Arch. Biol. Sci., Belgrade, 63 (3), 811-817, 2011 DOI:10.2298/ABS1103811G

PHYTOCOENOLOGICAL CHARACTERISTICS IN POPLAR PLANTATIONS IN THE PROTECTED REGION OF THE CENTRAL DANUBE BASIN

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Abstract - Following the water regulation along the Danube river, the area of natural forests decreases and the vegetation is fragmented. The goal of the study was to survey the recent phytocenological characteristics of the region of the protected floodplain outside the dam. We surveyed three site types in poplar plantations near Novi Sad. In the poplar plantations phytocoenological relevés were made. The elevation of the study plantations is between 75 and 76 m a.s.l. The most represented species on the ground layer are the species *Dactylis glomerata, Urtica dioica* and *Rubus caesius* identified on the humofluvisol. The most represented species on the sandy part of the fluvisol were *Rubus caesius, Solidago serotina, Dactylis glomerata* and *Equisetum arvense.* The loamy form of *fluvisol* occurs at an elevation of 75.50 m. The most numerous species on the loamy form of the fluvisol in the flooded region were *Rubus caesius, Solidago serotina, Polygonum hydropiper, Dactylis glomerata* and *Urtica dioica*. Based on the above data, we determined the differences between ground vegetation in the study areas and in the part of the alluvial plain affected by additional moisture by both floodwater and ground water.

Key words: Phytocoenological characteristics, poplar, Danube, protected floodplain

UDC 630.18(282.243.7)(497.11)

INTRODUCTION

The Central Danube Basin is situated in the zone of temperate continental climate which determines the type of vegetation. The forest sites in the conditions of semiarid to arid climate grow only in the inundations of lowland rivers. The semi-natural wetlands are limited to a small area along the lowland rivers after water regulation (Schweitzer 2003). The inundation area can be divided into two parts with dikes: the more or less regularly inundated flood plain and the protected flood plain outside the dike (Makra and Zalatnai 2006). Patches of the original vegetation become smaller and more isolated due to river control and intensive land use. There are no sites in the floodplain which remain completely in its natural state. The manifold exchange processes that occur between land surface and atmosphere are largely determined through the vegetation that dynamically responds to atmospheric conditions such as humidity, temperature (Hank and Mauser 2009) and additional moisture of underground waters.

For this reason, special attention should be focused to the protected part of the alluvial plain because of the absence of flooding. The consequence is the changed direction of the pedogenetic process compared to the part of the alluvial plain affected by flooding. The differences are seen in the vegetation type compared to the part of the alluvial plain influenced by additional moisture and flood and underground waters. This paper presents the study of ecological conditions in the protected part of the Central Danube Basin alluvial plain.

MATERIAL AND METHODS

The study sample plots are situated in the protected part of the alluvial plain near Novi Sad in three poplar plantationts. In test plantations, phytocoenological research was based on the combined Braun-Blanquet's method (1964) with the values for abundance and sociability. Comparison was made with the phytocoenological characteristics in the flooded region of the Central Danube Basin.

Depending on the micro-relief conditions, soil profiles were opened for the study of soil morphology and soil samples were taken for laboratory analysis. Particle size composition (%) was determined by the international B-pipette method, prepared in sodium pyrophosphate (Group of authors, 1997). Soil particle classification was based on Atterberg's classification. Water retentions at $Rv_{0.1\ b}$ and $Rv_{0.33b}$ (% mass) were determined in a Pressure plate extractor (Richards, 1947), and water retention $Rv_{6.25b}$ (% mass) was determined by Richards pressure membrane and differential mercury regulator (Richards, 1947). The available water capacity (Kvk) (% mass) was calculated as the difference between $Rv_{0.33b}$ and $Rv_{6.25b}$ by the formula:

$$Kvk = Rv_{0.33b} - Rv_{6.25b},$$

Total porosity (P) was calculated from soil specific gravity and soil density by the formula:

$$P= ((Sp - Sv) \times 100) / (Sp)$$

Air capacity (Ka) was calculated as the difference between total porosity (P) and water retention $Rv_{0.33b}$ by the formula:

$$Ka = P - Rv_{0.33b} \text{ (\% mass)}.$$

RESULTS AND DISCUSSION

Climate characteristics

Multi annual averages of temperature and precipitation indicate that during the vegetative growth period the prevailing character is semiarid. The average value of the climate characteristics (air temperature, precipitation) is reduced by extremely cold days in winter months, as well as by a greater number of cloudy and rainy days during summer months. Exceptional aridity occurs during July and August. This characteristic is also indicated by the number of tropical days (29) during the growth period. A special characteristic of climate factors is that during the vegetative growth period, especially in July and August, the monthly average is achieved in two to three days while periods without rainfall can be longer than two months. However, in the protected part, there is no flooding and additional moisture is provided only by ground water which determines the occurrence of the particular vegetation type.

Soil Properties

Classification of systematic soil units is based on the Soil Classification of Yugoslavia (Škorić et al., 1985). According to the Classification, the two designated soil types are humofluvisol and fluvisol. The forms of fluvisol are classified based on the particle size composition of the soil.

Fluvisol is mostly formed in the riparian genetic part of the alluvial plain, characterized by sudden changes of the micro relief. The marked micro relief is the consequence of the changes in the intensity of the river competence. This causes a great variability of soil properties, especially the textural composition, and the water and air regimes of the soils (Živanov and Ivanišević, 1986, Galić, 2006; 2008). The properties of humofluvisol are spatially variable, but less so than fluvisol (Živanov and Ivanišević 1986, Ivanišević et al. 1999, Galić et al. 2006). Potential productivity of this soil type is very high, depending on the particle size composition, the percentage of humus and groundwater level.

The dominant fraction in humofluvisol (profile 1) is silt, ranging between 43.4 and 58.0 %, average 51.9 %. The most significant fraction silt+clay ranges

Table 1. Particle size composition of the soil in the study systematic soil units

Horizon	Depth	Particle size composition %						Textural class
		Coarse sand	Fine sand	Silt	Clay	Total sand	Total clay	
		> 0.2	0.2 – 0.02	0.02 - 0.002	< 0.002	> 0.02	< 0.02	
	Cm	mm	mm	mm	mm	mm	mm	
1	2	3	4	5	6	7	8	9
Sample plot on humofluvisol- Profile no. 1								
A_a	0-45	3.3	17.3	58.0	21.4	20.6	79.4	silty loam
C	45-85	0.4	29.0	54.4	16.2	29.4	70.6	silty loam
G_{so}	85-150	11.1	30.7	43.4	14.8	41.8	51.2	Loam
Average	0-150	4.9	25.7	51.9	17.5	30.6	69.4	
Sample plot sandy fluvisol – Profile no. 2								
A_{mo}	0-30	3.1	62.8	30.7	3.4	65.9	34.1	sandy loam
I	30-80	0.8	82.0	16.0	1.2	82.8	17.2	loamy sand
II G_{so}	80-140	1.3	72.2	19.5	7.0	73.5	26.5	sandy loam
III G_{so}	140-225	1.8	90.8	1.2	6.2	92.6	7.4	Sand
Average	0-225	1.8	77.0	16.9	4.3	78.8	21.2	
Sample plot loamy fluvisol - Profile no. 3								
A_{mo}	0-40	2.8	32.8	47.3	17.1	35.6	64.4	Loam
I G_{so}	40-75	0.4	57.1	28.8	13.7	57.5	42.5	Sandy loam
II G_{so}	75-180	1.2	86.2	9.3	3.3	87.4	12.6	Loamy sand
Average	0-180	1.5	58.7	28.5	11.3	60.2	39.8	

from 51.2 to 79.4 % (with an average of 69.4 %). The high content of silt + clay fraction, taking into account the relation between volume and this fraction (Živanov, 1977), had a negative effect on the yield of the study plantation. This is especially intensified by the high content of silt, as silt results in soil compactness and poor aeration.

In the group of fluvisol profiles (profiles 2 and 3), the dominant fraction is fine sand. The average content of this fraction in the sandy form (profile 2) is 77.0 %, and in the loamy form (profile 3) it is 58.7%. The content of the fine sand fraction increases regularly with depth in the loamy form. This shows that the process of fluvial sedimentation here is very similar to that in humofluvisol.

Regarding the silt + clay fraction, fluvisols differ significantly at the level of the forms. The sandy form of fluvisol contains on the average 21.2% and the loamy form contains 39.8% (Table 1). T This property could have an adverse effect on the water and air properties of loamy fluvisol.

The percentage of readily available water in humofluvisol was between 16.14% and 21.83%, average 18.64% (table 2). In the sandy fluvisol, the content of readily available water ranged from 3.39% to 12.17% (with an average of 6.94%), while in the loamy fluvisol, it was from 4.19% to 13.95% (average 10.51%).

The content of soil air, in addition to the content of readily available water, is a very important factor in vegetation management. The average air capacity in humofluvisol is 15.73 % and in fluvisol it is 33.42 % (Table 2). This indicates that the average air capacity in fluvisol is twice as high than that in humofluvisol. In fluvisol, the air capacity is 28.00% in the loamy form (profile 3) and 38.85% in the sandy form (profile 2).

During the vegetative growth period, the level of ground water was the closest to the surface in humofluvisol (ground water level ranged from 70 to 180 cm). The physiologically active depth of this profile is 150 cm, meaning that the level of ground water was below this depth only in September.

Table 2. Water and air properties of the soil

Horizon	Depth	Coarse pores	Medium pores	Fine pores	Air capacity	Readily available water 0.33 – 6.25 bar
	Cm	%	%	%	%	%
1	2	3	4	5	6	7
Sample plot on humofluvisol – profile no. 1						
A_a	0-45	13.08	0.91	16.14	13.99	16.14
C	45-85	9.25	0.05	21.83	9.30	21.83
G_{so}	85-150	20.01	3.89	17.96	23.90	17.96
Average	0-150	14.11	1.62	18.64	15.73	18.64
Sample plots on sandy fluvisol – profile no. 2						
A_{mo}	0-30	21.89	7.19	12.17	29.08	12.17
I	30-80	29.99	13.02	6.57	43.01	6.57
II G_{so}	80-140	25.8	11.15	5.66	36.95	5.66
III G_{so}	140-225	35.81	10.57	3.39	46.38	3.39
Average	0-225	28.37	10.48	6.94	38.85	6.94
Sample plots on loamy fluvisol – profile no. 3						
A_{mo}	0-40	18.66	1.09	13.38	19.75	13.38
I G_{so}	40-75	17.07	4.26	13.95	21.33	13.95
II G_{so}	75-180	28.97	13.97	4.19	42.94	4.19
Average	0-180	21.56	6.44	10.51	28.00	10.51

Phytocoenological characteristics

The alluvial plains of lowland rivers with poplar and willow are classified in the alliance *Salicion albae* (Soo). In the alliance *Salicion albae,* the distribution and development of poplar and willow communities are conditioned by permanent moisture by floodwater, i.e. by additional moisture by ground water. The differentiation of associations within the alliance *Salicion albae* is conditioned by the type of moisture. The differentiation of the associations within the alliance due to moisture change in the flooded part of the Danube basin was studied by Wandelberger-Zelinka (1952), Oberdorfer (1953), Toth (1958), Jurko (1958), Paskalovski-Leandru (1958). In the study region, the following tree and shrub species occur in the alliance *Salicion albae* after Tomić (1992): *Populus nigra*, *Populus alba*, *Salix fragilis*, *Ulmus effusa*, *Ulmus minor*, *Fraxinus angustifolia*, *Frangula alnus*, *Viburnum opulus*, *Cornus sanguinea*, *Crategus nigra*, *Crategus oxycantha*, *Rubus caesius*, *Amorpha fruticosa,* etc. The same author reported that hygrophytes are prevalent among the herbaceous plants, e.g.: *Iris pseudoacorus*, *Agrostis alba*, *Lycopus europaeus*, *Lysimachia vulgaris*, *Lysimachia nummularia*, *Ranunculus repens*, *Polygonum spp.*, *Aristolochia clematitis,* and others.

Natural stands of flooded soft broadleaves which developed in the area are today mostly substituted by plantations of Euramerican poplar. The cultivation technology of black poplar clones requires the application of agro engineering measures. Šafar (1963) has reported on the differences in composition of ground flora between poplar plantations and natural stands that were due to the application of agro engineering measures.

The areas on which the plantations were established were flooded until 1928. After the construction of levees to protect from Danube flooding, the areas received additional moisture from ground water. The elevation of the study plantations is between 75 and 76 m a.s.l. The plantation on *humofluvisol* is at the lowest elevation. The average duration of floods in this area of the Central Danube Basin is about 73 days. The observed vegetation types are *Salicetum albae Myosotidetosum palusthrees* var. *Agrostis alba*

Table 3. Phytocoenological relevés in the study plantations

Soil type	Humofluvisol	
Phytocoenological relevé no.	1	2
Plant name	Abundance and sociability	
Dactylis glomerata	3.3	2.2
Urtica dioica	2.2	3.3
Rubus caesius	2.2	2.2
Stanactys annua	1.1	
Verbrena officinalis	1.1	+.1
Amaranthus retroflexus	1.1	
Lamium purpureum	1.1	+.1
Erygeron canadensis	1.1	
Ascelpias syriaca	1.1	
poplar seedlings	1.1	+.1
Amorpha fruticosa	+.1	+.1
Galium cruciata	+.1	1.1
Equisetum arvense	+.1	
Sambucus ebulus	+.1	+
Alopecurus pratensis	+.1	+.1
Potentilla recta	+.1	
Chelidonium majus	+.1	
Mentha arvensis	+.1	
Lycopus europeus	+.1	+.1
Polygonum hydropiper	+.1	
Eupatorium cannabinum	+.1	
Glechoma hederacea	+.1	
Rumex acetosa	+	
Erigeron canadensis	+	
Cychorum intibis	+	
Daucus carota	+	
Chaerophyllum temulum	+	
Rosa canina	+	+
Lythrum salicaria	+	
Articum lappa	+	
Achilea millefolium	+	
Agrimonia eupatoria	+	+
Syphytum officinalis		+.1
Prunella vulgaris		+

Soil type	*Fluvisol* f. *sandy*	
Phytocoenological relevé no.	1	2
Plant name	Abundance and sociability	
Rubus caesius*	1.1	1.1
Solidago serotina	1.1	1.1
Polygonum hydropiper	1.1	1.1
Dactylis glomerata	1.1	1.1
Equisetum arvense	1.1	+.1
Erygeron canadensis	+.1	+
Galium album	+.1	+
Stellaria graminea	+.1	+
Melica transsilvanica	+.1	+

Soil type	*Fluvisol* f. *loamy*	
phytocoenological relevé no.	1	2
Plant name	Abundance and sociability	
Rubus caesius*	1.1	3.3
Solidago serotina	1.1	2.2
Polygonum hydropiper*	1.1	+
Dactylis glomerata	1.1	1.1
Urtica dioica	1.1	1.1
Stellaria graminea	1.1	1.1
Equisetum arvense	1.1	+
Erygeron canadensis	+.1	+
Galium album	+	1.1
Tussilago farfara		1.1
Melica transsilvanica	+	
Conium maculatum	+	
Articum lappa	+	
Rosa canina	+	
poplar seedlings	+	+
Achilea milefolium		+
Symphytum officinalis		+

*denotes the species characteristic for phytocoenological characteristics in flooded region of the Central Danube Basin (Herpka, 1979)

with *Polygonum hydropiper* (Herpka, 1979). The most represented species in the ground layer in the flooded region are *Agrostis alba*, *Polygonum hydropiper*, *Myosotis palusthrees* and *Solanum dulcamara*. Based on the above observations, the species *Dactylis glomerata, Urtica dioica* and *Rubus caesius* identified on *humofluvisol*, are the consequence of the absence of flooding in this area (Table 3).

The sandy form of *fluvisol* occurs at the highest elevation. The average flood duration in the flooded part of the Central Danube Basin alluvial plain is about 43 days. Based on the ground vegetation, this area is classified according to the vegetation type *Salicetum albae Rubetosum caesii* var. *typicum* (Herpka, 1979). The most represented species are *Rubus caesius*. *Rubus caesius, Solidago serotina, Dactylis glomerata* and *Equisetum arvense* were identified in the study area (Table 4). The *loamy* form of *fluvisol* occurs at an elevation of 75.50 m, which means that the average flood duration in the flooded part of the Danube Basin lasts about 60 days. Based on the ground vegetation, this area is classified according to the vegetation type *Salicetum albae Rubetosum caesii* var. *Polygonum hydropiper* (Herpka, 1979). The most represented species in the ground layer are *Rubus caesius* and *Polygonum hydropiper*. Depending on the above characteristics, the following species are the most numerous on the *loamy* form of *fluvisol* in the flooded region: *Rubus caesius, Polygonum hydropiper, Solidago serotina, Dactylis glomerata* and *Urtica dioica*.

Based on the above data, we determined the differences between ground vegetation in the study areas and in the part of the alluvial plain affected by additional moisture by both floodwater and ground water.

CONCLUSION

Multiannual averages of temperature and precipitation indicate that during the vegetative growth period the prevailing character is semiarid. In the protected part there is no flooding and the additional moisture is provided only by ground water which determines the occurrence of the particular vegetation type.

During the vegetative growth period, the level of ground water was the closest to the surface in humofluvisol. The physiologically active depth of this profile is 150 cm, meaning that the level of ground water was below this depth only in September.

The elevation of the study plantations is between 75 and 76 m a.s.l. The plantation on humofluvisol is at the lowest elevation. The average duration of floods in this area of the flooded region of the Central Danube Basin is about 73 days, which classifies this area according to the vegetation type *Salicetum albae Myosotidetosum palusthrees* var. *Agrostis alba* with *Polygonum hydropiper* (Herpka, 1979). The most represented species in the ground layer in the flooded region are *Agrostis alba*, *Polygonum hydropiper*, *Myosotis palusthrees* and *Solanum dulcamara*. Based on the above observations, the species *Dactylis glomerata, Urtica dioica* and *Rubus caesius* identified on humofluvisol are the consequence of the absence of flooding in this area.

The sandy form of fluvisol occurs at the highest elevation. The average flood duration in the flooded part of the Central Danube Basin alluvial plain is about 43 days. Based on the ground vegetation, this area is classified according to the vegetation type *Salicetum albae Rubetosum caesii* var. *typicum* (Herpka, 1979). The most represented species are *Rubus caesius*. *Rubus caesius, Solidago serotina, Dactylis glomerata* and *Equisetum arvense*.

The loamy form of fluvisol occurs at an elevation of 75.50 m, suggesting that the average flood duration in the flooded part of the Danube Basin is about 60 days. Based on the ground vegetation, this area is classified according to the vegetation type *Salicetum albae Rubetosum caesii* var. *Polygonum hydropiper* (Herpka, 1979). The most represented species in the ground layer are *Rubus caesius* and *Polygonum hydropiper*. Depending on the above characteristics, the following species are most numerous on the loamy form of fluvisol in the flooded region: *Rubus caesius, Polygonum hydropiper, Solidago serotina, Dactylis glomerata* and *Urtica dioica*.

Based on the above data, we determined the differences between ground vegetation in the study areas and in the part of the alluvial plain affected by additional moisture by both floodwater and ground water.

Acknowledgment - This study is results of project III 43002 financed by the Ministry of Education and Science of the Republic of Serbia.

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