorded in the wide area of Croatian Posavina. In the first community which resides on flood-plains, the presence of Pedunculate Oak as well as the majority of other species is conditioned by additional water influx by groundwater and flood, i.e. its distribution is not climatogenic. The second community is floristically similar to the climatogenic community of the Sessile Oak and Common Hornbeam (*Tipimedio-Carpinetum betuli* (Ht.1938) Borhidi 1963).

Croatian forest *Genisto elatae-Quercetum roboris aceretosum tatarici* is very similar to our Forest of Pedunculate Oak and Hornbeam with Field Maple and Tatar Maple. It is defined by microrelief, mother rock substrate and soil. While direct floods of river Sava were common, these areas were obligatorily flooded, even to the 2 m level of water. When these floods started to disappear, the terrain become less humid, cool and dry, and Tatar Maple *(Acer tataricum)*, well suited to this type of terrain, quickly appeared and spread (Vukelić & Barićević, 2004).

Table 2. SIMPER analysis based on TWINSPAN groups separated by Bray-Curtis index (overall average dissimilarity).

Taxon	A	B	C	000	001	01	100	101	110	111
Carpinus betulus L.	2.193	2.726	2.726	7.07	6.8	7.5	0.2	7.47	0.8	1.2
Fraxinus angustifolia Vahl.	1.971	2.45	5.176	0.0889	0	0.7	1.88	7.7	7.2	7.8
Quercus cerris L.	1.524	1.894	7.07	5.24	5.8	0.5	0	0	0.1	0.12
Amorpha fruticosa L.	1.41	1.753	8.823	1.24	1	1.67	5.25	3.8	6.8	3.56
Convallaria majalis L.	1.266	1.574	10.4	0.356	2.4	2.83	3.25	2.2	1.9	2.84
Crataegus oxyacantha L.	1.184	1.472	11.87	3.02	1	2	0	1.87	1.5	3.36
Quercus robur L. subsp.robur	1.075	1.336	13.2	6.78	5.23	8,17	7.13	5.82	3,7	4.2
Lysimachia nummularia L.	1.023	1.272	14.48	1.31	2.4	0	1.63	1.93	1.3	2.88
Tamus communis L.	1.023	1.271	15.75	2.2	1	0.833	1.38	2.27	2	1.28
Galium aparine L.	1.012	1.258	17.01	2.49	1.6	2.17	1.5	1	1.1	1.2
Rubus caesius L.	0.9904	1.231	18.24	1.09	3.6	4	2	1.8	1.7	1.88
Ulmus carpinifolia G. Suckow (b)	0.9453	1.175	19.41	1.4	0.6	0.5	1.63	1.27	1.2	1.76
Ajuga reptans L. subsp.	0.8824	1.097	**20.51**	1.62	1.6	1	0.625	1.8	1	0.2
Geum urbanum L.	0.833	1.035	21.54	0.244	0	0.5	3.75	1.33	1.2	0.96
Glechoma hederacea L.	0.8308	1.033	22.58	2.09	1	1	0.375	1.2	0	1.64
Galium palustre L.	0.8277	1.029	23.61	0.778	0.6	0	3.13	0.733	1.5	0.96
Lycopus europaeus L.	0.7819	0.972	24.58	1.31	0	1	1.5	0.733	1.3	0.56
Carex remota L.	0.7673	0.9538	25.53	0.578	3.8	1.33	3.13	0.333	0.8	0.16
Hedera helix L.	0.7542	0.9375	26.47	0.378	2.4	3.67	0	1.2	0.6	1.2
Rumex sanguineus L.	0.738	0.9174	27.39	1.53	2.2	3	0.5	0	0.6	0
Oenanthe fistulosa L.	0.7332	0.9114	28.3	0.0667	0	0	0	1.6	2.4	1.64
Poa trivialis L.	0.7055	0.8769	29.17	1.91	0	0	1	0.8	0	0
Carex vulpina L.	0.6826	0.8486	30.02	1.62	1.6	3.67	1.38	0.533	0.5	2.04
Brachypodium sylvaticum (Hudson) Beauv.	0.678	0.8428	30.87	0.867	2.2	2.67	2.25	0.533	1	1.32
Cornus sanguinea L.	0.6741	0.8379	31.7	1.18	2.4	0.833	0.25	0.667	0	1.12
Cornus mas L.	0.6716	0.8348	32.54	0.333	1.2	0.333	0.5	1.67	1.9	1.72
Veronica chamaedrys L.	0.6605	0.8211	33.36	0.756	2.4	0	0	1	1.5	1
Hypericum hirsutum L.	0.6598	0.8202	34.18	0.444	0	0	0	0.533	0.3	2.24
Acer campestre L. (b)	0.6584	0.8184	35	0.711	1.6	1.33	1.63	1.6	1.8	1.24
Carex sylvatica Hudson	0.6528	0.8115	35.81	0	0	0	0	0.733	1	2.08
Juncus effusus L.	0.6329	0.7867	36.6	1.31	1	0.5	0	1	0.7	0.72
Thymus glabrescens Willd. subsp. *Glabrescens*	0.629	0.7819	37.38	0.178	1	2.83	0.625	0	0	1.44
Crataegus monogyna Jacq.	0.6023	0.7487	38.13	0.422	0	0.333	1.25	1.27	2.1	1.48
Ranunculus repens L.	0.6009	0.7469	38.87	0.133	2.6	1.83	2.63	0.2	0.6	0.68
Fragaria vesca L.	0.5928	0.7369	39.61	0.289	0.6	0	0	0.933	0.5	1.84
Cardamine pratensis L.subsp. *pratensis*	0.5832	0.725	40.34	0.6	0.6	1	1.38	1	1	1.56
Acer tataricum L.	0.5807	0.7219	41.06	0.933	0.6	0	1.25	0	0.3	0.44
Ulmus effusa Willd. (c)	0.5666	0.7044	41.76	0.644	0.6	0.5	0	1.13	0.5	1.12
Taxon	**A**	**B**	**C**	**000**	**001**	**01**	**100**	**101**	**110**	**111**
Frangula alnus Miller	0.5455	0.6781	42.44	0.867	0	1	0.75	1.47	1.2	1.2
Vitis sylvestris C.C.Gmelin	0.5442	0.6765	43.12	0.0667	0	0	0	1.73	1.9	0.24
Poa nemoralis L.	0.5372	0.6678	43.78	0.422	1.2	2	0	0.6	0.3	1.4
Polygonum hydropiper L.	0.5297	0.6585	44.44	0.444	1	0	0.625	0.867	1.3	0.72
Pyrus pyraster Burgsd. (c)	0.5259	0.6537	45.1	0.4	0.6	0.333	0.75	2	2.1	0.52
Fraxinus pennsylvanica Marshall (b)	0.5254	0.6531	45.75	0.2	0.4	0.333	0	0.733	0.5	2.52
Mentha aquatica L.	0.5192	0.6453	46.4	0.778	0.6	0.833	0.75	0.533	0.8	0.52
Ranunculus polyanthemos L.	0.5191	0.6453	47.04	0.0667	0	0	1.38	0.267	2.2	0.92
Ranunculus acer L.	0.4955	0.6159	47.66	0	0	0	0	0.933	0.5	1.2
Prunus spinosa L.	0.4929	0.6127	48.27	0.222	0.6	0	0	0.667	2.1	0.48
Rosa arvensis Hudson	0.4849	0.6028	48.87	0.978	1	1.67	0	1	1.4	1.8
Festuca gigantea (L.) Vill.	0.479	0.5955	49.47	0.578	0	0	0	1	0	0.76
Asparagus tenuifolius Lam.	0.478	0.5942	50.06	0	0.3	0	0	0.267	0.4	0

Marks (b) and (c) next to the taxon names indicate that taxon belongs to second or third forest stratum, respectively. A = Average dissimilarity, B = [Contribution (%) = Av. Dissim. / SD (Av.Dissim.)] , C = Cumulative contribution (%).The columns marked with codes of determined twinspan groups from 000 to 111 include the average values of combined abundance and cover values for present taxa, consistent with the van der Marel scale

Forest of Pedunculate Oak, Hornbeam and Turkey Oak was also recorded within the forest complex of Croatian flood forests, especially in Posavina, which are known as *Carpino betuli - Quercetum roboris quercetosum cerris*. The driest sub-association was that of Pedunculate Oak – hornbeam forest, which was climate-induced. Of the 45 sample plots in our study, in 16 plots *Carpinus betulus* was dominant over Pedunculate Oak, which is a high number. Due to strong anthropogenous pressure on these forests by forestry management services, Pedunculate Oak become significantly more uncommon in the dominant stratum, and may occasionally dominate only the second level of association structure. These *Carpinus betulus*-dominated forests in the study area may be found in the drier parts of the Posavina region. *C. betulus* is less competitive on very moist to wet sites (Baričević, 1998; Kramer *et al*., 2008). Drier sites are covered by *C. betulus*-dominated forests Turner *et al*., 2004 obtained similar results in floodplain forests, finding that flood-tolerant and flood-intolerant species were grouped separately in floodplain forests.

Summarizing we can conclude the following:

- Using the quantitative classification method (TWINSPAN) and ordination technique (CA), the analyses presented in this article clerlay describe the distribution patern of flood forests in the study area.

- The TWINSPAN classification and ordination CA analysis have shown a clear differentiation of floristic composition within the studied forest area of Posavina, for two large groups of forest stands completely corresponding to alliances, and within them seven groups of oak forest associations corresponding to associations determined at national level.

- Despite different concepts used for establishing community types by either approach the obtainde results are rather similar. The rationality of TWINSPAN classification were well verified in this study. The results showed that each association group appeared within a limited range and had almost a clear border against other forest associations in the two-dimensional ordination biplot.

- The main differences among forest associations inside each alliance are not as prominent in changes in floristic composition as in the changes of quantitative relationship among the species (in their abundance and cover values) included in their composition, resulting in appearance of specific stands that are easily recognizable as different associations i.e. groups of ecological units.

- On the other hand if we compare forest groups (at the level of the alliance) determined by TWINSPAN: forest of Pedunculate Oak and Alder on one hand and forest of Pedunculate Oak and Hornbeam on the other hand, the results of all analyses clearly indicate that the main differences among them are not prominent only in changes of quantitative relationships among the species included in their composition, but also in the more significant changes in floristic composition of their species.

- According to SIMPER and ANOSIM analyses the greatest floristic discontinuity is between the associations of forest of Pedunculate Oak, Hornbeam and Turkey Oak and forest of Pedunculate Oak and Ash. This is indicated by quantitative indicators, with Bray-Curtis overall average dissimilarity of 84.32% between the two groups, while ANOSIM statistics is $R = 0.8824$; $p<0.001$.

- The lowest floristic dissimilarity was between the forest of Pedunculate Oak, Hornbeam and Turkey Oak and forest of Pedunculate Oak, Hornbeam and Turkey Oak with Lindens, where overall average dissimilarity is 68.84% and ANOSIM statistics is $R = 0.2009$; $p<0.01$.

- The greatest recorded species richness was in forest of Pedunculate Oak, Hornbeam and Turkey Oak (212 taxa), while the least number of taxa was present in the forest of Pedunculate Oak and Hornbeam (71 taxa).

- Althogh certain geographic peculiarities are evident, Posavina floodplain forests in Serbia generally show good agreement with analogous communities in neighbouring countries in the Balkan peninsula and Central Europe.

- The results of floristic studies in floodplain and periodically flooded forests in riparian area of river Sava obtained in this study are supposed to be use to determine, harmonize and direct the forms of forestry management used in renewal of these forests, particularly the threatened forests of Pedunculate Oak, according to their recent condition and floristic composition.

- The performed analyses additionally enable possible correction of the very old floristic characterization, where the list of recent floristic composition obtained in this study and degree of its differentiation would be incorporated into the foundations of forestry during their regular revision.

- Such revised foundations of forestry therefore have important implications for future studies that should be proposed to examine the management procedures of distinctive associating groups as given in this study, with respect to priority in conservation, ongoing active planning and ecological rehabilitation.

References

Ali, S.I. 2008. The significance of flora with special reference to Pakistan. *Pak. J. Bot*., 40(30): 967-971.

Badshah, L., F. Hussain and Z. Sher. 2013. Foristic inventory, ecological characteristics and biological spectrum of rangeland, District Tank,Pakistan. *Pak. J. Bot*., 45(4): 1159-1168.

Baričević, D. 1998. Ecological-Vegetational properties of Forest Žutica. *Glasmik za Šumarske Pokuse*, 35: 1-91.

Baričević, D., N. Pernar, J.Vukelić, S. Mikac and D. Bakšić. 2009. Floristic composition as an indicator of destabilisation of lowland forest ecosystems in Posavina. *Period. Biol*., 111(4): 443-451.

Bern convention. 1979. *Convention on the conservation of European wildlife and natural habitats*. Council of Europe, Bern/Berne.

Braun-Blanquet, J. 1964. *Pflanzensoziologie*. Grundzüge der Vegetationskunde. 3. Auflage. Springer, Wien – New York, 865. pp.

Breckle, S.W. 2002. *Walter's vegetation of the Earth.* The ecological system of the geo-biosphere. 4th edition. Springer Verlag, Berlin.

Brullo, S. and G. Spampinat. 1999. Syntaxonomy of hygrophilous woods of the *Alno-Quercion roboris*. *Ann. Bot.*, 57: 133-146.

Čavlović, D., D. Obratov-Petković, M. Ocokoljić and V.Đurđević. 2012. Climate change impact on wetland forest plants of Special Nature Reserve Zasavica. *Bulletin of the Faculty of Forestry* 105: 17-34.

Clarke, K.R. 1993. Non-parametric multivariate analysis of changes in community structure. *Aust. J. Ecol.*, 18: 117-143.

Davies, C.E. and D. Moss. 2002. EUNIS Habitat classification, February 2002 European Topic Centre on Nature Protection and Biodiversity. Paris.

Douda, J., K. Douda and J. Kochánková. 2009. Development of alder carr after abandonment of wet grasslands during the last 70 years. *Ann. For. Sci*., 66(7): 712-725.

Drescher, A. 2007. *Ulmenion* Oberd. 1953. In: *Die Wälder und Gebüsche Österreichs.* (Eds.): W. Willner & G. Grabherr. Elsevier Verlag, München, pp. 123-127.

Flora Europaea - on-line database. Royal Botanic Garden Edinburgh, Edinburgh – (http://rbg-web2.rbge.org.uk/FE/fe.html), seen: april 2011.

Ghulam, R.S. and M. Qaiser. 2012. Distribution pattern, ecology and endemism of family Crassulaceae in Pakistan and Kashmir. *Pak. J. Bot.,* 44(6): 2055-2061.

Glaeser, J. and H.Volk. 2009. The historical development of floodplain forests in Germany – a review. *Allgemaine Forsts - und Jagdzeitung*, 180: 140-151.

Glavač, V. 1959. O šumi poljskog jasena s kasnim drijemovcem. *Sumar. List*., 83: (1-3): 39-45.

Habitat Directiva. 1992. Council directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. - The Council of the European Communities-Brussels.

Hammer, O., D.A.T. Harper and P.D. Ryan. 2001. PAST: Paleontological statistics software package for education and data analysis. Palaeontologia Electronica 4(1): 9pp. http://palaeo-electronica.org/2001_1/past/issue1_01.htm

Hill, M.O. 1979. *DECORANA: A Fortran program for detrended correspondence analysis and reciprocal averaging*. Department of Ecology & Systematics, Cornell University Ithaca, New York

Hill, M.O. and H.G. 1980. Detrended correspondence analysis: an improved technique. *Vegetatio*, 42: 47-58.

Hill, M.O. and P.Šmilauer. 2005. TWINSPAN for Windows version 2.3. Centre for Ecology and Hydrology & University of South Bohemia, Huntingdon & České Budějovice.

Horner, G.J., P.J. Baker, R. Mac Nally, S.C. Cunningham, J.R. Thomson and F. Hamilton. 2010. Forest structure, habitat and carbon benefits from thinning floodplain forests: Managing early stand density makes a difference. *For. Ecol. Manag*., 259: 286-293.

Jović, N. and M. Knežević. 1986. Zemljišta u šumama Ravnog Srema. *Zemljište i biljka*, 35(1): 87-92.

Jurišić, B., D. Obratov-Petković, I. Bjedov, N. Bojat and V. Stevanović. 2011. Phytogeographical analysis of vascular flora of ravni Srem flood forests (Vojvodina, Serbia). *Bulletin of the Faculty of Forestry,* 104: 41-56.

Kavgaci, A., A. Čarni, B. Tecimen and G. Özalp. 2010. Diversity and Ecological Differantiation of Oak Forests in NW Thrace (Turkey). *Arch. Biol. Sci*., 62(3): 705-718.

Kavgaci, A., A. Čarni, B. Tecimen and G. Özalp. 2011. Diversity of floodplain forests in the Igneada region (Turkey). *Hacquetia*, 0/1 :73-93

Klimo, E. and H. Hager. 2001. *The floodplain forests in the Europe, Current situation and perspective*, (Eds.), *Eur. For. Inst. Res. Rep*., 10, 268.

Kramer, K., S.J. Vreugdenhil, J. Stefan and D.C. van der Werf. 2008. Effect of flooding on recruitment, damage and mortality of riparian tree species: A field and simulation study on the Rhine floodplain. *For. Ecol. Manag.*, 255: 3893-3903.

Kratochwil, A. 1999. Biodiversity in ecosystems: Some principles. In: *Biodiversity in ecosystems*. (Ed.): A. Kratochil. Dordrecht: Kluwer Academic Publishers. pp. 5-38.

Lakušić, D., J. Blaženčić, V. Ranđelović, B. Butorac, S. Vukojičić, B. Zlatković, S. Jovanović, J. Šinžar-Sekulić, D. Žukovec, I. Ćalić and D. Pavićević. 2005. Staništa Srbije – Priručnik sa opisima i osnovnim podacima. In: (Ed.): D. Lakušić, *Staništa Srbije,* Institut za Botaniku i Botanička Bašta "Jevremovac ", Biološki fakultet, Univerzitet u Beogradu

Lepš, J. and P. Šmilauer. 2003. Multivariate analysis of Ecological data using *CANOCO*. Cambridge University Press, Cambridge.

Machar, I. 2008. Historical development of floddplain forest in the upper Moravian Vale (Vrapč National Nature Reserve Czech Republic). *J. For. Sci*., 54(9): 426-437.

Mitch, B. and J.G. Gosselink. 1983. *Wetlands.* (Eds. 3.) John Wiley & Sons, Inc., New York.

Nillson, C. 1992. Conservation management of riparian communities. In: *Ecological principles of nature conservation*, (Ed.): L. Hannson, Elsevier Applied Science, London, pp. 352-372.

Paal, J., R. Rannik, E.M. Jeletsky and N. Prieditis. 2007. Floodplain forests in Estonia: Typological diversity and growth conditions. *Folia Geobot*., 42: 383-400.

Pavlov, D. and M. Dimitrov. 2002. A syntaxonomi analysis of the floodplain forests in the maintained reserves "Dolna Topchiya" and "Balabana". Hayka ГОРОТА. *Forest Sci*., 1: 3-19.

Prax, A., W. Richter, J. Cermak and V. Hybler. 2008. The hydrological and moisture regime of soils in floodplain forests. In: *Floodplain forests of the temperate zone of Europe*. (Eds.): E. Klimo, H. Hager, S. Matić, I. Anić and J. Kulhavy. Lesnická práce, Kostelec nad Cernými lesi, pp. 75-10.

Sarić, M. 1992. (Ed) *Flora SR Srbije 10*. (The flora of Serbia 10), Serbian Academy of Sciensis and Art, Belgrade, Serbia.

Schnitzler, A., B.W. Hale and E. Alsum. 2005. Biodiversity of Floodplain forests in Europe and eastern North America: A comparative study of the Rhine and Mississipi Valleys. *Biodivers. Conserv*., 14: 97-117.

Sperduto, D.D. and W.F. Nichols. 2004. *Natural Communities of New Hampshire*. The NH Natural Heritage Bureau and The Nature Conservancy.

Štirba, O., B. Prpić and H. Killian. 2008. History of the relationship between man and European floodplain forests. In: *Floodplain forests of the temperate zone of Europe*. (Eds.): E. Klimo, H. Hager, S. Matić, I. Anić and J. Kulhavy, Lesnická práce, Kostelec nad Cernými lesi, pp. 39-74.

ter Braak, C.J.F. and P. Šmilauer. 2002. *CANOCO* reference manual and canodraw for windows user's guide: software for canonical community ordination (version 4.5). Microcomputer Power Ithaca, NY, USA

Tockner, K. and J.A. Standford. 2002. Riverine flood plains: present state and future trends. ***Environ.** Conserv*., 29: 308-330.

Turner, M.G., S.E. Gergel, M.D. Dixon and J.R. Miller. 2004. Distribution and abundance of trees in floodplain forests of the Wisconsin River: Environmental influences at different scales. ***J. Veg.** Sci*., 15(6): 729-738.

Vukelić, J. and D. Baričević. 2004. *The association of spreading elm and narrow-leave ash* (*Fraxino- Ulmetum effusae* Slav. 1952) *in floodplain forest of Podravina and Podunavlje*. Hacquetia forest of Podravina and Podunavlje. Hacquetia.

Wallnöfer, S. 2009. A new *Alnion incanae* association of the Inner Italian Alps: *Hedero helicis-Alnetum glutinosae. Phyton* (Austria) 49: 9-23.

Ward, J.V., K. Tockner and F. Schiemer. 1999. Biodiversity of floodplain river ecosystems: ecotones and ecotones and connectivity. ***Regul.** River*. 15: 125-139.

Wenger, E.L., A. Zinke and K.A. Gutzweiler.1990. Present situation of the European floodplain forests. ***For. Ecol.** Manag*., 33/34: 5-12.

Westhoff, V. and E. van der Maarel. 1973. The Braun-Blanquet approach. In: *Ordination and classification of* ***Communities.*** (Eds.): R.H. Whittaker. Handbook of Vegetation Science 5. The Haque, pp. 619-726.

Willner, W. 2007. *Carpinion betuli* Issler 1931. In: Willner, W. And G. Grabherr. (Eds.), *Die Wälder und Gebüsche* ***Österreichs.*** Elsevier Verlag. München, 137-144.

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