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STRUCTURE ANALYSIS, DYNAMICS AND PROPOSED MANAGEMENT MEASURES OF THE RIPARIAN FOREST OF RICHIOS RIVER PROTECTED AREA N. GREECE

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Abstract

The aim of this research is to study the structure and dynamics of the riparian forest which is found in Richios river. It is a river of small length in northern Greece but with great ecological and functional significance for wetland ecosystems of the wider protected area of Lakes Koronia, Volvi and Redina's Gorge. The research area listed in the European ecological network Natura 2000, with code GR1220009 as SPA and GR1220003 as SCI.

The Richios riparian forest consists of Platanus orientalis pure stands and mixed stands of Platanus orientalis, Polulus alba, Salix alba and Ulmus minor. The structure of the Richios riparian forest consists of two different stand types, pure and mixed. In the mixed type we can distinguish two trends of the riparian forest dynamics or two succession stages, a mixed softwood riparian forest and its conversion to a hardwood riparian forest.

The study of different types of structure of the riparian forest aims in addition to identify the current situation of potential problems, to study the forest dynamics of it and to propose management treatment.

Key words: *riparian forest, structure, dynamic, management measures, Richios river*

1. INTRODUCTION

Riparian forests are ecosystems of great value because of their high biodiversity. Riparian forests play multiple functional roles affecting water quality, as aquatic and terrestrial biodiversity, among others (Fierke, et al. 2005). These forests are degraded due to severe pressure from human activities. In recent decades efforts have been made at European and global level, for the protection, conservation and restoration of riparian ecosystems and therefore of riparian forests. Also our country follows this scientific trend with several examples throughout Greece, most important of them are Volvi lake, Nestos delta, Agras wetland etc. About the evaluation of a riparian forest it is needed to study its structure in order to record the existing situation, identify the problems, pressures and propose appropriate management measures (Efthimiou 2000).

The term forest structure includes species composition, their distribution in different tree layers, diameter and height distribution (Hedman & Van Lear 1995). According to Prichard et al. (1998), the riparian tree age structure is one measure of ecological health used by land managers to access impacts from livestock grazing (Stromberg 2002). Consequently, the structure analysis of a riparian forest is the basic tool for the rational and ecological management.

Depending on their species composition, structure, dynamics and ecological conditions of the riparian forests are distinguished in softwood and hardwood forests (Yon 1980; Mayer 1984; Dister 1988; Wenger et al 1990; Kuhn 1991). Lack of management of wetland ecosystems during the last century led to degradation, shrinking and often disappearance of riparian forests. A common process worldwide that is well established in the relevant literature; most form being the conversion to agricultural land (Schoenholtz et al. 2001; Hamberry et al. 2012). The dynamic of many riparian tree species are influenced by flood disturbance (Duncan 1993; Sakai et al. 1999; Stromberg 2002).

Rendina's Gorge or Macedonian Tempi in northern Greece is an area of rare natural beauty, protected by national legislation and international conventions related to the avifauna, ecology and biodiversity. This area belongs to the National Park of Koronia-Volvi and Macedonian Tempi, as endorsed by State

Law 248/D/5_3_2004, which in turn belongs to the Ramsar networks and NATURA 2000 network and is in an area of refuge wildlife. It is managed by the Management Body of National Park Koronia-Volvi and Macedonian Tempi which aimed at restoring, improving and perpetual protection and preservation of Richios River which is the natural extractor of lakes Koronia and Volvi and ensures communication with the sea and the "specially protected Mediterranean region" and high aesthetic value riparian forest.

1.1. Study area

Richios river was chosen as the research area. Richios flows from Rendina village and after crossing the valley between the mountains Kerdylio and Stratoniko (Map 1 & Map 2), forms the "Macedonian Tempi" and flows into the Strymonikos gulf between the villages of Stavros and Asprovalta. The ancient Via Egnatia were going through the valley of Richios, which indicates the importance of the region since ancient times and leads to the Castle of Rentina.

The study areas is a protected area of Natura 2000 network with two codes, GR1220003 as CSI area and GR1220009 as SPA (http://natura2000.eea.europa.eu/#).

The riparian forest vegetation of Richios is rich and consists of *Platanus orientalis*, *Populus alba*, *Salix alba*, *Ulmus minor*, *Juglans regia*, *Cornus sp*., While in the area found *Tilia sp*., *Fraxinus sp*., *Carpinus orientalis* and *Ostrya carpinifollia*. In understorey *Vitex agnus-castus Nerium oleander*, *Ruscus spp* and *Phragmites australis*, *Pteridium aquilinum* and *Rubus sp.* dominate. The presence of climbing plants, *Hedera helix*, *Clematis vitalba*, *Humulus lupulus*, is very impressive.

Concerning the fauna of Richios there are no references of bibliography. In the region of the neighboring lakes Volvi and Koronia recorded 248 species of birds, a figure equal to 58% of the total of Greece, of which 106 nest in the area. Indicative species of fish recorded in Richios are: *Chelon labrosus*, *Rhodeus amarus* and *Leuciscus cephalus*. (Koutrakis et al. 2000).

Richios river has flow of 0.8 m^3/sec and the water temperature ranges from 7.9°C - 29.4°C. (Koutrakis et al. 2003; Tzimopoulos et al. 2005) and it is part of the basin of an ancient lake Mygdonia (Efthimiou et al. 2014).

Map 1. Sample plots (PL1, PL2 & PL3) (Google Map Data)

Map 2. Study area

2. MATERIALS AND METHODS

In order to study the structure of the riparian forest of the low-water river, three representative sample plots were established, 0.2 Ha in size. (Map 1). In each sample plot, diameter at breast height (Dbh), total tree height, and height to the crown base (HCB) of all trees with a diameter greater than 4 cm, were measured. Then, from the field data we estimated crown length (total tree height – height to the crown base), crown ratio (crown length / total tree height), slenderness index (total tree height /

diameter at breast height), and the dominant height (mean height of the tallest 100 trees per hectare). The measurements were made in spring 2015.

Additionally, all trees were classified according to the IUFRO classification system. The method of Leibundgut is now widely used and is known as the IUFRO classification system (Dafis 1966, 1989; Smiris 1987; Dister & Drescher 1987; Efthimiou 2012). The statistical analysis was carried out by the use of SPSS (v. 21.0).

3. RESULTS

Three different stand types form the specific riparian forest (Map 1):

a) *Pure stand of Platanus orientalis (PL2),*

b) *Mixed stand Platanus orientalis – Ulmus minor – Populus alba (PL1)* and

c) *Mixed stand Platanus orientalis – Populus alba – Salix alba (PL3).*

3.1 Pure stand of Platanus orientalis

The structure is an irregular even-aged because the stand originated from stump – sprouts. It's an old coppice stand which is suffered by the irregular cuttings.

It's a two-storied stand with mean Dbh = 64.5 cm in the upper storey and 46.9 cm in the middle storey (Table 1; Figures 1 & 2). The H_{dom} is 23.75 m. Diameter ranges from 30 cm to 100 and height ranges between 10m and 33m.

Table 1. Stand parameter statistics of *Platanus orientalis* pure stand.

Stand parameter	***Upper storey***	***Middle storey***	***Total***
Dbh (cm) [1]	65.32	47.3	58.9
Dbh [min – max]	30 - 100	33 - 68	30 - 100
H (m) [2]	21.7	13.1	18.7
H [min – max]	16 - 33	10 - 15	10 - 33
Slenderness Index (H/D) [3]	34	29	32
CR (%) [4]	60	46	55
Total G (m^2/Ha) [5]	54.9005	15.4166	70.3172
N/Ha [6]	160	85	245
H_{dom} (m) [7]			23.75

[1] Dbh = diameter at breast height, [2] H = total tree height, [3] Slenderness Index (H/D) = total tree height / diameter at breast height, [4] CR (%) = crown ratio = crown length / total tree height, [5] basal area, [6] number of trees per hectare, [7] mean height of the 100 tallest trees per hectare

The 78% of the total basal area produced from the upper storey. The stand density is 245 trees per hectare (N/Ha) (160 trees/Ha in the upper – storey). The mean slenderness index (H/D) is 32 (34 for the upper storey and 28 for the middle storey). The 65.31% of the trees (81.25% in the upper storey) belong to the long Crown Length Class (tree crown length is greater than 0.5 of the total tree height).

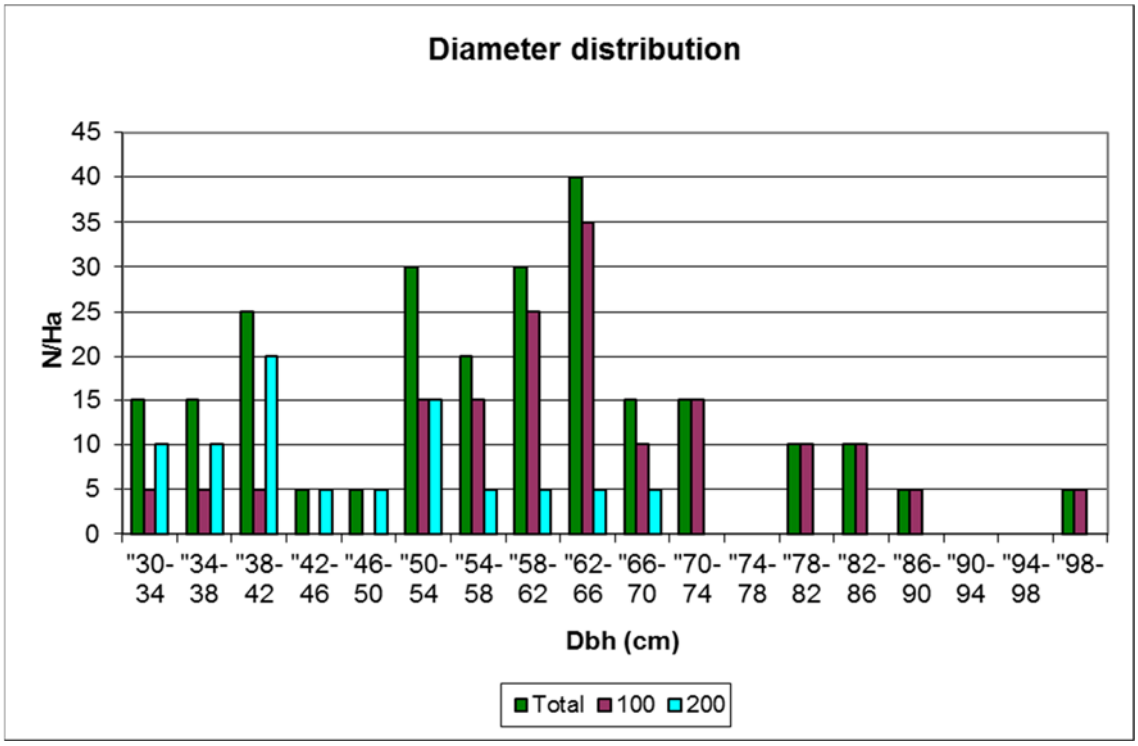

Figure 1. Diameter distribution of the *Platanus orientalis* pure stand.

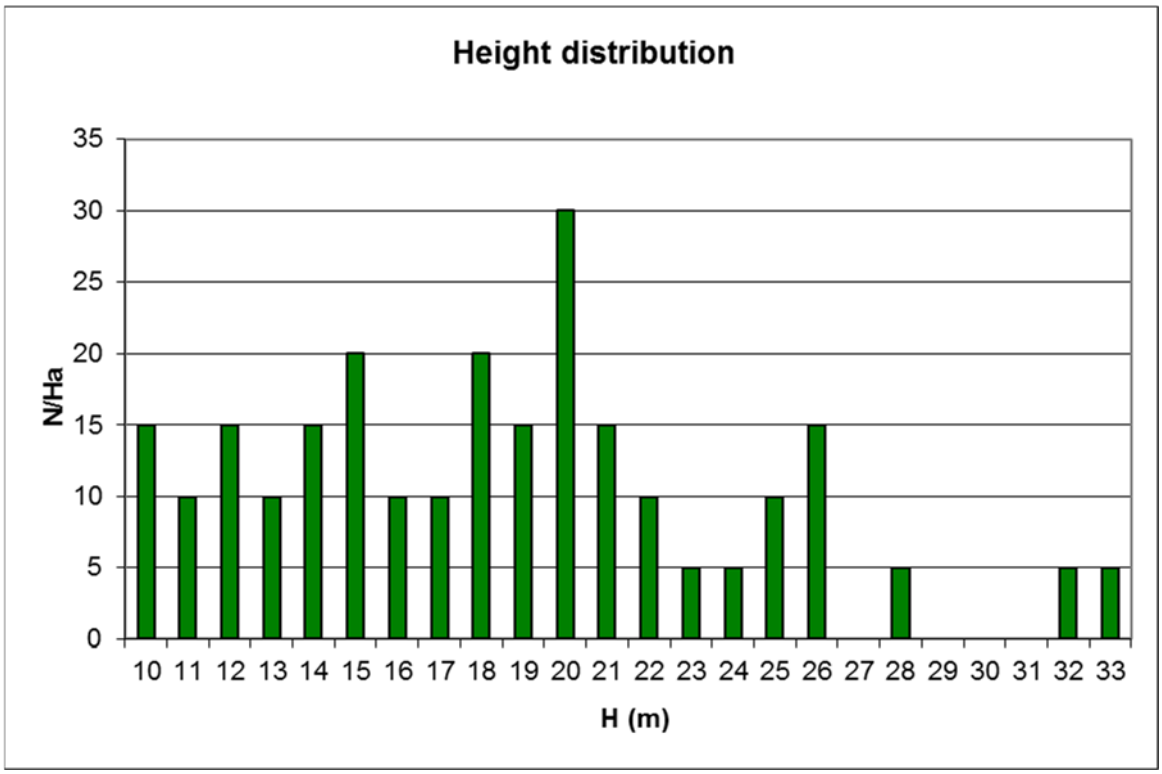

Figure 2. Height distribution of the *Platanus orientalis* pure stand.

3.2 Mixed stand Platanus orientalis – Ulmus minor – Populus alba

It's a three-storied irregular uneven-aged mixed stand. The dominant species is *Platanus orientalis* and the other species are *Populus alba*, *Ulmus minor*, and *Juglans regia*. The species *Platanus orientalis*, *Populus alba*, and *Juglans regia* form the upper storey, while *Platanus orientalis* and *Ulmus minor* form the middle storey and the under storey (Tables 2 & 3; Figures 3, 4 & 5).

The H_{dom} is 26.4 m. The stand density is 230 trees/Ha (195 trees/Ha for *Platanus orientalis*, 20 trees/Ha for *Ulmus minor*, 10 trees/Ha for *Populus alba*, and 5 tress/Ha for *Juglans regia*). The mean Dbh for the *Platanus orientalis* is 50.54 cm and 31.25 cm for the *Ulmus minor*.

The mean height is 21.82m and 13.00m correspondingly. The basal area is 52.63 m^2/Ha for the *Platanus orientalis* (55.59 m^2/Ha is the total basal area). The mean slenderness index is 48 for the *Platanus orientalis* and 41 for the *Ulmus minor*. Over the 50% of all trees (of all the species) have the crown length greater than the ½ of the total tree height.

Table 2. Stand parameter statistics of *Platanus orientalis – Ulmus minor – Populus alba* mixed stand (stories).

Stand parameter	***Upper storey***	***Middle storey***	***Under storey***	***Total***
Dbh (cm)	56.42	25.67	29.67	50.54
Dbh [min – max]	25 - 115	16 - 86	9 - 18	9 - 115
H (m)	22.94	15.50	12.00	21.22
H [min – max]	17 - 29	10 - 16	7 - 8	7 - 29
Slenderness Index (H/D)	47	65	40	49
CR (%)	52.51	43.00	71.90	52.54
Total G (m^2/Ha)	50.1876	5.3254	2.2871	57.8001
N/Ha	185	30	15	230
H_{dom} (m)				26.4

Table 3. Stand parameter statistics of *Platanus orientalis – Ulmus minor – Populus alba* mixed stand (species).

Stand parameter	***Platanus orientalis***	***Ulmus minor***	***Total***
Dbh (cm) [1]	53.00	31.25	50.54
Dbh [min – max]	9 - 115	18 - 37	9 - 115
H (m) [2]	21.82	13.00	21.22
H [min – max]	7 - 29	18 - 37	7 - 29
Slenderness Index (H/D) [3]	48	41	49
CR (%) [4]	51.35	67.99	52.54
Total G (m^2/Ha) [5]	52.6261	1.6269	55.5922
N/Ha [6]	195	20	230
H_{dom} (m)			26.0

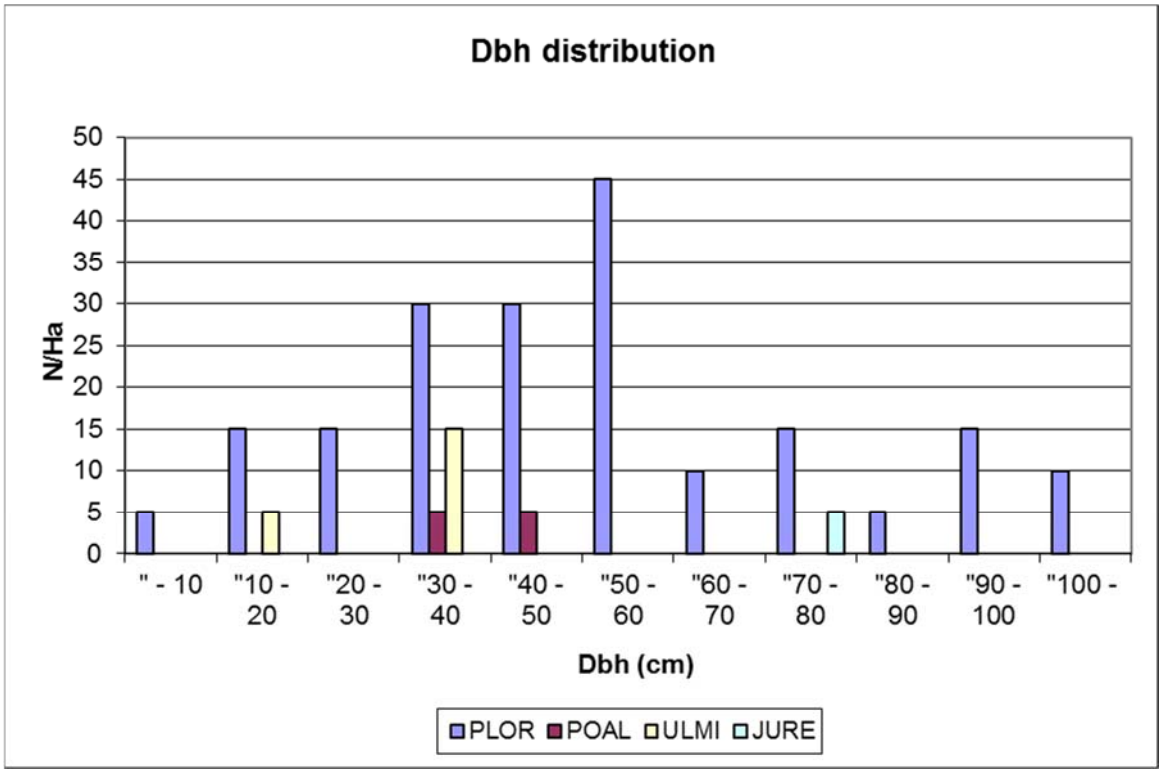

Figure 3. Diameter distribution of *Platanus orientalis – Ulmus minor – Populus alba* mixed stand (species).

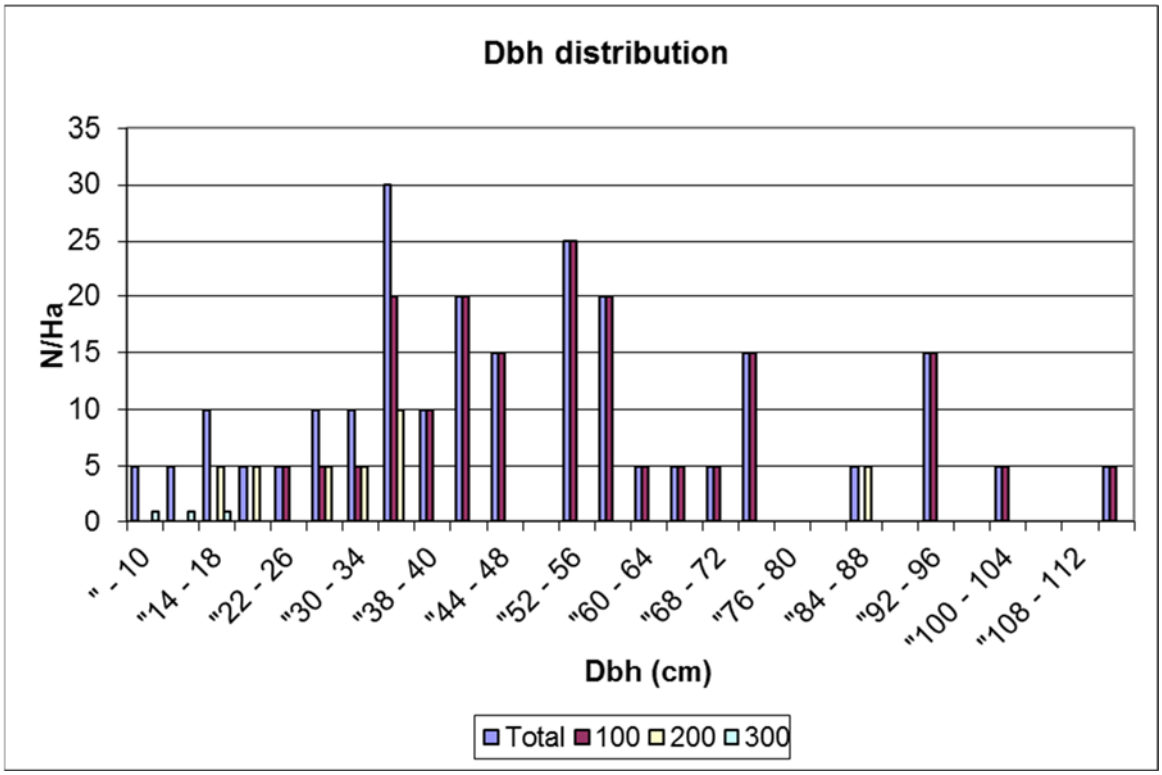

Figure 4. Diameter distribution of *Platanus orientalis – Ulmus minor – Populus alba* mixed stand (stories).

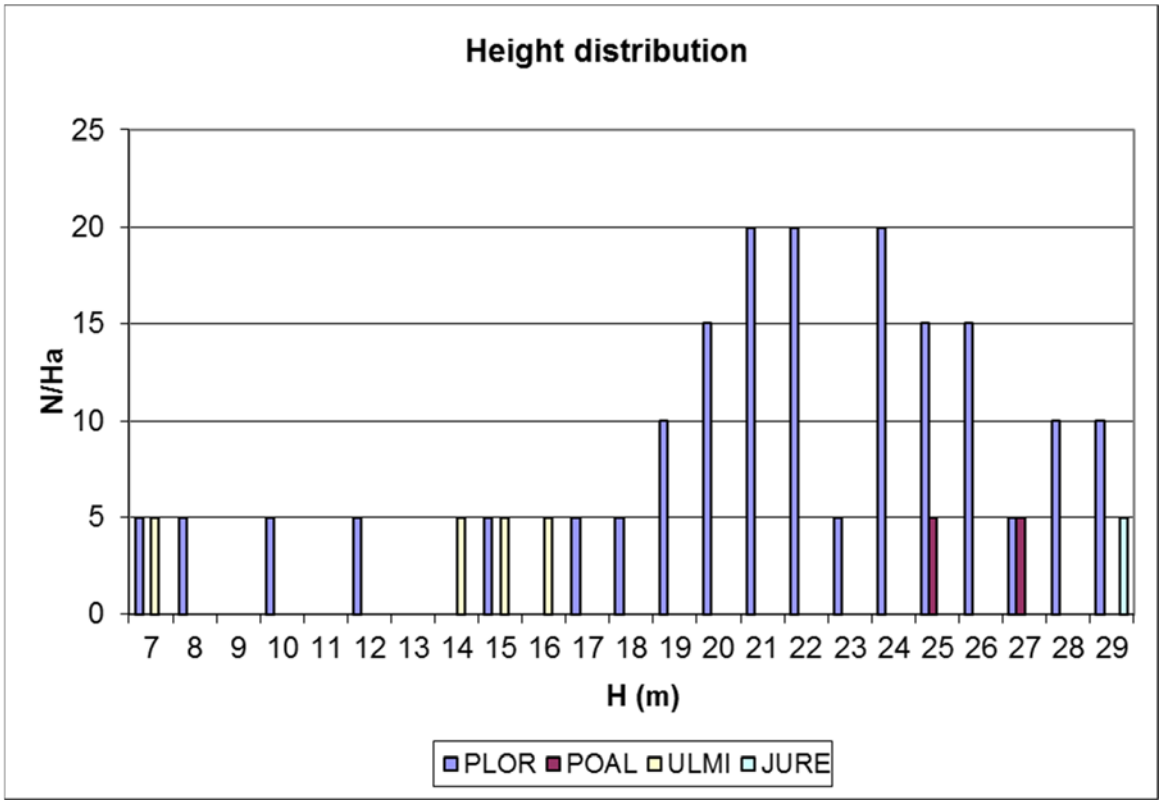

Figure 5. Height distribution of *Platanus orientalis – Ulmus minor – Populus alba* mixed stand.

3.3 Mixed stand Platanus orientalis – Populus alba – Salix alba

It's a three-storied irregular uneven-aged mixed stand. The dominant species is *Platanus orientalis* and the other species are *Populus alba*, and *Salix alba*. The species *Platanus orientalis*, and *Salix alba* form the middle storey and the under storey, while the upper storey is formed by the three species. The individuals of the *Populus alba are found only in the upper storey*. (Table 4 & 5; Figures 6, 7 & 8).

Table 4. Stand parameter statistics of *Platanus orientalis – Populus alba – Salix alba* mixed stand (stories).

Stand parameter	***Upper storey***	***Middle storey***	***Under storey***	***Total***
Dbh (cm)	58.75	52.25	28.00	56.88
Dbh [min – max]	29 - 121	15 - 75	7 - 24	7 - 121
H (m)	20.89	23.75	15.67	20.99
H [min – max]	18-28	10 - 17	4 - 7	4 - 28
Slenderness Index (H/D)	41	44	59	42
CR (%)	51.51	43.30	84.37	51.94
Total G (m^2/Ha)	106.4677	6.3393	0.2771	113.0841
N/Ha	330	40	15	385
H_{dom} (m)				22.6

Table 5. Stand parameter statistics of *Platanus orientalis – Populus alba – Salix alba* mixed stand (species).

Stand parameter	***Platanus orientalis***	***Populus alba***	***Salix alba***	***Total***
Dbh (cm)	59.47	46.85	27.00	56.88
Dbh [min – max]	7 - 121	22 - 62	15 - 40	7 - 121
H (m)	20.45	23.90	13.50	20.99
H [min – max]	4 - 26	16 - 28	7 - 19	4 - 28
Slenderness Index (H/D)	37	53	52	42
CR (%)	55.69	36.16	81.13	51.94
Total G (m^2/Ha)	88.0873	23.3204	1.6764	113,0841
N/Ha	265	100	20	385
Hdom (m)				22.6

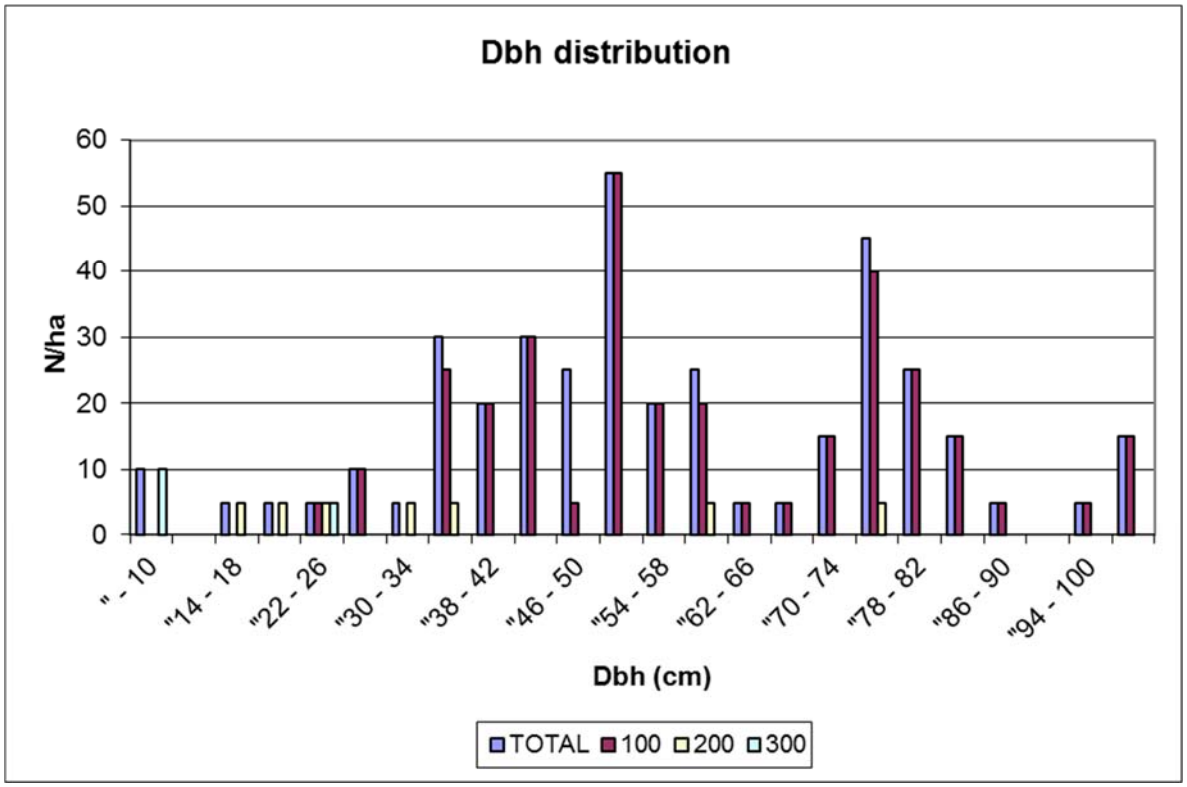

Figure 6. Diameter distribution of *Platanus orientalis – Populus alba – Salix alba* mixed stand (stories).

The H_{dom} is 22.6 m. The stand density is 385 trees/Ha (265 trees/Ha for *Platanus orientalis*, 100 trees/Ha for *Populus alba, and 20 trees/Ha for Salix alba*).

The mean Dbh for the *Platanus orientalis* is 59.47 cm and 46.85 cm and 27.00 cm for the *Populus alba and Salix alba* correspondingly. The mean height is 20.45m, 23.90 cm, and 13.50 cm for the three species. The basal area is 88.08 m^2/Ha for the *Platanus orientalis*, 23.32 m^2/Ha for the *Populus alba*, and 1.68 for the *Salix alba*. The mean slenderness index is 56 for the *Platanus orientalis*, 36 for the *Populus* alba, and 81 for the *Salix alba*. About 60% of the *Platanus orientalis* and 100% of the

Salix alba have the crown length greater than the ½ of the total tree height, instead of *Populus alba* in which only the 5% of their individuals have the crown length greater than ½ of the total tree height.

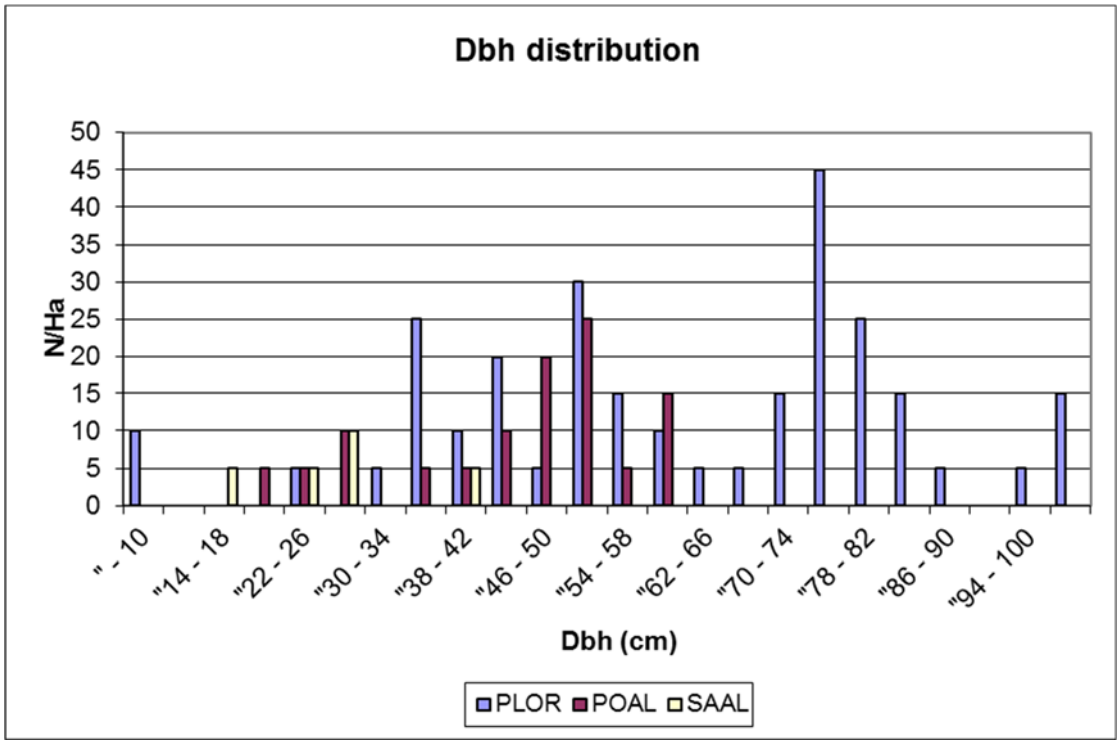

Figure 7. Diameter distribution of *Platanus orientalis – Populus alba – Salix alba* mixed stand (species).

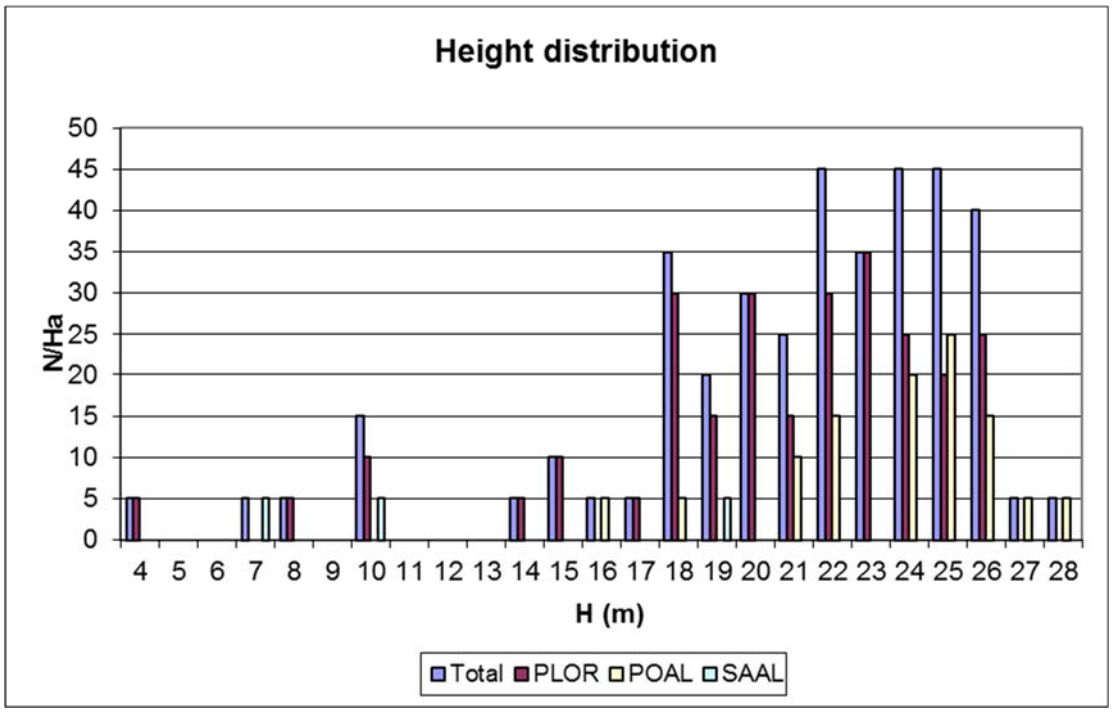

Figure 8. Height distribution of *Platanus orientalis – Populus alba – Salix alba* mixed stand.

4. CONCLUSION

The structure of the Richios riparian forest consists of two different stand types, pure and mixed:

The structure of pure stand of *Platanus orientalis* is an irregular even-aged because the stand originated from stump – sprouts. It's an old coppice stand which is suffered by the irregular cuttings.

In the mixed type we can distinguish two trends of the riparian forest dynamics:

i) The structure of mixed stand *Platanus orientalis – Populus alba – Salix alba* is a three-storied irregular uneven-aged mixed stand. The dominant species is *Platanus orientalis* and the other species are *Populus alba*, and *Salix alba*. The species *Platanus orientalis*, and *Salix alba* form the middle storey and the under storey, while the upper storey is formed by the three species.

The mixed stand *Platanus orientalis – Populus alba- Salix alba* is a mixed softwood riparian forest and it replaced an old pure forest of *Platanus orientalis*.

The species *Populus alba* colonized the area and now is a co-dominant species and together with the species *Platanus orientalis* form the upper storey. Gradually, the species *Salix alba* colonized the area and participate in all three storeys (Fig. 7). Similar stand structure and riparian forest dynamics is noted by Stromberg (2002): *"At lower elevations Platanus wrightii co-occurs with Populus fremontii and Salix gooddingii"* in riparian deciduous forest in southwestern United States and northern Mexico, in which the *Platanus wrightii* is a pioneer tree species.

ii) The structure of mixed stand *Platanus orientalis – Ulmus minor – Populus alba* is a three-storied irregular uneven-aged mixed stand. The dominant species is *Platanus orientalis* and the other species are *Populus alba*, *Ulmus minor*, and *Juglans regia*. The species *Platanus orientalis*, *Populus alba*, and *Juglans regia* form the upper storey, while *Platanus orientalis* and *Ulmus minor* form the middle storey and the under storey.

The mixed stand *Platanus orientalis – Ulmus minor – Populus alba* was previously a pure stand of *Platanus orientalis*. Individuals of oriental plane form all the diameter and height classes with few trees of *Populus alba*. Gradually the species *Ulmus minor* colonized the stand.

It is concluded that conversion from softwood riparian forest to a hardwood riparian forest is in progress. This is probably due to lower level of the underground water. The sparse appearance of *Juglans regia* may occur either to man or to birds.

As a conclusion the riparian forest in Richios river is a pure forest of oriental plane with few small mixed stands of softwood and hardwood riparian forest species. Furthermore, the specific structure of the pure forest of oriental plane is a result of human activities such as irrational cuttings, over-grazing, wildfires, intense agricultural activity.

The absence of natural regeneration should be dealt with the prevention of access, reduction of grazing and artificial reforestation in positions where drafted accordingly to a study (Efthimiou et al., 2015). Artificial reforestation with impressive results have already been in the riparian forest of N. Madytos at lake Volvi (Efthimiou et al., 2014). It's necessary, the recording and removal of alien species in the region and the non-use of these plantations and surrounding settlements to reduce the risk of natural riparian vegetation of the alien species.

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