Silvicultural properties of several species of the genus Sorbus L. in the Republic of Croatia

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DENDROFLÓRA STREDNEJ EURÓPY – VYUŽITIE POZNATKOV VO VÝSKUME, VZDELÁVANÍ A PRAXI
DENDROFLORA OF CENTRAL EUROPE – UTILIZATION OF KNOWLEDGE IN RESEARCH, EDUCATION AND PRACTICE
ZVOLEN, TECHNICKÁ UNIVERZITA VO ZVOLENE, 2015 65 – 76

SILVICULTURAL PROPERTIES OF SEVERAL SPECIES OF THE GENUS *SORBUS* L. IN THE REPUBLIC OF CROATIA

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Abstract:

There are 13 species and subspecies of the genus *Sorbus* L. growing wild in the Republic of Croatia. Due to their fleshy fruit, species of the genus *Sorbus* L. belong to forest fruits, similar to other secondary tree species that contribute to the biological diversity of stands, serve as a suppport for the principal tree species and improve soil quality. During the autumn of 2003, trees of four species of the genus *Sorbus* L. (*S. aria, S. aucuparia, S. domestica* and *S. torminalis*) were recorded in different localities in the Republic of Croatia. Dendrometric data, tree coordinates, altitude and exposure were measured. The social position of each tree was assessed and the degree of yield was determined over a period of 6 years (2003–2008). Of the total of 77 registered trees, there were 13 whitebeams, 14 rowan trees, 13 service trees and 37 wild service trees. A good seed crop of whitebeam, service tree and wild service tree in the Republic of Croatia occurs at intervals of every four years, while that of rowan takes place at intervals of every three years. The properties of these species include sensitivity to competition and the non-existence of pure stands.

Keywords: whitebeam, rowan, service tree, wild service tree, seed crop

INTRODUCTION

The genus *Sorbus* L. belongs to the *Rosaceae* family, the subfamily *Pomoideae*, and comprises 80 to100 species of deciduous trees and shrubs that are distributed across the Northern Hemisphere (Chalupa, 1992; Little, 1979). The fruits are an important source of food for birds and rodents (Englund, 1993; Van Dersal, 1938) and are also used for human consumption or for the production of alcoholic beverages (Chalupa, 1992; Pojar and Mackinnos, 1994). They are an important source of food for wildlife and domestic animals (Van Dersal, 1938). According to Šatalić and Štambuk (1997), the trees and shrubs of edible fruits play a multiple role in forest ecosystems. They serve as food to numerous animal species that live in the forest. Forest fruit trees are species that are frequently planted to form protective belts (agroprotective, snow-protective, water-protective and anti-erosion).

Forest fruit trees are exceptionally important for the stability of forests because they are:

- the constituent part of the genetic wealth of our forests,
- an indispensible link in the food chain for a number of species ranging from micro-organisms, insects, birds, rodents and large herbivores to large predators,
- a factor of health resistance of forest stands,
- the habitat for a large number of other species together with other tree and shrub species, and
- the micro-habitat for different species that develop in them.

Because of their fleshy fruits that contain seeds, the species of the genus *Sorbus* L. belong to forest fruits, together with, according to MATIĆ and VUKELIĆ (2001), other secondary tree species that contribute to the biological diversity of stands, serve as a support to principal tree species and improve soil quality. In addition, some individual forest fruit trees have timber of exceptional quality that attains high prices and that has recently been in increasing demand on the market.

According to the Flora Croatica Database (http://hirc.botanic.hr/fcd/), the Republic of Croatia is home to 13 species and subspecies of the genus *Sorbus* L.. These are *Sorbus aria* (L.) Crantz, *Sorbus aria* (L.) Crantz ssp. *aria*, *Sorbus aria* (L.) Crantz ssp. *lanifera* (A Kerner) Jáv., *Sorbus aucuparia* L., *Sorbus aucuparia* L. ssp. *aucuparia*, *Sorbus austriaca* (Beck) Hedl. ssp. *croatica* Kárpáti, *Sorbus austiaca* (Beck) Hedl., *Sorbus austriaca* (Beck) Hedl. ssp. *austriaca*, *Sorbus borbasii* Jav., *Sorbus chamaemespilus* (L.) Crantz, *Sorbus domestica* L., *Sorbus torminalis* (L.) Crantz and *Sorbus velebitica* Kárpáti. The species *Sorbus aria* (L.) Crantz ssp. *lanifera* (A Kerner) Jáv., *Sorbus borbasii* Jav., and *Sorbus velebitica* Kárpáti are listed as insufficiently known, whereas the species *Sorbus austriaca* (Beck) Hedl. ssp. *croatica* Kárpáti is considered almost threatened. The species *Sorbus aucuparia* L. and particularly *Sorbus domestica* L. and *Sorbus torminalis* (L.) Crantz have commercial importance.

In Croatia, the service tree and wild service tree have a higher ecological than commercial value, but are neglected despite their highly valued wood. Today, they are grown only for fruits, whereas some sixty years ago their wood was used for the manufacture of different products and for fuel.

The whitebeam is a species that grows on shady terrains in the belt of beech-fir forests, but often occurs at lower elevations. It is also found in thermophilic forest communities, in thickets and on open rocky ground. It reaches up to 1.700 m a.s.l. Common whitebeam is a European-Mediterranean-montane species (HEGI, 1981) native to Central Europe from the lowland area up to the upper boundary of forest vegetation.

In the Republic of Croatia rowan is distributed in the zones of oriental hornbeam, sessile oak, hilly beech forest and submontane forest of beech and spruce (ŠATALIĆ and ŠTAMBUK, 1997). According to FORENBACHER (2001), in Croatia it grows in deciduous forests, primarily those of beech, but is also found in spruce forests as a low tree that does not flower. It can sporadically occur in large karst fields (550-1.600 m).

MATIĆ and VUKELIĆ (2001) report that the centre of the distribution of the service tree in the eu-Mediterranean zone of Croatia is in the communities of holm oak and in the sub-Mediterranean zone in the community of pubescent oak and oriental hornbeam. It is rare in the continental part and occupies dry, exposed positions in the community of pubescent oak and hop hornbeam. It is also cultivated in orchards and along vineyards, roads and similar.

According to TRINAJSTIĆ and ŠUGAR (1976), the wild service tree is rare in the Mediterranean zone of the Republic of Croatia. MATIĆ and VUKELIĆ (2001) observe that it is more common in the sub-Mediterranean zone, especially in its more humid and colder part. It is more copiously present in higher positions of the Mediterranean-montane belt (up to 700 m a.s.l.) in the community of pubescent oak and hop hornbeam (*Ostryo-Quercetum pubescentis* Ht. 1938). This community also occurs as an out-of-zone type in the continental part of Croatia, as a rule on rendzinas, limestones and dolomites, and in exposed and warm positions. In continental Croatia, wild service tree is found in larger amounts on hilly terrains (150 - 400 m a.s.l.), growing in deep, humus-rich soils, in the community of sessile oak and common hornbeam (*Epimedio-Carpinetum* /Ht. 1938/ Borh. 1963).

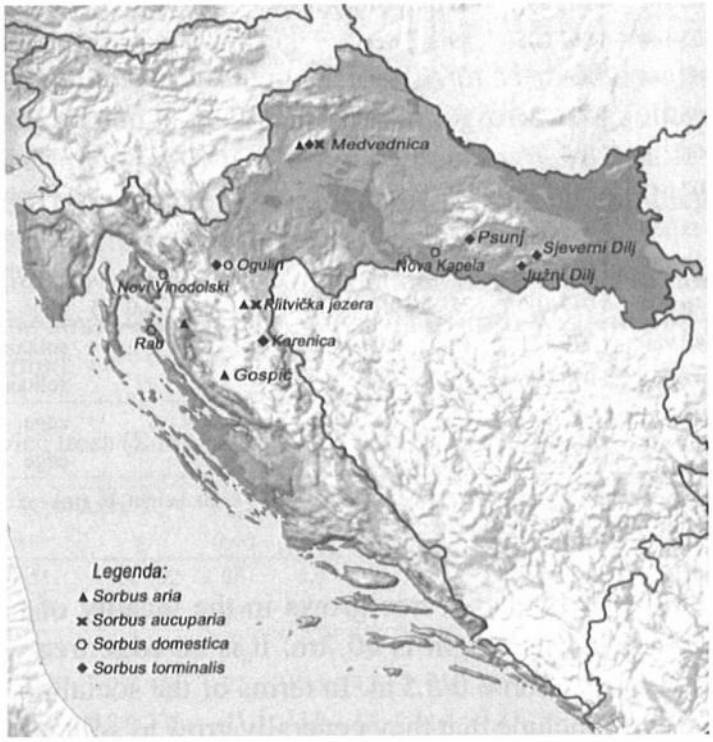

Figure 1 Research area of the four species of the genus ***Sorbus*** L. in the Republic of Croatia

Whitebeams (*Sorbus aria*) were studied in the following localities: Krasno (6), Gospić (3), Plitvice Lakes (2) and Mount Medvednica (2). Rowan (*Sorbus aucuparia*) trees were found in the localities of Plitvice Lakes (4) and Mount Medvednica (10). Service trees (*Sorbus domestica*) were studied in the localities of the island of Rab (2), Novi Vinodolski (3), Ogulin (5) and Nova Kapela (3). Wild service trees (*Sorbus torminalis*) were found in the localities of Ogulin (4), Korenica (1), Medvednica (10), Psunj (10), Južni Dilj (10) and Sjeverni Dilj (2).

MATERIALS AND METHODS

During the autumn 2003, the trees of four species of the genus *Sorbus* L. were found in different sites in the Republic of Croatia. For each tree, the total height, the height up to the crown and the height up to the first live branch were measured using the Vertex III device. Tree diameter at breast height ($d_{1,30}$) and crown projection to the ground were measured with the calliper and measuring tape. Each tree was photographed with a digi-

tal camera and its coordinates and altitude were determined by means of the GPSMAP 60CSx. Tree exposure was determined with a compass. The social position and yield were assessed for each tree. A total of 77 trees were registered, of which there were 13 whitebeams, 14 rowans, 13 service trees and 37 wild service trees. Yield degrees were assessed on the trees during the autumn periods from 2003 to 2008.

RESEARCH RESULTS AND DISCUSSION

Table 1 Data on whitebeam (*Sorbus aria* L.) trees from four localities in the Republic of Croatia

Location	O. n.	Coordinate		$d_{1,30}$	h_{tot}	H_t	H_c	H_{vb}	X_c/Y_c	Social position	Altitude	Exposure
		x	y	(cm)	(m)	(m)	(m)	(m)	(m)			
Krasno	1	5 505 202	4 962 902	11	6,0					solitaire	874	NI
	2	5 505 144	4 963 005	9	6,5					solitaire	869	NI
	3	5 505 044	4 963 098	7	6,0					solitaire	868	NI
	4	5 508 216	4 963 786	16	8,0					solitaire	798	W
	5	5 508 216	4 963 786	16	6,5					solitaire	798	W
	6	5 507 045	4 963 909	14	6,5	1,0	5,5	1,0		solitaire	820	W
Gospić	7	5 545 730	4 947 204	13	7,0		7,0			solitaire	980	W
	8	5 545 730	4 947 204	12	5,5		5,5			solitaire	980	W
	9	5 546 094	4 947 106	25	10,7	3,5	7,2	1,9	6,0/5,5	edge	990	W
Plitvice	10	5 549 989	4 970 171	19	4,0	1,7	2,3	1,7		solitaire	680	SW
	11	5 547 564	4 975 036	10	4,0					solitaire	580	SW
Medvednica	12	5 575 246	5 081 399	12	7,5	4,5	3,0	4,5		edge	548	S
	13	5 575 328	5 081 228	11	8,0	3,0	5,0	3,0		edge	521	SI

$d_{1,30}$ (cm) – tree diameter at breast height, h_{tot} (m) – total tree height, H_t (m) – trunk height, H_c (m) – crown height, H_{vb} (m) – height to the first live branch, X_c/Y_c (m) – crown projection to the ground

The thickest studied whitebeam tree grows in the locality of Gospić. Its diameter at breast height is 25 cm and its height is 10.7 m. It is an edge tree with a leaning trunk and asymmetric crown projection 6.0/5.5 m. In terms of the social position of the studied whitebeams only, we can conclude that they generally grow as solitary trees (10) and much less frequently as edge trees (3). The largest number of the whitebeams under study grows in the western, and the smallest number in the southern and south-eastern exposures.

Table 2 Data on rowan (*Sorbus aucuparia* L.) trees from two localities in the Republic of Croatia

Location	O. n.	Coordinate		$d_{1,30}$	h_{tot}	H_t	H_c	H_{vb}	X_c/Y_c	Social position	Altitude	Exposure
		x	y	(cm)	(m)	(m)	(m)	(m)	(m)			
Plitvice	1	5549509	4970782	10	4,5					solitaire	602	S
	2	5549509	4970782	11	4,0					solitaire	602	S
	3	5549332	4971405	14	8,0	3,5	4,5	3,5		edge	585	SI
	4	5549509	4970782	12	5,0					solitaire	602	S
Medvednica	5	5575706	5087686	16	9,5	6,0	3,5	6,0	2,5/0,0	edge	630	NI
	6	5575706	5087686	23	13,0	5,5	7,5	5,5	3,0/3,8	edge	630	NI
	7	5575706	5087686	23	16,0	7,0	9,0	5,0	4,5/4,0	edge	630	NI
	8	5575706	5087686	24	9,5	7,5	2,0	1,8	4,9/3,0	edge	630	NI

Table 2 Data on rowan (*Sorbus aucuparia* L.) trees from two localities in the Republic of Croatia – continued

Location	O. n.	Coordinate		$d_{1,30}$	h_{tot}	H_t	H_c	H_{vb}	X_c/Y_c	Social position	Altitude	Exposure
		x	y	(cm)	(m)	(m)	(m)	(m)	(m)			
	9	5 575 802	5 087 662	10	8,0	5,6	2,4	2,0	2,2/2,3	solitaire	619	NI
	10	5 575 802	5 087 662	17	6,5	1,0	5,5	1,0	4,6/2,0	solitaire	619	NI
	11	5 575 802	5 087 662	9	10,2	6,3	3,9	2,0	1,8/2,0	solitaire	619	NI
	12	5 575 686	5 087 524	21	8,0	1,0	7,0	1,0	7,5/5,0	solitaire	651	NW
	13	5 575 661	5 087 592	28	12,0	1,5	10,5	1,1	8,5/7,0	solitaire	638	NW
	14	5 575 486	5 086 648	29	11,0	1,0	10,0	1,0	6,5/6,0	solitaire	701	NW

$d_{1,30}$ (cm) – tree diameter at breast height, h_{tot} (m) – total tree height, H_t (m) – trunk height, H_c (m) – crown height, H_{vb} (m) – height to the first live branch, X_c/Y_c (m) – crown projection to the ground

The thickest rowan tree is found in the locality of Medvednica. Its .diameter at breast height is 29 cm and tree height is 11.0 m. The tree grows as a solitaire in a pasture and has a very low and drooping crown with a projection of 6.5/6.0 m. In terms of the social position of the studied rowan trees only, it can be concluded that they generally grow as solitary trees (9), and much less frequently as edge trees (5).

The largest number of the rowan trees under study grows in north-eastern, and the lowest number in the south-eastern exposures. The north-western and southern exposures are equally represented.

Table 3 Data on service trees (Sorbus domestica L.) from four localities in the Republic of Croatia

Location	O. n.	Coordinate		$d_{1,30}$	h_{tot}	H_t	H_c	H_{vb}	X_c/Y_c	Social position	Altitude	Exposure
		x	y	(cm)	(m)	(m)	(m)	(m)	(m)			
Island Rab	1	5 480 541	4 956 792	26	5,0					solitaire	30	
	2	5 481 070	4 956 488	10	4,0					solitaire	20	N
Novi Vinodolski	3	5 479 946	5 003 626	53	11,0	2,0	9,0	2,0	11,1/9,2	solitaire	240	W
	4	5 485 045	4 998 448	22	10,5	4,5	6,0	4,5		stand	29	SI
	5	5 485 325	4 998 329	43	13,0	1,8	11,2	1,8		solitaire	24	SI
Ogulin	6	5 523 355	5 014 828	33	10,0	2,0	8,0	2,0		solitaire	247	SI
	7	5 523 355	5 014 828	46	18,5	4,0	14,5	4,0		solitaire	247	SW
	8	5 522 993	5 017 917	53	14,0	2,2	11,8	2,2	12,0/11,3	solitaire	274	S
	9	5 525 511	5 016 858	65	17,5	5,0	12,5	3,2		edge	229	S
	10	5 525 582	5 016 762	32	13,0	3,5	9,5	1,8		solitaire	233	SW
Nova Kapela	11	5 698 201	5 016 225	22	10,0	2,8	7,2	2,8		solitaire	217	SI
	12	5 698 201	5 016 225	18	8,0	1,8	6,2	1,8		solitaire	217	SI
	13	5 698 201	5 016 225	65	13,5	4,5	9,0	4,5		solitaire	217	SI

$d_{1,30}$ (cm) – tree diameter at breast height, h_{tot} (m) – total tree height, H_t (m) – trunk height, H_c (m) – crown height, H_{vb} (m) – height to the first live branch, X_c/Y_c (m) – crown projection to the ground

The two thickest service trees grow in the localities of Ogulin and Nova Kapela. One tree has a diameter at breast height of 65 cm and a height of 17.5 m. It grows as an edge tree with a leaning trunk and asymmetric crown. The other tree, like the first one, has a diameter at breast height of 65 cm, but is 4.0 m shorter than the first one. It grows as a solitaire with a very straight trunk and symmetrical crown. In terms of the social position of the investigated service trees only, it can be concluded that in the majority of cases they grow as solitary trees in old orchards, vineyards, along pathways, in meadows and around homesteads (11), while only a small number are found in stands (1) or on forest edges (1).

The largest number of the studied service trees occurs in the south-eastern, and the smallest number in the northern and western exposures. The southern and south-western exposures are equally represented.

Table 4 Data on wild service trees (*Sorbus torminalis* (L.) Crantz) from six localities in the Republic of Croatia

Location	O. n.	Coordinate		$d_{1,30}$	h_{tot}	H_t	H_c	H_{vb}	X_c/Y_c	Social position	Altitude	Exposure
		x	y	(cm)	(m)	(m)	(m)	(m)	(m)			
Ogulin	1	5524 142	5014701	21	10,0	3,0	7,0	3,0		edge	245	SW
	2	5523633	5015907	62	13,5	2,5	11,0	2,5	13,5/13,8	solitaire	263	SW
	3	5523697	5016168	33	9,5	2,2	7,3	2,2		solitaire	251	SW
	4	5523531	5016708	74	22,0	2,5	19,5	2,5	13,8/15,3	solitaire	259	SW
Korenica	5	5554743	4973326	56	15,5	2,0	13,5	2,0	12,5/11,0	solitaire	355	SI
Medvednica	6	5575257	5080886	28	12,0	8,0	4,0	6,0	4,1/5,1	stand	488	S
	7	5575257	5080886	13	12,0	6,0	6,0	6,0	3,6/4,0	stand	488	S
	8	5575247	5080973	26	14,0	5,0	9,0	5,0	5,0/6,0	stand	541	S
	9	5575220	5080960	36	14,0	7,0	7,0	6,0	5,8/6,6	stand	542	S
	10	5575249	5080990	25	13,5	6,5	7,0	4,5	5,4/6,0	stand	526	SI
	11	5575260	5080879	30	14,0	4,0	10,0	4,0	5,6/5,0	stand	488	SI
	12	5575314	5081040	19	10,0	4,5	5,5	4,5	3,5/3,0	stand	490	SI
	13	5575343	5081147	9	5,5	1,5	4,0	1,5	1,5/3,0	stand	498	SI
	14			21	17,0	6,0	11,0	6,0	5,8/4,5	stand		SI
	15	5575079	5080619	25	17,0	12,0	5,0	4,5	4,0/7,0	stand	434	SW
Psunj	16	5664499	5025115	47	21,5	10,5	11,0	10,5		edge	265	SW
	17	5664393	5023755	56	29,0	12,0	17,0	11,0		stand		SW
	18	5668070	5020965	11	9,0	1,9	7,1	1,9		edge	208	S
	19	5668103	5020953	16	11,0	3,0	8,0	3,0		edge	216	S
	20	5668103	5020953	11	8,0	4,0	4,0	2,7		edge	216	S
	21			9	5,0	2,0	3,0	1,3		stand		S
	22			9	7,0	4,0	3,0	3,0		stand		S
	23	5674751	5018173	39	17,5	5,5	12,0	5,5		edge	217	S
	24	5674915	5020622	24	20,0	12,0	8,0	12,0		stand	235	SW
	25	5674700	5019684	25	14,0	7,0	7,0	2,5		stand		SI
Južni Dilj	26	5698542	5016394	30	21,0	4,5	16,5	2,2		edge	187	SI
	27	5698542	5016394	23	15,0	2,5	12,5	2,5		edge	187	SI
	28	5578868	5013500	10	6,0	1,3	4,7	1,3		edge		W
	29	5735799	5018380	7	5,0	2,0	3,0	1,8		edge	282	W
	30	5735402	5018801	4	4,0	1,5	2,5	1,5		edge	277	W
	31	5735613	5018727	8	7,0	2,2	4,8	2,2		edge	286	W
	32	5735697	5018436	11	8,0	4,5	3,5	2,5		edge	278	W
	33	5735851	5018354	7	5,0	1,8	3,2	1,8		edge	290	S
	34	5736221	5019011	4	5,0	2,2	2,8	1,0		edge	330	S
	35	5736221	5019011	4	5,0	1,5	3,5	1,0		edge	330	S
Sjeverni Dilj	36	5748678	5020090	38	14,0	3,0	11,0	3,0		edge	240	W
	37	5754188	5021274	57	17,0	2,5	14,5	2,0		solitaire	135	W

$d_{1,30}$ (cm) – tree diameter at breast height, h_{tot} (m) – total tree height, H_t (m) – trunk height, H_c (m) – crown height, H_{vb} (m) – height to the first live branch, X_c/Y_c (m) – crown projection to the ground

The thickest studied wild service tree grows in the locality of Ogulin with a diameter at breast height of 74 cm and a tree height of 22.0 m. It grows as a solitary tree with a low-laid and highly branched symmetrical crown of the 13.8/15.3 m projection. In terms

of the social position of the studied wild service trees only, it can be concluded that they generally grow as edge trees (17), then in stands (15) and as solitary trees (5). The largest number of the studied wild service trees grows in the southern and the smallest number in the western exposures. South-eastern and south-western exposures are almost equally represented.

Good crops of the whitebeam (*Sorbus aria* L.), service tree (*Sorbus domestica* L.) and wild service tree (*Sorbus torminalis* (L.) Crantz) in the Republic of Croatia occur at intervals of every four years, whereas that of the rowan (*Sorbus aucuparia* L.) occurs at intervals of every three years. The best crops of whitebeam, service tree and wild service tree were recorded in 2003 and 2007, and those of the rowan in 2003 and 2006. When the crops of rowan and wild service trees are poorer, the crop degree should be assessed and fruit for nursery production collected as soon as possible to avoid danger of birds. Unlike the other three species, no cropless years were recorded for the service trees in the studied period (2003 – 2008).

In terms of whitebeam crop in the four localities in the Republic of Croatia in the period from 2003 to 2008, a good crop on average occurred in 2003 and 2007, with the best crop recorded in 2007. There is no data in literature related to whitebeam crops, which renders comparison impossible.

According to Harris and Stein (1974), the rowan begins bearing seed at about 15 years of age, and a good crop occurs almost annually, which is contrary to research by Drvodelić (2010), where the interval of full yield was found to be every three years. Wallenius (1999) reported that in Finland, annual fruit yield correlated negatively with the previous year yield (data from 1956 to 1996).

According to Schmeling (2000), the service tree bears abundant quantities of fruit, and every two to three years solitary trees bear hundreds of kilograms of fruits. In the research by Drvodelić (2010), the interval of full yield occurs every four years.

Barengo et al (2001) point out that a full yield of the wild service tree occurs every two years or three times in four years, while in stands the fruit-bearing trees are those whose crowns are exposed to light. According to research by Drvodelić (2010), the interval of full yield occurs every four years.

Oršanić et al. (2006) studied, among other things, the fructification of four species of the genus *Sorbus* L. in different localities in the Republic of Croatia in the period from 2003 to 2005 and found that the studied species did not fructify copiously every year. In terms of the fructification capacity, the mentioned species in Croatia manifest properties of transitional rather than pioneer tree species.

According to Euforgen (2007), vegetative regeneration is important for the species of the genus *Sorbus* L. Moreover, these species are highly sensitive to competition: they do not form pure stands. In general, these species occur as individual trees or small groups of trees. Due to the exceptionally high commercial value of the wood, especially that of wild service tree (*Sorbus torminalis*), the increasingly growing demand on the market leads to uncontrolled seed production and transfer.

The rowan is one of the most important pioneer tree species in the ecosystems of mountain spruce forests of Central Europe. It plays a significant role in the stability and natural regeneration of forest stands (Tesar and Tichy, 1990 and Raspe et al., 2000). In the progressive succession of vegetation after forest dieback caused by air pollution and other factors, the rowan has an indispensible role in forming the conditions for the occurrence of other tree species and preventing site weeding (Tesar and Tichy, 1990). Limiting the

growth of young rowan trees due to damage by wildlife can lead to a disturbance in the process of natural regeneration of forest stands and ecosystem stability.

The service tree belongs to pioneer tree species with a broad ecological valence. It is sensitive to competition of other species. It occurs individually or in smaller groups at altitudes up to 1.400 m (in the Mediterranean area), while in Central Europe it reaches altutides of up to 650 m (IDŽOJTIĆ and DRVODELIĆ, 2005).

More than any other species of the genus *Sorbus* L., the service tree has spread beyond its natural distribution range, primarily under the anthropogenic impact (planting seedlings). In Croatia, service trees currently grow as solitary trees in old private orchards, vineyards, along forest edges, pathways and similar. The service tree commonly regenerates vegetatively by root suckers, especially in warm and suitable sites. Due to inadequate silvicultural measures, it occurs very rarely within a stand. According to the technical bulletin for the preservation of service tree genofund EUFORGEN (2007), this species flowers regularly and produces large quantities of fruits that are dispersed effectively by birds and mammals, but natural regeneration from seed is scarce throughout Europe. The reasons for poor generative regeneration have not yet been fully understood. BARENGO et al. (2001) also report that natural regeneration from seed is very poor in Central Europe. The fruit contains only 1 – 2 seeds, and the suppressed trees in stands do not fructify at all. Since they frequently grow individually, such isolated trees are self-fertilized, which results in the less vital progeny, or in other words, in lower seed germination, lower seedling survival and lower increment of survived plants.

Autovegetative propagation of service tree by root suckers in some sites enables its survival. Forest (KOLLMAN and PFLUGSHAUPT, 2001) and/or rare old tree species (HUENNEKE, 1991) have certain advantages, such as, e.g. vegetative propagation and/or high resilience to stress, which allows them to survive even when there are very few specimens within a population or in isolation.

According to EUFORGEN (2007), the service tree is a heliophyte which tolerates shade only in the first few years. Despite its good growth capacity, it is a very weak competitor. It does not withstand lateral crown closure (crowns of neighbouring trees touching each other) and consequently, the service tree never dominates a stand. It is usually present as a few individuals in a mix of less competitive species. Due to its high drought tolerance, which compares to that of pubescent oak, it finds its niche on warm, dry, to extremely dry, poor, shallow sites. As a result of human activity, it may also be found in coppice and former coppice in standard type forests or in other favourable positions such as forest fringes or extreme slopes.

According to IDŽOJTIĆ (2004), the wild service tree belongs to noble tree species because it grows in mixed forests, has specific ecological requirements and produces high quality and valuable wood. Unlike the countries of Western Europe, it does not have any commercial value in the Republic of Croatia, but it is an important factor of biological diversity. Not only does its presence increase the number of trees in a community, but it also contributes to a higher number of animal species in a forest ecosystem. According to MATIĆ and VUKELIĆ (2001), the wild service tree is a pioneer or post-pioneer species with a broad ecological valence. It is a semi-sciophyte which tolerates shade well at an early age, but requires abundant light later on. It is a thermophilic to mesophylic species that is resistant to drought, cold and late spring frosts. Wild service trees and whitebeams generally occur in the communities of a hilly vegetation belt that belong to the alliance *Quercion pubescentis-petraeae*. These are thermophilic forests growing on the carbonate parent rock and rendzinas in warmer and more exposed positions. The terrains usually

include steep, dry and warm slopes. The forest areas are fragmented, degraded and generally privately owned. In the syndynamic sense, the above stands most frequently develop in the direction of forests of sessile oak and common hornbeam.

The wild service tree is out-competed by other silviculturally stronger species, while its growth is limited to dry and warm sites with shallow soils, where competition from other species is relatively reduced. In suitable sites, such as deep and mineral-rich fresh soils and in warm positions with relatively long vegetation periods, the wild service tree may attain heights of up to 30 m and may achieve a diameter at breast height (at rotation of 100 – 120 years) that surpasses 60 cm. In such sites, after the crown is freed, the annual diameter increment amounts to 1.0 – 2.0 cm. Since the wild service tree is highly susceptible to competition from other species in the community, its successful growth requires adequate silvicultural measures (adequate thinning). In old stands, the wild service tree should be utilized for propagation by root suckers (KOTAR, 1998).

The wild service tree grows abruptly in height (40 – 60 cm to 100 cm annually) in the first years of life and can reach 25 – 30 m in height under optimum site and light conditions. The tree grows slowly in diameter, but may reach up to 50 – 60 cm (or even 70 or 80 cm). It shows good self-pruning and does not develop epicormic branches following heavy artificial pruning or thinning. The more common defects on the wild service tree is the presence of low forks (at a height up to 3 m), hindering the production of high quality veneer logs. The wild service tree is a heliophyte and a post-pioneer species (early succession) that is highly sensitive to the competition from other species in a stand. It responds well to late thinning.

The wild service tree shows a good potential for natural regeneration (both generative by seeds and vegetative by stump sprouts or root suckers). The root suckers are more shade-tolerant that the seed-originated seedlings. The silviculture recommended for wild service trees is intensive, dynamic and tree-oriented. It involves high intensity weeding and cleaning-re-spacing, targeting the complete elimination of tall surrounding trees. Formative pruning is applied in order to remove the forks and the thick ascending branches and prevent the occurrence of the chandelier crown form. Formative pruning is performed after high pruning, the goal being to obtain a branch-free bole of minimum 3 m (best 6 – 7 m). There is a relatively high correlation (R = 0.7687) between the tree D. B. H. and the mean crown diameter of the wild service tree (HOCHBIRCHLER et al., 2001 and NICOLESCU, 2007). Heavy thinning from above is performed to favour the growth and development of the final crop trees selected at the end of the pole stage. At rotation ages of 100 – 120 years, the well tended trees grown for veneer production are expected to have at least 60 cm D.B.H., which will correlate firmly with the crown width. The width of their annual rings will be equal and will range between 2.5 and 4 mm (NICOLESCU et al. 2008).

RASMUSSEN and KOLLMANN (2004) report that, unlike it poor generative propagation, the wild service tree is capable of forming a large number of root suckers which may maintain the local population, since individual specimens reach a maximum age of only 150 – 200 years. Solitary wild service trees may form suckers in a 5 m circle from the trunk. According to EUFORGEN (2007), vegetative propagation by root suckers may increase the tree's competing abilities. This is the major way to colonize degraded sites and to survive the competition from other tree species.

Such a method of vegetative propagation is frequent in stunted, overshadowed trees (BARENGO et al. 2001). Their sprouting vigour from the stump is lower. In Europe, the wild service tree rarely propagates by seeds, and the most common way of propagation is vegetative by root suckers.

According to EUFORGEN (2007), for long-term sustainability of wild service tree genetic resources, forest management must be oriented in favour of each single tree. First, competition from neighbouring trees must be controlled and wild service trees need to be released at each marking and cutting operation. Second, the forester must be aware that the seed of the neighbouring compartments will also contribute to regeneration. Most importantly, regeneration of wild service tree must be established before that of social broadleaves. In this way, the young wild service tree seedlings are given a competitive advantage against oaks or beeches. It is also important to ensure a regular distribution of wild service tree even with small clusters of single individuals. The forester must ensure the presence of a favourable site for new establishments. On the regional scale, an effort must also be made to favour the greater presence of wild service trees.

CONCLUSIONS

The thickest studied of whitebeam tree has a D.B.H. of 25 cm a height of 10.7 m. of whitebeam trees usually grow as solitary trees and much less frequently as edge trees. The largest number of the investigated of whitebeam trees grows in the western, and the smallest number in the southern and south-eastern exposures. The thickest investigated rowan tree has a D. B. H. of 29 cm and a height of 11.0 m. The rowan generally grows as a solitary tree and much less frequently as an edge or stand tree. The largest number of the investigated rowan trees grows in the north-eastern, and the smallest number in the south-eastern exposures. The north-western and southern exposures are equally represented. The thickest service tree has a DHB. of 65 cm and a height of 17.5 m. In the majority of the cases the trees grow as solitaires in old orchards, vineyards, along pathways, in meadows and around homesteads, while only a small number grows in forest stands or on forest edges. The largest number of the studied trees grows in the south-eastern and the smallest in the northern and western exposures. Southern and south-western exposures are similarly represented. The thickest wild service tree has a d.b.h. of 74 cm and a height of 22.0 m. The trees generally grow as edge trees, and then in stands as solitary trees. The largest number of the investigated trees grows in the southern and the smallest number in the western exposures. South-eastern and south-western exposures are almost equally represented. A good crop of the whitebeam, service tree and wild service tree in the Republic of Croatia occurs at intervals of every four years, while that of the rowan at intervals of every three years. Unlike the other three species, no cropless years were recorded form the service tree in the study period (2003 – 2008). Vegetative propagation is important for the species of the genus *Sorbus* L. These species are characterized by sensitivity to competition and the non-existence of pure stands. More than any other species of the genus *Sorbus* L., the service tree has spread beyond its natural distribution range, primarily under the anthropogenic impact.

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