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Full Length Research Paper

The slenderness of the softwood Riparian forest species *Salix alba* L. and *Salix fragilis* L. in the protected area of Nestos Delta, Greece

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The slenderness (height/diameter or h/d ratio) is an important factor, which describes the type of stem that each forest species develops. It depends on the species, the tree age and the site conditions. It is a basic factor that characterizes the structure and stability of the stand and a means for the assessment of the dynamics of height course. The objective of the present study is to compare the slenderness (h/d ratio) of the riparian forest species *Salix alba* L. and *Salix fragilis* L., which are found in mixed and pure stands in a protected area of international importance. 25 sampling plots (5 replicates in five different types of forest structure) were established in the riparian forest of Nestos. The structure and the dynamics of the stands were studied according to the IUFRO classification using slenderness as the overarching instrument. While the stands of both willow species have a high forest structure, slenderness values of *S. fragilis* stands were lower (degree of slenderness 40), which in turn indicates a more stable stand structure, in younger stages compared to *S. alba*, which attains similar values at nearly twice as large the stem diameters.

Key words: Slenderness, height/diameter ratio, *Salix alba*, *Salix fragilis*, riparian forest, Nestos Delta.

INTRODUCTION

The study of the h/d ratio (height/diameter ratio) or slenderness of riparian tree species is particularly important since riparian forests are among the most dynamic natural ecosystems (Dafis, 1992) as well as among the least studied ones in Greece (Efthimiou, 2000). Riparian forests are important elements of the European and global natural heritage because of their biological wealth. This wealth consists of their genetic, floristic and ecological diversity and high aesthetic, recreational, environmental, scientific and ecological value (Efthimiou, 2000; Efthimiou and Smiris, 2002). Depending on their species composition, structure, dynamics and ecological conditions riparian forests are distinguished in two types: softwood forest and hardwood forest (Yon, 1980; Mayer, 1984; Dister, 1988; Wenger et al., 1990; Kuhn, 1991). Riparian forests in Europe were excessively destroyed during the 20th Century. For example, up to 90% of riparian forests at the Upper Rhine was destroyed at the beginning of the second half of the 20th Century (Carbiener, 1974), while 60% of them was destroyed during the period 1955 to 1977 (Dister, 1988). In South Rhine, only the 6% of natural riparian stands are preserved (Hugin, 1981). In Bavaria, almost 80% of natural riparian forests have been destroyed (Wenger et al., 1990). During the same period in Greece around 60% of the larger natural riparian forest, the Kotza Orman (Papaioannou, 1953; Efthimiou, 2000; Emmanouloudis et al., 2006) in Nestos Delta, was destroyed.

The degree of slenderness is determined for each tree, via the relation between the height (h) and stem diameter (d) and characterises approximately the type of its stem. Slenderness is characteristic for each tree species and reflects the stem variability (Smiris, 1987). For this reason, it varies depending on tree species, age and conditions of the site (Röhle, 1982, 1984). The slenderness of the trees was often used for the characterization of the structure and the assessment of the dynamics of height development (Leibundgut, 1959, 1978; Dafis, 1966;

Smiris, 1987). The degree of slenderness according to Assmann (1959; 1961) is an important factor for the important factor for the characterization of the stability of the stand (Röhle, 1982; 1984). More concretely low degrees of slenderness show constant conditions, while high degrees are characteristic for stands of non-constant structure (Röhle, 1982).

The species of the genera *Populus* and *Salix* colonized Europe as companion species of *Pinus* and *Betula pendula* at the beginning of the intergracial period (Firbras, 1949, 1952; Straka, 1957; Strassburger, 1978; Ellenberg, 1996; Jenik, 1998). *Salix alba* is considered the most competitive species in an active riparian forest (Carbiener, 1974), which forms the most important category of softwood riparian forest (Dister, 1988; Kuhn, 1991), with hardness value 206 kp/cm^2 (Vorreiter, 1949; Tsoumis, 1986). The bark of *S. alba* has pharmaceutical properties (Arabatzis, 1998) because of salicin that it contains. *Salix fragilis* is a photophilus species and belongs also to softwood riparian species. It is present almost in the whole of Greece and in central European riparian forests (Athanasiadis, 1986; Dister, 1988; Arabatzis, 1998). Arabatzis (1998) reports that it may coincide with "Eliki" that Theofrastus mentions.

Knowledge of the forest structure and dynamics is a necessary precondition for the knowledge of a forest in general, its production potential as well as for developing proposals for its cultivation and development as well as making relevant decisions (Heller, 1963; Dister and Drescher, 1987). Forest structure used to be presented partly in the form of drawings and partly in the form of numerical indexes or combinations of both. The method of Leibundgut that finally prevailed is now widely used and is known as the IUFRO classification (Smiris and Dafis, 1983, 1984; Smiris, 1985; Dafis, 1989). The aim of the present study was to explore and describe the degree of slenderness of the tree forest species *S. alba* and *S. fragilis* in the riparian forest of Nestos Delta with regard to the dynamics of the stands where they occur. They are both softwood species that occur under similar or even identical conditions (Dister, 1988; Kuhn, 1991). Dister (1988) reports differences in the dynamics between softwood and hardwood riparian forests.

In the frame of this study, it was asked whether differences occur in the structure and the dynamics of the stands in which the two willow species were present using slenderness as a criterion. The working hypothesis was that these closely related species with similar ecological characteristics should exhibit a comparable behavior with regard to the conditions of the different stands.

MATERIALS AND METHODS

Study site

The study site was the riparian forest at the Delta of River Nestos, which is located in the north-eastern utmost of Greece. It occupies the flat part of the river course and it is extended in the area between the exit of the Thracian Gorge (north), the estuaries of Nestos River by the sea (south), the region of lagoons by Abdira (East) and the lagoons by N. Karvali (west). The Delta area is divided by the river in two parts, the West (of Kavala) and the East (of Xanthi). The altitude of the region ranges from zero (sea level) to 40 m (gorge exit). The inclination of the river is relatively high (0.725%) compared to other rivers. The total distance between gorge exit and the sea is 29 km. The study site is delimited by the following parallels: 40° 50' 52" and 41° 5' 4" N and 24° 42' 22" and 24° 51' 38" E.

Administratively the region belongs to the Region of Eastern Macedonia and Thrace and to two prefectures, the western part in the prefecture of Kavala and the Eastern in the prefecture of Xanthi. As far as management is concerned, the Forest service of Kavala is responsible for both parts of the riparian forest, in order to achieve uniform protection, administration and management.

Sampling and analyses

By using as a criterion of discrimination on a phytosociological basis, the composition of dominant woody vegetation, five different forest conditions were distinguished as types of structure (TS) in which willow species were present and were numbered from TS 1 until TS 5. 25 sampling plots (5 in each TS) of 0.1 acre extent for mixed and 0.05 acre for the monospecific forest stands were established in the riparian forest of Nestos. Every effort was made in order to ensure the uniformity of the sampling plots. In each sampling plot the following measurements and recordings were carried out:

1) Measurement of stem diameter at breast height (d) of all trees with diameter larger than 4 cm, with a precision of 1 cm.
2) Measurement of height of trees with a Haga hypsometer.

The degree of slenderness is determined via the relationship of height (h) and diameter at breast height (d) and is calculated as the quotient h to d (h/d ratio). A number of different equations were considered for describing the relationship between h and d for each species in each type of forest structure. The equation that provided the best fit was based on the model:

$$h/d = d/(a_0 + a_1{*}\ d + a_2{*}\ d^2)$$

For the estimation of the parameters, a_0, a_1, a_2 the following transformation (Prodan, 1968) was used:

$$d^2 / h = a_0 + a_1{*}\ d + a_2{*}\ d^2$$

Tree age was established by extracting increment cores by means of a corer and counting tree rings under a dissecting microscope (Husch et al., 1982; Speer, 2010).

RESULTS

In the riparian forest of Nestos, different types of structures were distinguished based on the composition of the dominant woody vegetation. The willow species *S. alba* and *S. fragilis* were found in five types of forest structure (TS), namely:

Type of Structure (TS 1): *S. alba – Populus alba – Alnus*

glutinosa Type of Structure (TS 2): *P. alba – S.fragilis-A. glutinosa.*
Type of Structure (TS 3): *S. alba – A. glutinosa*
Type of Structure (TS 4): *S. fragilis – A. glutinosa - Salix amplexicaulis*
Type of Structure (TS 5): *S. alba*

The estimated equations describing slenderness for the species *S. alba* and *S. fragilis* for every type of structure (TS) are presented in Figures 1 and 2. The respective equation parameters are shown in Table 1.

S. alba stands

S. alba was present in three types of structure of the riparian forest of Nestos, namely TS 1, TS 3 and TS 5. TS 1 consisted of mixed stands of *S. alba, P. alba* and *A. glutinosa*. *S. alba* was present at ages ranging from 21 to 28 years old, with a frequency peak at the diameter group of 26 cm. More generally, this species reached its highest frequency at the sapling and mature stages. The curves of the degree of individual tree slenderness are presented in Figure 3. It is apparent that *S. alba* exhibited the lowest degree of slenderness for d<10 cm compared to the other tree species while for d>35 cm the degree of slenderness was lower than the one of *P. alba* but higher than the one of *A. glutinosa*.

TS 3 consisted of mixed stands of *S. alba* and *A. glutinosa*, where *S. alba* was present at an age range of 20 to 33 years, while the frequency of its diameter groups exhibited two maximums for the groups of d=22 cm and d=30 cm and a numerical dominance of the young stage. The degree of slenderness of *S. alba* (Figure 4) below the diameter of 20 cm was lower than that of *A. glutinosa*, while for d>20 cm the degree of slenderness for *S. alba*, was slightly higher than that of *A. glutinosa*. Both exhibited a declining trend.

TS 5 consisted of pure stands of *S. alba*, which were found directly on the river bank, at an age range of 30 to 40 years old. They were even aged stands with the higher numerical frequency observed for the diameter group of d=18 cm. The degree of slenderness of *S. alba* (Figure 5) exhibited an increasing trend up to a diameter of 15 cm, where the maximum values were observed. Afterwards a mild declining trend with increasing diameter was observed.

S. fragilis stands

S. fragilis was present in two types of structure (TS 2 and TS 4) in the riparian forest of Nestos. In TS 2, which consisted of mixed stands of *P. alba, S. fragilis* and *A. glutinosa, S. fragilis* was present on a large island in the River Nestos. Individuals were aged 25 to 30 years old, with a numerical peak at the diameter group of d=22 cm. *S. fragilis* exhibited the highest degree of slenderness

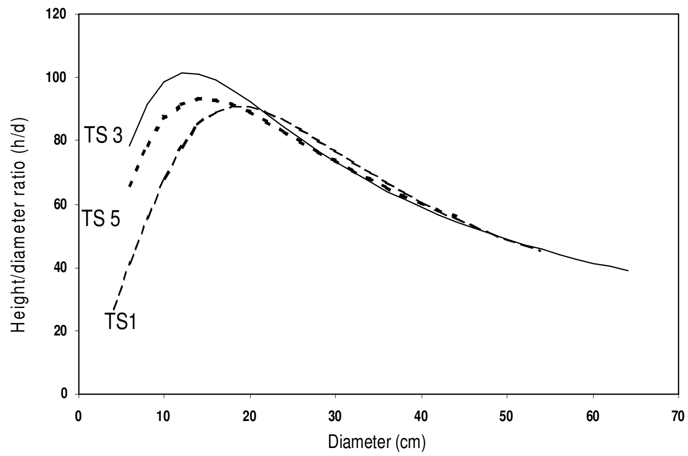

Figure 1. Slenderness curves of *S. alba* in different types of forest structure (TS).

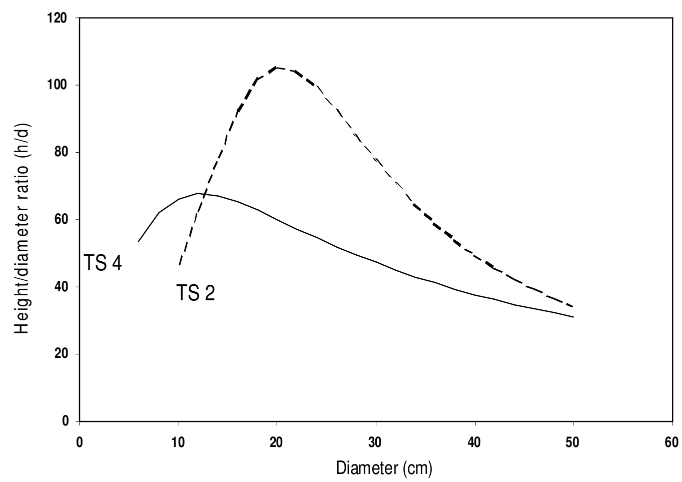

Figure 2. Slenderness curves of *S. fragilis* in different types of forest structure (TS).

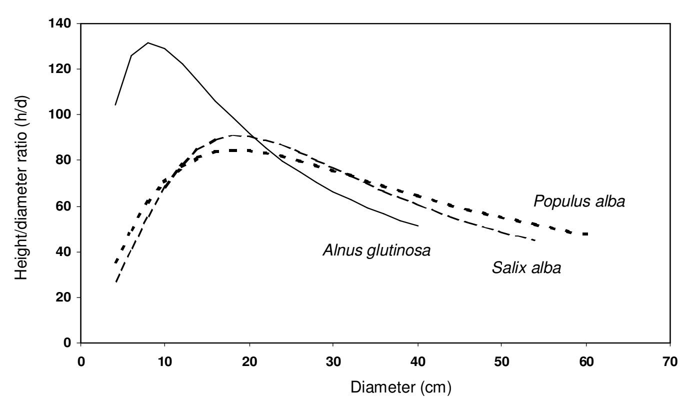

Figure 3. Slenderness curves of species *S. alba* - *Populus alba* - *Alnus glutinosa* in structure type TS1.

Table 1. Slenderness equation parameters of *S. alba* and *S. fragilis* in stands of the different structure types (TS) of the Nestos Riparian Forest.

Parameter	R^2 (Adj. R^2)	S.E.	Sign. F	Equation parameter	S.E.	Sign. T
S. alba *TS1*	0.944 (0.943)	5.6718	<0.001	a_0=17.0879	3.3487	0.0034
				a_1= -0.7248	0.2423	<0.001
				a_2= 0.4854	0.0039	<0.001
S. alba TS3	0.862 (0.861)	10.132	<0.001	a_0= 6.2815	0.9738	<0.001
				a_2= 0.0385	0.0009	<0.001
S. alba *TS5*	0.774 (0.770)	7.9259	<0.001	a_0= 7.8311	1.7792	<0.001
				a_2= 0.0366	0.0026	<0.001
S. fragilis *TS2*	0.901 (0.896)	8.609	<0.001	a_0= 46.3881	10.592	<0.001
				a_1=-3.5982	0.7559	<0.001
				a_2= 0.1114	0.0128	<0.001
S. fragilis *TS 4*	0.803 (0.802)	14.356	<0.001	a_0=9.03348	1.6464	<0.001
				a_2=0.06062	0.0023	<0.001

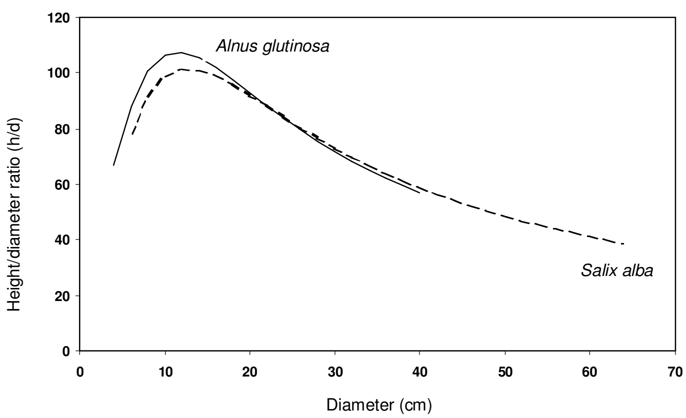

Figure 4. Slenderness curve of *S, alba – Alnus glutinosa* in structure type TS3.

(Figure 6) for a diameter of 20 cm, while within the range 20 cm<d<30 cm it had a higher degree of slenderness in comparison with the two other species. On the contrary for d>40 cm it had the lowest degree.

TS 4 consisted of mixed stands of *S. fragilis* and *A. glutinosa*. *S. fragilis* was present in all the layers of the mixed stands along with *A. glutinosa* and *S. amplexicaulis*. The largest proportion of *S. amplexicaulis* individuals was found in the understorey. The age of *S. fragilis* individuals laid between 15 and 25 years and the dominant diameter groups were those with d=18 cm and d=26 cm. *S. fragilis* slenderness degree (Figure 7) up to a diameter of d=20 cm was lower compared to the two other tree species. From d=20 cm onwards the degree followed a mild declining trend, but it still remained higher than the degree of *A. glutinosa* and *S. amplexicaulis*. At the diameter of about 29 cm there were no differences in the slenderness degree of the three species.

DISCUSSION

The knowledge of forest structure and dynamics is a necessary precondition of the forest's knowledge in general and of forestry capacity as well as decision making regarding their management in particular (Heller, 1963, 1969; Dister and Drescher, 1987). Even today studies on the structure and dynamics of riparian forests remain limited. The degree of slenderness according to Assmann (1961) is an important factor for the characterization of the stability of the stand (Röhle, 1982; Petras and Mecko, 2010). Low values of slenderness show stable conditions, while high values indicate stand of non-constant structure (Röhle, 1982). Values of slenderness equal to hundred mean that the height of tree in m is equal with its diameter in cm. The degree of slenderness in dense young stands may exhibit values higher than one (Röhle, 1982), something that is observed in many stands in the riparian forest of Nestos.

Numerical domination of *Salix* species (Heller, 1963) in the overstorey in mixed stands with *A. glutinosa* was observed in riparian forests in Switzerland and Austria as well as in mixed stands with *Alnus incana* and *Fraxinus excelsior*, in Switzerland and Yugoslavia. The degree of slenderness of *Salix* is lower than that of *Alnus* for the same diameter group (Heller, 1963). From Figures 1 to 7, it is evident that the slenderness curve is different even for the same species in the different types of forest structure where it occurs. Slenderness is related to the conditions of growth of the trees, the stand structure (density) and their age. In Figure 1 the slenderness

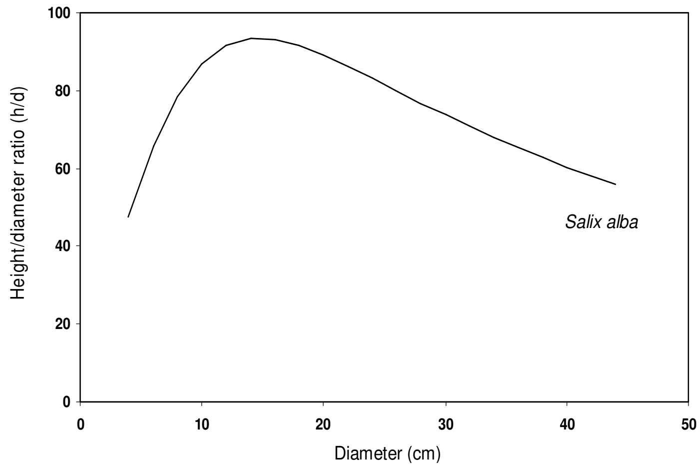

Figure 5. Slenderness curve of *Salix alba* in structure type TS 5.

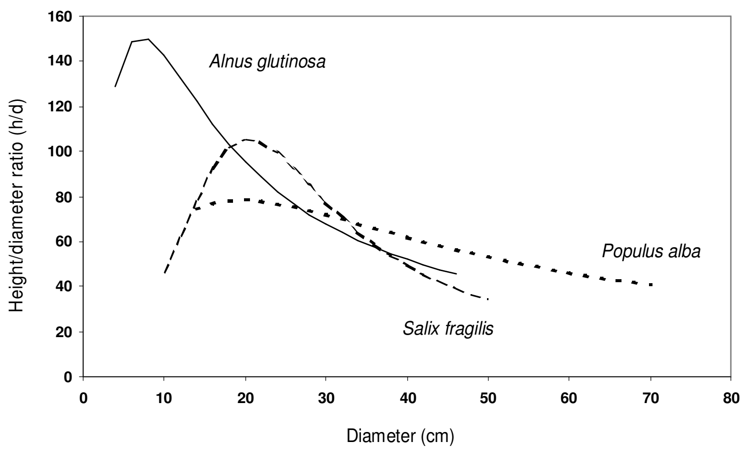

Figure 6. Slenderness curve of *Populus alba -Salix fragilis - Alnus glutinosa* in structure type TS2.

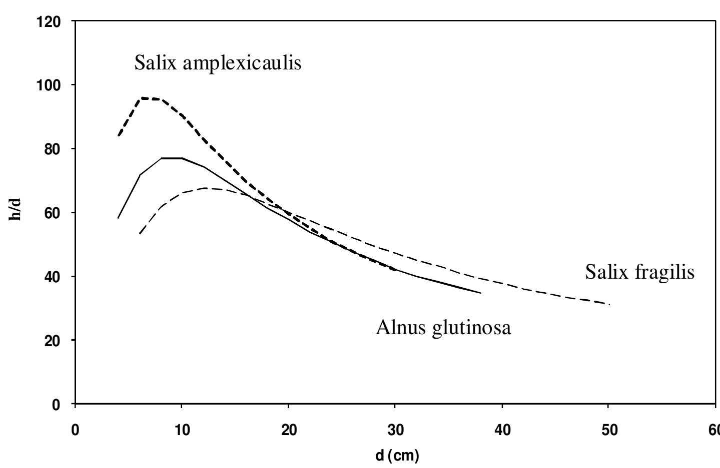

Figure 7. Slenderness curve of *Salix fragilis – Alnus glutinosa - Salix amplexicaulis* in structure type TS4.

curves for the three distinct structure types of *S. alba* are given. Up to the diameter of 20 cm the higher degree of slenderness is exhibited in mixed stands with *A. glutinosa* (TS 3), in which it dominates in the overstorey. The pure stands of *S. alba* (TS 5) follow with slightly lower values of slenderness. Individuals with diameter less than 20 cm exhibit the lowest slenderness values in mixed stands with *A. glutinosa* and *P. alba* (TS 1), where the higher percentage of *S. alba* individuals is found in the overstorey. The most constant conditions with regard to *S. alba* were observed in individuals with d>45 cm in which the lowest values of the slenderness degree were found.

With regard to *S. fragilis* considerably higher degree of slenderness (Figure 2), therefore more unstable conditions, and its highest dynamics are exhibited by the youngest individuals with diameter d<30 cm in mixed stands with *P. alba* and *A. glutinosa* (TS 2). More stable conditions, that is, a lower degree of slenderness of *S. fragilis* is found in mixed stands with *A. glutinosa* and *S. amplexicaulis* (TS 9). In these stands *S. fragilis* is numerically dominant in the overstorey and in the middlestorey and an almost stable degree of slenderness for diameters larger than 20 cm (Efthimiou, 2000) has been found. The most stable conditions for *S. fragilis* were observed for trees with d>50 cm. To sum up, the different behavior of the degree of slenderness of the riparian forest tree species *S. alba* and *S. fragilis* can be summarized as follows.

The degree of slenderness of *S. alba* young stands equals hundred. Young trees with d<25 cm appear to exhibit faster growth and dynamic evolution, while structure is stabilized around a tree diameter d>30 cm. In mixed stands (TS 3) co-domination with *A. glutinosa* in the overstorey dynamically tends to be replaced by the domination of *A. glutinosa* that numerically dominates in the middlestorey. In mixed stands (TS 1) *S. alba* numerically dominates in the overstorey along with *P. alba* and tends to be gradually displaced by *A. glutinosa* with which it co-dominates the middlestorey and competes at d<25 cm as it is shown by the high degree of slenderness of *S. alba*. *S. fragilis* exhibits more stable structure (low degrees of slenderness) in mixed stands with *A. glutinosa* and *S. amplexicaulis* (TS 4), at which it numerically dominates (frequency close to 69%) in the middlestorey and overstorey, a fact that indicates that it was established first on those surfaces and will be dynamically displaced by *A. glutinosa*, which numerically dominates the middlestorey and the understorey. In mixed stands with *A. glutinosa* and *P. alba* (TS 2), *S. fragilis* is numerically outnumbered by the other two species, while the largest percentage of the individuals is present in the overstorey and in the middlestorey. In those stands (TS 2), young trees (d<25 cm) of *S. fragilis* exhibit a higher dynamic and its structure is becoming stable for mature trees with d>40 cm. The dynamic of these stands leads to the replacement of the overstorey domination of *S. fragilis* and *P. alba* by *A.glutinosa* domination, which numerically dominates already in the middlestorey.

S. fragilis exhibits a stable structure (degree of slenderness 40) for young trees of d=30 cm, while *S. alba* presents the same stability for mature trees of d>60 cm. This finding leads to a rejection of the working hypothesis of this study since the differences in the dynamics of the two willow species are profound. The remaining riparian forest areas in Greece are of small surface. The anthropogenous pressures (grazing, agriculture, fire, urban expansion) exerted continue to be multiple and severe, resulting in limited areas that are not suitable for management targeting economic returns. The sound management of Greek riparian ecosystems in the future should strictly target their preservation (Jerrentrup and Lösing, 1991) in a way that the remaining natural stands are allowed to resume their natural succession trajectories and dynamics. This is confirmed by the findings of this study, since it is evident that natural stands of *Salix* sp. attain a stable structure at high ages.

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REFERENCES

Arabatzis TH (1998). Bushes and trees in Greece. Publ. Ecological Movement of Drama and Technological Educational Institute of Kavala, Drama, Greece, 1: 292.

Athanasiadis H (1986). Forestal Botany II (Trees and shrubs of Greek Forests). Publ. Giachoudi-Giapouli, Thessaloniki, Greece, p. 309.

Assman E (1959). Height quality and real earnings power. Sci. Cent. For. Leaf., 78: 1-20.

Assmann E (1961). Forest Yield Science, Organic Production, structure, growth and yield of forest Passed. Publ. BLV, Munich, Bonn and Vienna, p. 490.

Carbiener R (1974). The left bank natural areas and forests and the protected areas of Rhinau Daubensand (Frankreich): a phytosociological and landscape ecological study. Nat. Lands B. Würt, 7: 438-535.

Dafis S (1966). Structure and growth analysis of natural pine forests. Beitr Geob. Land. .Switz, 1: 1-75.

Dafis S (1992). Stability, balance and self-regulation (omoiostasi) the forestal ecosystems. Scientific Annals of Dept. of Forestry and Natural Environment, of Aristotle Univ. of Thessaloniki, 5: 521-531.

Dister E, Drescher A (1987). The structure, dynamics and ecology of flooded hardwood riparian forest long at the lower March (Lower Austria). Ver. Ges. Ecol., 5: 295-302.

Dister E (1988). Ecology of riparian forests of central Europe. Gem Pen. For Pub. Heal. Hik, Nat. Her. Prot., 19: 6-26.

Efthimiou G (2000). Structure Analysis, Dynamic and Ecological meaning of the riparian forest of Nestos River. Ph.D. dissertation, Aristotle University of Thessaloniki, Thessaloniki, Greece.

Efthimiou G, Smiris P (2002). Management, Protection and Restoration measures of the riparian ecosystems of Nestos Delta. In Koungolos AG, Liakopoulos AB, Korfiatis GP, Koutsospyros AD, Katsifarakis KL, Demetracopoulos AD (eds) Protection and restoration of the Environment VI: Proceedings of an International Conference, held at Skiathos, Greece, Grafima, pp. 1871-1874.

Emmanouloudis D, Myronidis D, Panilas S, Efthimiou G (2006). The role of sediments in the dynamics and preservation of the aquatic forest in the Nestos delta (N. Greece). IAHS-AISH, 306: 214-222.
Ellenberg H (1996). Vegetation of Central Europe with the Alps. 5th ed. Eugen Ulmer, Stuttgart, pp. 1-1095.
Firbas F (1949). Spar and late-glacial forest history of Central Europe North of the Alps. Publ. G. Fischer, Vienna, 1: 480.
Firbas F (1952). Spar and late-glacial forest history of Central Europe North of the Alps. Publ. G. Fischer, Vienna, 2: 256.
Heller H (1963). Structure and dynamics of riparian forests. Geob. Beitr. Land. Switz., 42:1-75.
Heller H (1969). Living conditions and sequence of the floodplain vegetation in Switzerland. Mémoire de l'Institut suisse de recherches forestières, 45(1):1-124.
Hugin G (1981). The riparian forests of the southern Upper Rhine Valley - and its change by the Rhine endangerement Expansion. City Land, 13(2): 78-91.
Husch B, Miller CI, Beers TW (1982). Forest mensuration. 3rd edition. Publ. John Wiley and Sons, p. 402.
Jenik J (1998). Biodiversity of the Hercynian Mountains of Central Europe. JACA, 151/152: 83-99.
Jerrentrup H, Lösing J (1991). Situation of the flood plains in Greece. Akad Nat. Lands. (ANL), 4: 86-92.
Kuhn N (1991). The nature of the riparian forest as a habitat. Switz. J. For., 142(9): 731-749.
Leibundgut H (1959). About the purpose and methodology of the structure and growth analysis of native forests. Switz. J. For., 110: 111-124.
Leibundgut H (1978). About dynamics of European Natural forests. Gen. For. J. Mun., 33(24): 686-690.
Mayer H (1984). Forests in Europe. Publ. G. Fischer, Stuttgart, New York, USA, p. 691.
Papaioannou IK (1953). The forest Kotza – Orman. Publ. Eclogi. Athens, Greece, 88: 55-64.
Petrαš R, Mecko J (2010). Stability of the development of basic stand parameters of beech yield tables constructed on the basis of short-term observations on research plots. J. For. Sci., 56 (7): 323-332.
Prodan M (1968). Forest Biometrics. Pergamon Press. First English Edition. Translated by S. H. Gardiner, p. 447.
Röhle H (1982). Structure and growth of mixed stands of oak-influenced groundwater locations in the riparian forest areas of southern Bavaria. For. Res. Rep., No. 52, Munich.
Röhle H (1984). Yield characteristics of oak-mixed stands on underground water influence locations in the riparian forest areas of southern Bavaria. FWCbl, 103(6): 330-349.
Smiris P (1987). The dynamic development of Structure in virgin forests of Paranesti-Dramas. Sci. Ann. Dept. For. Nat. Environ. Aristotle Univ. Thessaloniki, 13: 480-593.
Speer JH (2010). Fundamentals of Tree-Ring Research. University of Arizona Press, Tucson, Arizona, U.S.A.
Straka H (1957). Pollenanalysen.0.0 and vegetation history. The new Bremen bookstore, Wittenberg, Germany, p. 109.
Strassburger E (1978). Textbook of Botany. In: von Denffer D, Ehrendorfer F, Maegdefrau K, Ziegler H (eds), Publ. Fischer, Stuttgart, 31th ed., p. 895.
Tsoumis G (1986). Science and Technology of Timber. v. A' Structure and attributes. Publ. Aristotle Univ. of Thessaloniki, Thessaloniki. Greece, p. 351.
Vorreiter L (1949). Wood Technological Manual, Vol. I. Publ. G. PIOUS and Co, Vienna, p. 548.
Wenger EL, Zinke A, Gutzweiler KA (1990). Presend situation of the European floodplain forests. For. Ecol. Manag., 33/34: 5-12.
Yon D (1980). Strategic elements of conservation. Symp. Phyt., 9: 1-18.