Ecology and distribution of *Sorbus torminalis* (L.) Crantz. in Slovakia

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ABSTRACT: Wild service tree belongs among rare woody plants tolerant to higher temperatures and low soil humidity. There are available data from analyses of 34 wild service tree localities in Slovakia. The majority of analyzed localities (70%) were on south-exposed stands (SE, S, SW); 97% of these were in altitudes up to 600 m. Wild service tree prefers biotopes of the oak-hornbeam forests. The highest frequency of this woody plant was found in group of forest site types *Fageto-Quercetum.* According to altitudinal vegetation stages, the majority of stands (85%) were in the 3rd and 2nd vegetation stage, where potential evapotranspiration is higher than the sum of precipitation. From March to September the water deficit is approximately 100–150 mm. The most frequent are stands with mountain climate (62%) with prevalence of moderately warm (38%) and warm (15%) climate. Wild service tree grows mainly on soils with favourable physical characteristics and adsorbing complex (65% of stands). The soils are fertile and well supplied with nutrients (Luvisols, Cambisols). Some localities (35%) have soils rich in minerals; however, their soil chemistry is one-sided, so they are mostly little fertile (Rendzinas). Regarding the water content in soils, Cambisols have generally sufficient water supply; Luvisols have lower water supply with a possibility of their aridization; Rendzinas are mostly loose soils with good permeability, regarding their shallow profile with lower water capacity they have usually less water supply. According to the obtained data, it is possible to evaluate wild service tree as a light-demanding woody plant with requirements for higher temperatures and higher contents of nutrients in soil, able to grow on drier soils with infrequent occurrence of water deficit. With regard to the expected changes of global climate, wild service tree should substitute some tender woody plants with higher sensitivity to drought in landscape as well as in forestry.

Keywords: wild service tree; ecology; distribution; stand; community

Regarding the expected changes of global climate (Minďáš, Škvarenina 1994), much effort has been given recently to biodiversity preservation in woodland and forest crops. The attention is paid to rare woody plants, which were not at the top of interest for forestry in the past. They are tolerant to higher temperatures and low humidity. Ecological characteristics, intraspecific variability and timber production are investigated as well as other aspects important for their larger commercial utilization. Wider enforcement of these plants, as well as substitution of sensitive woody species is supposed in woodlands. Wild service tree (*Sorbus torminalis* [L.] Crantz.), also known as chequer tree, belongs among the above-mentioned tolerant plants, which occur on Slovak territory.

Present distribution of wild service tree in Slovakia is negatively affected by human activities related to conversion of oak stands to agricultural uses (crops and orchards, on the warmest stands vineyards). In addition, young plants are damaged by browsing of wildlife and by grazing of livestock. Wild service tree has a weak stool sprouting capacity; more frequent is root sprouting. However, the sprouts grow slowly, and thus in comparison with other predominant woody plants (hornbeam, lime) they are disadvantaged. For this reason wild service tree tree declined from vegetative regenerated forests (coppice forests). Its restoration on original stands as well as establishment in suitable conditions of higher vegetation zones are actually important. The distribution and phenotypic traits of wild service tree has already been studied in some regions of the Czech Republic (since 2001) within the project of *Preservation and Conservation of the Gene Pool of Forest Woody Plants* (Benedíková, Kyseláková 2005).

Supported by the Scientific Grant Agency of the Ministry of Education of the Slovak Republic and Slovak Academy of Sciences VEGA, Grant No. 1/3466/06 *Wild Service Tree in Slovakia*.

Wild service tree is distributed in warmer regions of Europe, grows in conditions of ocean and intermediate climate, and avoids stands with continental climate. The NW border of the area of its natural distribution starts on the British Isles, where it reaches up to 54 degrees north latitude. It does not occur in lowlands of the Netherlands, in the north-west part of Germany and on the Jutland Peninsula. Northern border of its distribution continues from the Labe River estuary along the coast of the Baltic Sea up to 20 degree of east longitude, where it turns south and crosses north foothills of Carpathian Mountains, leads up to the Dnieper River, and then continues to Caucasus Mountains. It grows in Asia Minor, on the Balkan Peninsula (except southern part of Greece), on the Italian and Iberian Peninsulas; some isolated occurrences are mentioned also from the north-east part of Africa. The most abundant occurrence is in France (Kausch 1994).

In Slovakia, wild service tree occurs mainly in the southern regions. The north border crosses Javorníky northward from Bytča and follows to the Strážov Mountains, crosses south part of Lesser Fatra, Žiar, Kremnica Mountains and Greater Fatra, it reaches up to Moštenica and follows to Muráň Plateau, Spišské Podhradie, Sabinov, Ondava Highlands and Vihorlat Mountains. It grows from the lowest localities approximately up to the altitude of 650 m, with the maximum altitude 800 m a.s.l. in Stolické Hills near Ratkovské Bystré (Blatný, Šťastný 1959).

According to Májovský (1992), it is a submediterranean species from the region Europe – Asia Minor; on our territory it generally occurs on warm stands of various oak forests and rarely on warm stands of beech forests (communities *Quercetalia pubescentis, Quercetalia robori-petraeae, Querco-carpinion, Cephalanhero-Fagion*). Wild service tree is considered to be a light-demanding/semi-shade and warm-requiring woody plant, grows single or in little groups from upland to submontaneous zone (there it occurs just on inversion stands or on specific exposures). Good height values and tree habit it reaches especially on deep or skeletal fresh loamy soils rich in basic components with neutral or moderately acid reaction. On rock soils it has lower height dimensions and less quality of trunk, more often grows in groups. Wild service tree is a thermophilic plant with good resistance to low temperatures. In our environmental conditions it is rarely damaged neither by stronger frosts.

Wild service tree requires higher contents of basic nutrients in soil (mainly lime). It grows best on deep loamy soils with neutral or moderately acid reaction, but occurs also on medium deep soils with higher content of skeleton, even on shallow, typologically non-developed soils and rocks; they are some subtypes of rankers, rendzinas, and para-rendzinas. The most favourable are fresh humid soils, but the tree is also able to grow on very dry localities with shallow soils and water deficiency in growing season. Wild service tree does not appear on wet soils (Pagan 1996). In past it was considered to be a woody plant of the poor soils and extreme south stands. A higher occurrence on mentioned stands was probably a result of its better resistance to competition of oak or beech individuals (Ewald et al. 1994).

The physiological optimum of wild service tree is similar to beech optimum, but it is slightly forwarded to drier conditions. The best growth is reached on fresh, deep and rich soils. The preference of arid and warm stands on poor soils is probably connected with lower competition of other woody plants, mainly beech (Namvar, Spethmann 1985).

MATERIAL AND METHODS

The wild service tree was studied in Slovakia in 1997–2000. The range of evaluated topics focused on variability of specific traits, growth abilities, as well as environmental conditions. The field data were collected in 34 localities.

The analyses of environmental conditions according to altitude, exposure, ecological-climatic amplitude and soil representatives on particular localities were performed; they allowed identifying the range of environmental conditions under which wild service tree occurs in Slovakia.

Altitudinal data of the analyzed localities were obtained from *Stand maps of forest management units* at scale 1:10,000, which were ellaborated by Lesoprojekt Zvolen. Exposure of each locality was identified using a compass. The classification of climate-geographic types and subtypes was done according to Tarábek (1980) and Špánik et al. (1999). Mean temperatures and sums of precipitation were obtained from the digital database Škvarenina and Minďáš et al. (2003). The identification of soil representatives was done according to the map of soils (Šály, Šurina 2002). The classification of the geomorphological units was done according to *Geomorphological classification of the SSR and CSSR* at scale 1:500,000 (Kolektív 1986).

Forest typological units (forest site types and groups of forest site types) were used for description of phytocoenological structure of the analyzed wild service tree habitats and their carrying capacity. Stands were also classified according to the Natura 2000 network. Conversion was done according to

Table 1. Characteristics of wild service tree stands in Slovakia

No.	Locality	Geomorphological unit	Exposure	Altitude (m)	Soils	Age	Description of stand and species structure
1	Sirková	Malé Karpaty	SE	270	K_1	135	*Fagus*, *Quercus*, *Carpinus*, *Alnus*
2	Fráterka	Chvojnická pahorkatina	E	380	H_5	110	*Quercus* 44, *Fagus* 33, *Tilia* 10, *Carpinus* 06, *Larix* 04, *Acer pseudoplatanus* 03
3	Haluzice	Považské podolie, Bielokarpatské podolie	SE	320	R_1		*Quercus* sp., *Fagus*, *Pyrus*, *Malus*, *Acer*, *S. torminalis*, *S. domestica*, *Rhamnus*, *Cornus*, *Berberis*, *Crataegus*, *Rosa* sp.
4	Záblatie	Považské podolie	SE	380	K_3	90	*Carpinus* 55, *Quercus* 40, *Acer pseudoplatanus* 05
5	Zlatovce	Považské podolie	S	300	K_3		Abandoned orchards: *Quercus*, *Cerasus*, *Carpinus*, *Castanea*, *S. torminalis*, *S. domestica*, *Pyrus*, *Malus*, *Berberis*, *Rhamnus*, *Crataegus*, *Rosa* sp.
6	Skalka	Považské podolie	E	300	R_1	70	*Quercus* 70, *Tilia* 15, *Carpinus* 10, *Fagus* 05
7	Dolná Súča	Biele Karpaty, Bánovské bradlá	SW	260	K_3	65	*Quercus* 55, *Carpinus* 25, *Cerasus* 05, *P. tremula* 05, *Pinus* 10
8	Dohňany	Javorník, Javornícka brázda	S	420	K_3	70	*Quercus* 80, *Fagus* 20, *Sorbus torminalis*, *Carpinus*
9	Držkovce	Podunajská pahorkatina, Bánovská pahorkatina	NE	250	K_3	60	*Pinus* 70, *Quercus* 10, *Q. cerris* 10, *S. torminalis* 05, *Populus* 05
10	Patrovec	Podunajská pahorkatina, Bánovská pahorkatina	SE	350	K_3	100	*Quercus* 90, *Q. cerris* 10
11	Trenčianske Mitice	Strážovské vrchy, Trenčianska vrchovina	SW	470	R_1	120	*Fagus* 77, *Carpinus* 10, *S. torminalis* 04, *Acer* 04, *Quercus* 03, *Q. cerris* 02
12	Soblahov	Strážovské vrchy, Trenčianska vrchovina	SW	380	R_1	70	*Carpinus* 45, *Fraxinus* 20, *Quercus* 10, *Fagus* 10, *Acer* 10, *Picea* 05
13	Hradište	Strážovské vrchy, Trenčianska vrchovina	SW	450	R_1	95	*Fagus* 90, *Carpinus* 05, *Fraxinus* 05
14	Motešice	Strážovské vrchy, Trenčianska vrchovina	SW	400	R_1	70	*Q. cerris* 85, *Fagus* 05, *Pinus* 10
15	Machnáč	Strážovské vrchy, Zliechovská hornatina	SE	560	R_1	95	*Fagus* 63, *Picea* 15, *Larix* 07, *Acer* 07, *Quercus* 05, *Pinus* 03
16	Veľké Lúky	Strážovské vrchy, Zliechovská hornatina	SE	580	R_1	120	*Fagus* 96, *Acer* 04
17	Kšinná	Strážovské vrchy, Nitrické vrchy	SW	720	R_1	80	*Fagus* 90, *Acer* 05, *Fraxinus* 05
18	Marušiná	Strážovské vrchy, Nitrické vrchy	S	300	K_3	85	*Quercus* 60, *Q. cerris* 40
19	Uhrovec	Strážovské vrchy, Nitrické vrchy	NE	580	K_1	85	*Fagus* 95, *Pinus* 05
20	Bajtava	Burda	SW	350	H_1	60	*Q. cerris* 65, *Quercus* 35
21	Krehora	Krupinská planina, Modrokamenské úbočie	E	380	K_1	85	*Quercus* 50, *Fagus* 30, *Carpinus* 20
22	Príbelce	Krupinská planina, Modrokamenské úbočie	SE	400	K_1	80	*Q. cerris* 60, *Quercus* 30, *Carpinus* 10
23	Turová	Kremnické vrchy, Turovské predhorie	SE	450	K_1	100	*Quercus* 54, *Carpinus* 20, *Fagus* 10, *Quercus cerris* 10, *Pinus* 06
24	Mičiná	Zvolenská kotlina, Zvolenská pahorkatina	E	420	R_2	50	*Fagus* 45, *Pinus* 35, *Carpinus* 20
25	Hrachovo	Revúcka vrchovina, Rimavské podolie	SE	300	K_1	100	*Quercus* 100
26	Slizské	Revúcka vrchovina, Železnícka brázda	SW	430	R_2	100	*Pinus* 40, *Carpinus* 20, *Quercus* 20, *Fagus* 10, *Picea* 10

Table 1 to be continued

No.	Locality	Geomorphological unit	Exposure	Altitude (m)	Soils	Age	Description of stand and species structure
27	Jelšava	Revúcka vrchovina, Hrádok	NW	500	K_1	80	*Fagus* 90, *Quercus* 05, *Carpinus* 05
28	Plešivec	Slovenský kras, Plešivská planina	NW	550	R_2	60	*Carpinus* 50, *Fagus* 30, *Fraxinus* 10, *Picea* 10
29	Terebľa	Slánske vrchy, Milíč	SE	500	K_6	120	*Fagus* 66, *Quercus* 32, *Carpinus* 01, *S. torminalis* 01
30	Čatoreň	Slánske vrchy, Milíč	SE	300	K_6	120	*Quercus* 57, *Fagus* 31, *Carpinus* 04, *Acer* 02, *Q. cerris* 02, *Alnus* 03, *S. torminalis* 01
31	Bunetice	Slánske vrchy, Olšavské predhorie	SW	320	K_1	120	*Fagus* 85, *Carpinus* 10, *Quercus* 05
32	Štefanovce	Ondavská vrchovina, Kurimská brázda	E	220	K_2	120	*Pinus* 59, *Fagus* 29, *Carpinus* 05, *S. torminalis* 05, *Quercus* 02
33	Vinné	Vihorlatské vrchy, Kyjovská planina	SE	400	K_1	60	*Quercus* 100
34	Senderov	Vihorlatské vrchy, Kyjovská planina	SE	300	K_1	85	*Quercus* 100

the *Catalogue of Slovak Biotopes* 2002 (Stanová, Valachovič 2002).

Localities were classified into packages according to the stand altitude, exposure, climate-geographic types and soil representatives. Afterwards, the analysis of value range for each environmental characteristic was done in packages, as well as in the whole file of studied stands.

RESULTS

Characteristics of the analyzed localities

34 localities with wild service tree were analyzed. Their distribution is illustrated in Fig. 1, brief characteristics are given in Table 1. It is important to mention that the majority of localities were found in woodlands, just two (Haluzice No. 3, Zlatovce No. 5) on a forest-steppe stand, in an abandoned fruit orchard with natural seeding of forest tree species. Number of evaluated plants in analyzed localities varied from 7 (Sirková No. 1) to 30 (Terebľa No. 29). We used a principle of plant concentration on smaller area in similar environmental conditions.

Classification of localities according to stand altitude

Considering the influence of stand altitude on environmental conditions, 9 groups of the wild service tree localities were created; they were divided with 50 m of the altitude difference. They are recorded in Table 2.

The majority of analyzed localities (23%) were in the altitude of 251–300 m. Slightly less occurrences were observed in the altitude of 351–400 m (20%).

Table 2. Classification of *Sorbus torminalis* (L.) Crantz. stands according to altitude

Altitude (m)	Locality identification number	*n*	%
201–250	9, 32	2	6
251–300	1, 5, 6, 7, 18, 25, 30, 34	8	23
301–350	3, 10, 20, 31	4	12
351–400	2, 4, 12, 14, 21, 22, 33	7	20
401–450	8, 13, 23, 24, 26	5	15
451–500	11, 27, 29	3	9
501–550	28	1	3
551–600	15, 16, 19	3	9
601–650			
651–700			
701–750	17	1	3
Total		34	100

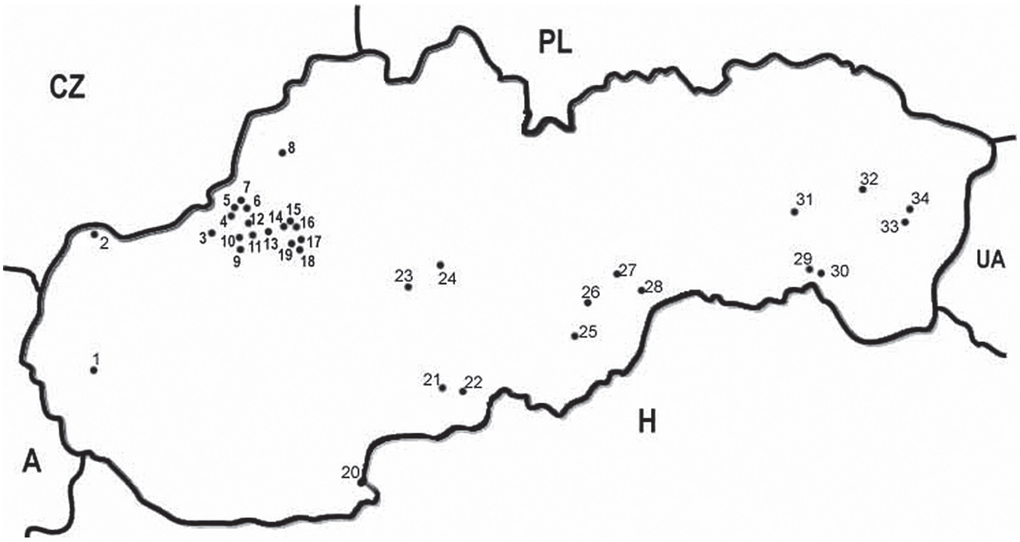

Fig. 1. Distribution of localities of the wild service tree (*Sorbus torminalis* [L.] Crantz.) in Slovakia

Less frequent (15%) were localities in the altitude of 401–450 m, as well as in 301–350 m (12%). Three localities (9%, identically) were in the altitudes of 451–500 m and 551–600 m. One locality (3%) was in the altitude of 501–550 m and one in 701–750 m.

More than 90% of analyzed localities were in the altitudes up to 500 m a.s.l.

Classification of the localities according to exposure

Localities were listed according their exposures (Table 3). The occurrence of localities according to exposure and stand altitude is illustrated in Fig. 2.

The obtained data show that no stands with satisfactory occurrence of wild service tree were found on northern and western exposures. The most of localities (25%) were on south-east exposures, other stands were on south-west exposures (26%) and on east exposures (15%).

On north-east and south exposures there were identically 9% of localities and two localities (6%) were on north-west exposure.

Locality 17 (Kšinná) with the highest altitude 720 m, had south-west exposure. It is evident from 34 analyzed localities that majority (70%) was on south-exposed stands (SE, S, SW); as opposed to that, only 15% of the localities were north-exposed (NE, NW).

However, no suitable locality was found on west exposure; which is in accordance with the prevalent occurrence and the requirements of the species.

Climatic characteristics of the analyzed stands with wild service tree

The stands with wild service tree were classified into climate-geographic types and subtypes (Tarábek 1980) for an analysis of their ecological-climatic amplitude. Data of the mean temperatures and annual sum of precipitation were obtained from the digital database (Škvarenina, Minďáš et al. 2003); they are given in Table 4.

The lowest number of localities with wild service tree (4 = 12%) belong to the type of plane climate (NK) and to the subtype of the mostly warm climate (PT) (this climate is arid to slightly humid, with

Table 3. Classification of *Sorbus torminalis* (L.) Crantz. stands according to exposure

Exposure	Locality number	*n*	%
N			
NE	9, 15, 19	3	9
E	2, 6, 21, 24, 32	5	15
SE	1, 3, 4, 10, 16, 22, 23, 25, 29, 30, 33, 34	12	35
S	5, 8, 18	3	9
SW	7, 11, 12, 13, 14, 17, 20, 26, 31	9	26
W			
NW	27, 28	2	6
Total		34	100

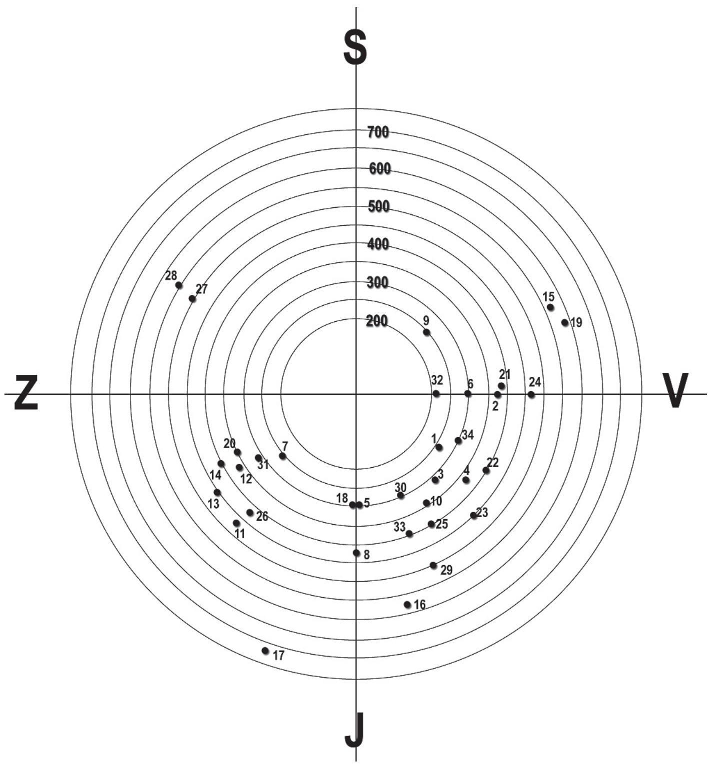

Fig. 2. The arrangement of the wild service tree localities according to altitude and exposure

mild inversion of the air temperatures). The average temperature in January (T I.) ranges from –2.0°C to –2.8°C, average temperature in July (T VII.) ranges from 17.0°C to 18.5°C, the average annual temperature (T I.–XII.) is 8.1–9.3°C. The annual sum of precipitation (Z) is 600–780 mm.

A higher number of localities (9 = 26%) belong to the type of fold "climate" with high inversion of air temperatures and arid to humid climate. Five of these belong to the subtype of warm climate (T) with average temperature in January (T I.) ranging from –2.5°C to –3.5°C, in July (T VII.) ranging from 17.0°C to 18.5°C, and average annual temperature (T I.–XII.) 7.0°C to 8.6°C. The annual sum of precipitation (Z) is 650–750 mm. The subtype of the other four localities is moderately warm climate (MT) with a range of average January temperatures (T I.) from –2.5°C to –3.9°C, in July (T VII.) from 17.5°C to 18.5°C and average annual temperature (T I.–XII.) from 7.9°C to 9.3°C, the annual sum of precipitation (Z) is 650–670 mm.

The highest number of localities (21 = 62%) belong to the climate-geographic type of mountain climate; it is moderately humid to humid with mild inversion of the air temperatures. Five of them belong to the subtype of warm climate with average January temperatures (T I.) ranging from –1.5°C to –2.8°C and average July temperatures (T VII.) from 17.8°C to 19.5°C. The average annual temperature (T I.–XII.) is 6.2–8.9°C, annual sum of precipitation 580–700 mm. The majority of localities belong to the subtype of moderately warm climate with average temperature in January (T I.) ranging from –1.7°C to –3.8°C, in July (T VII.) ranging from 16.5°C to 18.8°C. The average annual temperature (T I.–XII.) is 6.1–8.9°C and annual sum of precipitation 670–850 mm. Only three localities were classified in the subtype of moderately cold climate (MCh) with average January temperature (T I.) ranging from –3.5°C to –4.0°C, in July (T VII.) ranging from 16.0°C to 17.0°C. The average annual temperature (T I.–XII.) ranges from 6.0°C to 7.7°C and annual sum of precipitation is 880–900 mm.

The ecological climatic amplitude of the analyzed wild service tree localities is relatively wide. It ranges from plane climate through fold climate to the mountain climate. The most frequent stands are those with prevalence of the warm and moderately warm subtypes of the fold climate.

Within all groups of the analyzed localities, the average January temperatures range from –1.5°C to –4.0°C, the average July temperatures range from 16.0°C to 19.5°C. The annual average temperatures range from 6.0°C to 9.3°C and annual sum of precipitation reaches values ranging from 580 mm to 900 mm.

Phytocoenological characteristic of analyzed localities

Classification of the forest crops with occurrence of wild service tree into groups of forest site types (Zlatník 1976) was done according to the records given in the *Forest Management Plans* elaborated by Lesoprojekt Zvolen. The obtained data are listed in Table 5.

Table 4. Climatic characteristics of the *Sorbus torminalis* (L.) Crantz. localities in Slovakia

No.	Locality	Exposure	Altitude (m)	Climatic characteristics						
				T I. (°C)	T VII. (°C)	T IV.–IX. (°C)	average temperature (°C)	sum of precipitation (mm)	climate-geographic	
									type	subtype
1	Sirková	SE	270	–2.5	18.7	15.9	9.3	770	NK	PT
2	Fráterka	E	380	–2.8	17.8	14.7	8.2	780	NK	PT
9	Držkovce	SE	250	–2.0	19.0	14.9	8.6	600	NK	PT
10	Patrovec	SE	350	–2.3	18.5	14.4	8.1	700	NK	PT
6	Skalka	E	300	–3.0	18.5	14.5	7.9	650	KK	T
7	Dolná Súča	SW	260	–2.5	18.5	15.9	8.6	630	KK	T
8	Dohňany	S	420	–3.5	17.0	13.0	7.0	700	KK	T
12	Soblahov	SW	380	–2.5	18.5	14.9	8.3	700	KK	T
24	Mičiná	E	420	–3.5	17.5	14.9	7.8	750	KK	T
3	Haluzice	SE	320	–3.0	18.5	14.5	7.9	650	KK	MT
4	Záblatie	SE	380	–2.5	18.0	15.9	9.3	670	KK	MT
5	Zlatovce	S	300	–3.0	18.7	14.5	7.9	650	KK	MT
32	Štefanovce	E	220	–3.9	17.5	15.7	9.0	650	KK	MT
20	Bajtava	SW	350	–1.5	19.5	14.9	8.5	580	HK	T
26	Slizské	SW	430	–2.0	18.8	14.9	7.8	690	HK	T
29	Terebľa	SE	500	–2.8	17.8	12.6	6.2	700	HK	T
30	Čatoreň	SE	300	–2.0	18.2	15.3	8.9	680	HK	T
31	Bunetice	SW	320	–2.2	18.8	15.3	8.8	670	HK	T
11	Trenčianske Mitice	SW	470	–3.8	16.5	13.5	7.2	790	HK	MT
13	Hradište	SW	450	–2.0	17.5	13.3	7.1	750	HK	MT
14	Motešice	SW	400	–1.7	18.0	14.0	7.4	700	HK	MT
15	Machnáč	NE	560	–3.0	17.0	14.0	7.7	850	HK	MT
18	Marušiná	S	300	–1.7	17.7	15.3	8.9	700	HK	MT
21	Krehora	E	380	–3.0	17.0	14.7	8.2	680	HK	MT
22	Príbelce	SE	400	–3.0	17.0	14.2	7.6	685	HK	MT
23	Turová	SE	450	–3.5	17.0	14.5	7.3	770	HK	MT
25	Hrachovo	SE	300	–3.5	17.7	14.5	7.9	670	HK	MT
27	Jelšava	NW	500	–3.5	17.2	12.6	6.2	800	HK	MT
28	Plešivec	NW	550	–3.5	17.0	12.5	6.1	720	HK	MT
33	Vinné	SE	400	–3.5	18.5	14.9	7.8	850	HK	MT
34	Senderov	SE	300	–3.5	18.8	15.3	8.9	800	HK	MT
16	Veľké Lúky	SE	580	–3.5	17.0	14.0	7.7	880	HK	MCH
17	Kšinná	SW	720	–4.0	16.0	13.0	6.0	900	HK	MCH
19	Uhrovec	NE	580	–3.5	17.0	12.6	6.2	880	HK	MCH

NK – plane climate, KK – fold climate, HK – mountain climate, T – subtype of warm climate, MT – subtype of moderately warm climate, PT – subtype of mostly warm climate, CH – subtype of cold climate

The highest number of localities (34%) was identified as *Fageto-Quercetum,* which are classified as biotopes of the oak-hornbeam forests. High number of localities was in the group of *Fagetum pauper* (26%); these include the biotopes classified among 9150 Medio-European limestone beech forests (*Cephalanthero-Fagion*), as well as biotopes classified among 9130 *Asperulo-Fagetum* beech forests.

The forest site types *Querceto-Fagetum* include 24% of stands; the latter being classified also among 9130 *Asperulo-Fagetum* beech forests.

Table 5. Survey of the localities according to groups of forest site types (Zlatník 1976; Križová 1998)

Group of forest site types		Locality number	*n*	%
CQ	*Carpineto-Quercetum*	20	1	3
CoQ	*Corneto-Quercetum*	3, 5	2	6
FQ	*Fageto-Quercetum*	1, 2, 4, 8, 9, 10, 14, 22, 23, 25, 30, 32	12	34
QF	*Querceto-Fagetum*	6, 7, 11, 12, 21, 26, 31, 33	8	24
Fp	*Fagetum pauper inferiora*	13, 16, 18, 19, 24, 27, 29, 34	8	24
Fp	*Fagetum pauper superiora*	15	1	3
QFtil	*Querceto-Fagetum tiliosum*	28	1	3
Ftil	*Fagetum tiliosum*	17	1	3
Total			34	100

Table 6. Survey of the localities according to altitudinal vegetation stages

Altitudinal vegetation stages	Group of forest site types	Locality number	*n*	%
1. Oak	*Carpineto-Quercetum*	20	3	9
	Corneto-Quercetum	3, 5		
2. Beech-oak	*Fageto-Quercetum*	1, 2, 4, 8, 9, 10, 14, 22, 23, 25, 30, 32	12	35
3. Oak-beech	*Querceto-Fagetum*	6, 7, 11, 12, 21, 26, 31, 33	17	50
	Querceto-Fagetum tiliosum	28		
	Fagetum pauper inferiora	13, 16, 18, 19, 24, 27, 29, 34		
4. Beech	*Fagetum pauper superiora*	15	2	6
	Fagetum tiliosum	17		
Total			34	100

Only a low number of wild service tree localities were recorded in the other listed groups of forest site types (*Carpineto-Quercetum* – classified among 91G0* Pannonian woods with *Quercus petraea* and *Carpinus betulus*; *Corneto-Quercetum* – classified among 91H0* Pannonian woods with *Quercus pubescens*; Q*uerceto-Fagetum tiliosum;* and *Fagetum tiliosum* – classified among 9130 *Asperulo-Fagetum* beech forests).

Classification of the analyzed localities according to altitudinal vegetation stages

The groups of forest site types are classified according to altitudinal vegetation stages. Vegetation stages are basic units characterizing the altitudinal climate conditions (vertical differentiation) through vegetation biocoenosis. Vegetation stages are climax geobiocoenoses dominating an area by its coverage, determined by the vegetation and modified according to the changes of climatic conditions with the changing altitude (Zlatník 1976).

The first altitudinal vegetation stage (oak) includes stands of the groups of forest types *Carpineto-Quercetum, Corneto-Quercetum* in 3 localities (9%) from the total of analyzed stands. According to Škvarenina et al. (2002), in this vegetation stage the potential evapotranspiration is higher than the amount of the precipitation fallen in vegetation period. There is a negative climatic water balance with deficit approximately –300 mm in vegetation period (March–September). The forest communities are compelled to use winter water supply in the soil profile. In such conditions, the plants with high level of eco-physiological adaptation and tolerance to water deficit or low soil humidity will survive, which means an expansion of the forest-steppe vegetation communities.

The second vegetation stage (beech-oak) comprises of the stands of the groups of forest types *Fageto-Quercetum*, together 12 localities, which represents 35% of the whole number of the analyzed stands. According to Škvarenina et al. (2002) the climatic water balance in the second vegetation stage has also a negative water deficit during vegetation period, but in comparison with the first stage it is lower (–150 mm). Sessile oak (*Quercus petraea*) is a dominant woody plant in these environmental conditions. However, on extreme stands in scattered forests of warm regions, dominant species are several woody plants of

Table 7. Survey of the soil representatives of the *Sorbus torminalis* (L.) Crantz. localities in Slovakia

	Soil representative	Locality number	*n*	%
R_1	Rendzic Leptosols and Eutric Cambisols associated with Rendzi-Lithic Leptosols	3, 6, 11, 12, 13, 14, 15, 16, 17	9	26
R_2	Rendzic Leptosols and Chromi-Rendzic Leptosols	24, 26, 28	3	9
H_1	Haplic Luvisols – locally eroded and Calcaric Regosols from loess	20	1	3
H_5	Stagni-Haplic Luvisols, Luvic Stagnosols and Planosols	2	1	3
K_1	Eutric Cambisols and Dystric Cambisols	1, 19, 21, 22, 23, 25, 27, 31, 33, 34	10	29
K_2	Eutric Cambisols associated with Stagni-Eutric Cambisols	32	1	3
K_3	Eutric Cambisols associated with Rendzic Leptosols and Calcaric Cambisols	4, 5, 7, 8, 9, 10, 18	7	21
K_6	Dystric Cambisols and Calcaric Umbrisols, associated with Leptosols	29, 30	2	6
Total			34	100

forest-steppe communities including wild service tree.

In the third vegetation stage (oak-beech), there are 17 localities classified in the groups of forest types *Querceto-Fagetum, Querceto-Fagetum tiliosum* and *Fagetum pauper inferiora,* representing 50% of the whole samples. According to Škvarenina et al. (2002) the climatic water balance during vegetation period is also negative and potential evapotranspiration is higher than the sum of precipitation. Mentioned deficit is lower than 100 mm.

The fourth vegetation stage (beech) includes just 2 localities classified in groups of forest types *Fagetum pauper superiora* and *Fagetum tiliosum*, which represents 6% of the whole number of analyzed stands. The fourth vegetation stage has a fairly equalized water balance.

Characteristics of the soils

Within the analyzed wild service tree localities 8 soil units were recorded (Šály, Šurina 2002). The survey of soil representatives is given in Table 7.

The most frequent were Eutric Cambisols (53%); they are regarded as good soils, deep enough with favourable physical properties, with satisfactory, even very good form of humus and sufficient content of nutrients (C/N ratio = 10–11, degree of sorptive saturation [V] = 50–70%, soil reaction within the main rhizosphere 5.5–6.5). Among these soils it is also possible to classify Dystric Cambisols, at lower altitudes (up to 800 m) they have similar qualitative traits as Eutric Cambisols (with C/N ratio = 11–13).

Rendzinas are the second most frequent soil units (35%). These soils have favourable adsorbing complex. They are skeletal and shallow with low humus content, with good penetration of water and low water bearing capacity. There is a high content of minerals, but the uptake of nutrients by plants is often negatively influenced by water deficit. The abundance of minerals is rather one-sided (prevalence of Ca, Mg, while other nutrients K, P, can be deficient). Because of the water deficit, mainly in lower altitudes, and one-sided soil reaction, rendzinas are considered to be low fertile soils (C/N ratio 9–11, pH 7.2–8). Chromi-Rendzic Leptosols (9%) have slight sorptive saturation with soil reaction pH 6–7, generally with higher rain capacity than other rendzinas. If they are medium deep and medium skeletal they are considered to be quite favourable soils.

Haplic Luvisols are the rarest soils (6%), they are classified among the most fertile soils with moderately acid even neutral reaction in the top soil levels. These soils are rich in minerals, with high-quality mull humus and lower water supply. With regard to lower water supply and possibility of drying, the mentioned nutrients are partially unavailable (C/N ratio is 10–11, degree of sorptive saturation [V] is 60–70%).

In general, soils have favourable physical characteristics and adsorbing complex, they are fertile and well supplied with minerals (Haplic Luvisols, Cambisols), or some of them are rich in minerals but the soil chemistry is one-sided and therefore they are mostly little fertile (Rendzinas).

According to the values of the soil reaction (pH) ranging within these soil representatives from 5.5–6.5 (Eutric Cambisols) to 7.2–8 (Rendzinas), it is possible to define the area of the acid and neutral soils as suitable for root system of the wild service tree.

With reference to the water in soils, Cambisols have generally sufficient water-supply (59% of localities), Haplic Luvisols have lower water-supply with a possibility of drying (6% of localities), Rendzinas (they occur in 35% of the analyzed localities) are mostly loose soils permeable for water; with regard to their shallow profile and low rain capacity, the latter have high water losses caused by leaching, so water supply is usually low there (Šály 1998).

DISCUSSION

Within the study of the wild service tree in Slovakia, the attention has been paid to the requirements for specific environmental conditions. Basic data were obtained from an analysis of ecological characteristics (stand altitude, exposure, climate-geographic type, group of forest types) on 34 localities with occurrence of *Sorbus torminalis*. Information allowed at least a brief assessment of the wild service tree requirements.

The whole area of the wild service tree distribution spreads from the South of England to the North of Africa, from Iberian Peninsula to Caspian Sea, Syria and Lebanon. In the north part of the mentioned area, it is a tree of warmer lowlands, in the Central Europe it occurs in uplands or even in lower altitudes of the mountains (800–1,000 m). In Greece it grows up to the altitude of 1,000 m, in Italy up to 1,100 m, in Sicily 1,250 m, in Lebanon 1,400 m, in the Caucasus Mountains 1,500 m, and in Asia Minor (Turkey) it reaches the maximum of its vertical distribution in the altitude of 2,200 m (Kausch 1994).

In Slovakia the wild service tree grows in southern regions from uplands to submontaneous zone (Májovský 1992). The horizontal and vertical distribution of the analyzed localities confirmed previous information of other authors (Blatný, Šťastný 1959); according to them wild service tree in Slovakia appears from the lowest stands up to the altitude of 650 m, with the maximum altitude of 800 m.

The analysis of vertical distribution of the localities, confirmed the occurrence of the wild service tree also on lower stands. The lowest locality was in the altitude of 220 m (Štefanovce) on east exposure, the highest locality was in 720 m a.s.l. (Kšinná) on south-west exposure. The majority of analyzed stands (23%) from the total of 34 localities were in altitudes ranging from 251 m to 300 m; 20% in the altitudinal range 351–400 m. 85% of stands were in altitudes up to 500 m. Just one locality (3%) was in the altitude of 501–550 m and one in 701–750 m.

In Romania, the wild service tree grows in uplands in the altitudes between 100–400 m (Dinca 2000).

According to our findings, in Slovakia (similarly as in the whole area of its natural distribution) the wild service tree is just an admixed species of forest stands. It appears single, or in little groups (Namvar, Spethmann 1985; Zeitlinger 1990; Lobžanidze et al. 1991; Májovský 1992; Schrötter 1992; Aas et al. 1993; Ewald et al. 1994; Kausch 1994; Schütte, Beck 1996; Wilhelm 1998).

Generally, it is evaluated as a semi-shade loving woody plant (Aas et al. 1993), sometimes even as a light demanding woody plant (Zeitlinger 1990). In young age it is tolerant to shading, but the requirement of sunlight increases with age (Ellenberg 1979; Lobžanidze et al. 1991; Májovský 1992; Aas et al. 1993; Pagan 1996; Wilhelm 1998).

As for the crown competition, wild service tree has quite a low power; however, it is higher on warm and arid slope stands (Aas et al. 1993). Relatively higher occurrence of wild service tree on such stands is explained by a lower competition of other species (mainly beech) (Namvar, Spethmann 1985; Schrötter 1992; Ewald et al. 1994).

There is information about better tolerance of shading on rich and freshly humid soils. In the country Mecklenburg-Vorpommern, wild service tree grows on closed beech stands under crown level, but some plants grow even in the upper canopy (Schrötter 1992). The ability of wild service tree to bear up under beech competition on more humid stands is also reported by Ewald et al. (1994). In two localities in Hassenhagen, wild service tree grew in crown canopy of beech, but reached lower dimensions of dbh (diameter at breast height). Similarly, in Brandenburg a few older wild service individuals grew in general level of upper canopy together with beech and oak, but more plants reached just the bottom part of crown canopy (Ewald et al. 1994). According to the findings of Wilhelm (1998) in Lorraine (Plateau Lorrain), wild service tree is tolerant to stronger shading than wild pear (*Pyrus pyraster*). It is the only woody plant there, growing under an influence of oak canopy. The latter creates shade habit with quite long, thin branches with low foliage density. Under such circumstances, wild service tree grows into crown canopy of light-demanding trees (mainly oaks). According to our findings (Bajtava locality), several individuals of wild service tree grew in the second forest storey under oak crown canopy.

However, the majority of evaluated plants were growing in oak and beech crown storey.

Distribution of the natural wild service tree stands according to exposure can support the opinion about a high demand of this taxon for light and warmth. Data given by Geiger (1961) show that north slopes get just half sum of absolute light emission in comparison with south slopes. No stand within our research was found on north exposure. Quite rare there were stands (5 = 15%) on north-east and north-west exposures as well as on east exposures. The highest number of stands (24 = 70%), were found on sunny and warm south-exposed localities (SE, S, SW).

Similar findings from Romania are given by Dinca (2000), where at least (4%) of wild service trees were growing on stands with north exposure, other 16% of individuals were found on north-exposed stands (NE 10%, NW 6%), and the highest number of trees (57%) occurred on south-exposed stands. On east exposures there were 13% of trees and on west exposure 14% of trees. According to the findings from Brandenburg, the majority of the wild service tree stands were on plane, quite frequent there were stands on south and south-west slopes. Just one stand was on a partly north-exposed slope (Ewald et al. 1994).

It is evident form the climatic characteristics of wild service tree stands that their ecological-climatic amplitude is quite broad from the plane to the mountain climate. The most frequent are stands with mountain climate (62%) with prevalence of the moderately warm (38%) and warm (15%) climate. Only three stands (9%) were classified in the subtype of moderately cold mountain climate.

Within the whole number of analyzed stands, the January average temperatures ranged from –1.5°C to –4.0°C, the average July temperatures ranged from 16.0°C to 19.5°C and average annual temperatures from 6.0°C to 9.3°C.

According to data from Plateau Lorrain (Wilhelm 1998), where wild service tree is quite abundant in woodlands at altitudes about 200–400 m, the annual sum of precipitation ranges from 750 mm to 850 mm and it is quite equally distributed during a year.

On analyzed stands in Slovakia, the annual sum of precipitation ranged from 580 mm to 900 mm. According to climatic water balance of vegetation (Škvarenina et al. 2002), the first three vegetation stages (oak, beech-oak and oak-beech), which include 94% of all analyzed stands, are arid in vegetation period (March–September), they have negative climatic water balance, the potential evapotranspiration is higher than the amount of the fallen precipitation with deficit of precipitation ranging from 100 to 300 mm. The forest ecosystems are compelled to use winter water supply in the soil. The fourth vegetation stage (beech), containing only 2 stands, has equalized water balance.

These data are given for general climatic conditions (macroclimate); the real water balance of particular stand (locality) is influenced by several factors (altitude, exposure, vegetation, topography, soil conditions etc.). They nevertheless indicate wild service tree demands for water. According to the presented data, wild service tree can be described as a woody plant able to grow on arid stands with lower soil humidity and water deficit in vegetation period.

Wild service tree grows best on fresh deep soils well supplied with the nutrients (Namvar, Spethmann 1985; Schrötter 1992; Aas et al. 1993), however under an influence of interspecific competition it is forced out of optimum on poor soils (Aas et al. 1993).

In Switzerland, wild service tree prefers loose well-aerated soils, sometimes appears on heavier loamy soils as well as on shallow sandy and silicate soils but avoids wet soils. It grows successfully on more arid stands with even slightly fresh soils (Aas et al. 1993).

In the area of Plateau Lorrain (on the parent rock of mussel limestone), the wild service tree grows on deep terra fusca, even on shallow rendzinas with different humidity degrees (from very fresh to arid soils). On keupers there are prevalent more or less deep Vertic Cambisols with deficiency of oxygen during winter and water deficiency during summer. Generally, not only on mussel limestones, but also on keepers soils appear sometimes in 1 m deep layer of eolic material in large area, which allows good saturation of water with good soil aeration. These soils are regarded as well-, even very well-, supplied with the nutrients (Wilhelm 1998).

In the analyzed wild service tree stands in Slovakia 8 soil units were identified (Šály, Šurina 2002). Out of these soils, Haplic Luvisols (6% of stands) and Cambisols (59% of stands) have favourable physical properties and adsorbing complex, they are fertile, and very well supplied with nutrients. There were also Rendzinas (35% of stands), soils rich in minerals, but the soil chemistry is one-sided and therefore they are mostly little fertile. According to the values of the soil reaction (pH) ranging within these soil representatives from 5.5 to 6.5 (Eutric Cambisols) to 7.2–8 (Rendzinas), it is possible to define areas of the acid and neutral soils as suitable for root system. With reference to the water balance in soils, the sufficient water supplies is generally typical for Cambisols;

on Haplic Luvisols a possibility of water deficiency exists; Rendzinas have usually low water supply.

In Slovakia wild service tree occurs on stands of warm communities. According to Májovský (1992), it grows mainly in warm oak communities *Quercetalia pubescentis*, *Quercetalia robori-petraeae*, in oak-hornbeam forests *Querco-Carpinion,* and rarely in warm beech forests *Cephalanthero-Fagion*.

In Brandenburg (based on the findings from 19 localities), the wild service tree occurs on stands of warm arid brushwoods, warm mixed oak and beech woodlands, as well as in fresh and humid oak-hornbeam forests and on stands influenced by underground water within communities *Fagetalia sylvaticeae* (17.9%), *Quercetalia pubescenti-petraeae* (12.4%), *Prunetalia spinosae* (9.3%), *Alnetalia glutinosae* (2.1%) (Ewald et al. 1994). In Switzerland, wild service tree is a typical species of the communities *Quercetalia pubescenti-petraeae* (Aas et al. 1993).

In Slovakia (according to Zlatník 1976), wild service tree appeared in original forest communities mainly in groups of forest types *Carpineto-Quercetum*, *Fageto-Quercetum, Carpineto-Aceretum*, on limestones in groups of forest types *Corneto-Quercetum, Corneto-Fagetum* (very frequent), *Querceto-Fagetum dealpinum* and *Fagetum dealpinum* (Križová 1995). Prudič (1997) mentioned very frequent occurrence of wild service tree in the region of South Moravia in groups of forest types *Fageto-Quercetum* and *Corneto-Quercetum*.

According to the data from the forest management plans elaborated by Lesoprojekt Zvolen, forest stands with analyzed populations of wild service tree in Slovakia in the 1st vegetation stage belong to groups of forest types *Carpineto-Quercetum* and *Corneto-Quercetum* (9%), in the 2nd vegetation stage they belong to groups of forest types *Fageto-Quercetum, Querceto-Fagetum* and *Fagetum pauper inferiora* (72%) and in the 3rd vegetation stage to groups of forest types *Fagetum pauper superiora, Querceto-Fagetum tiliosum* and *Fagetum tiliosum* (9%).

CONCLUSION

Information about wild service tree demands for environmental conditions were obtained within the evaluation of ecological characteristics from 34 localities in Slovakia.

Wild service tree grows in southern regions of Slovakia. Localities were found in the altitudes from 220 to 720 m. From the whole group of analyzed stands, 97% of localities were in altitudes up to 600 m a.s.l.

70% of analyzed localities were on south-exposed stands (SE, S, SW), whereas no locality was found on north-exposed stands, which supports the opinion about high demand for light.

The most of localities (34%) were found in group of forest site types *Fageto-Quercetum,* mainly with biotopes of the oak-hornbeam forests. Several localities were in the group of forest site types *Fagetum pauper* (26%) and *Querceto-Fagetum* (24%), there are biotopes classified among 9150 Medio-European limestone beech forests (*Cephalanthero-Fagion*), as well as biotopes classified among 9130 *Asperulo-Fagetum* beech forests.

Wild service tree localities were further classified according to the altitudinal vegetation stages. The 1st altitudinal vegetation stage (oak) includes 9% of the analyzed localities, the 2nd altitudinal vegetation stage (beech-oak) comprises 35% of the analyzed stands, and 50% of localities were classified in the 3rd vegetation stage (oak-beech). In first three (mentioned) vegetation stages the potential evapotranspiration is higher than the sum of precipitation; in the oak vegetation stage the climatic water balance is negative with deficit 300 mm from March to September. In the beech-oak vegetation stage the water deficit is approximately 150 mm and in the oak-beech vegetation stage the climatic water balance has deficit 100 mm. However, in the 4th vegetation stage (beech), climatic water balance is fairly equalized.

In the analyzed localities 8 soil units were identified. The most frequent are Cambisols (59%). The second most frequent soils are Rendzinas (35%), the rarest group of soils are Haplic Luvisols (6%). Some of the soils have favourable physical characteristics and adsorbing complex, they are fertile, well supplied with nutrients (Haplic Luvisols, Cambisols), whereas some of them are rich in nutrients but the soil chemistry is one-sided and therefore they are mostly little fertile (Rendzinas). According to the values of the soil reaction (pH) ranging within these soil units from 5.5–6.5 (Eutric Cambisols) to 7.2–8.0 (Rendzinas) it is possible to define area of acid and neutral soils as suitable for root system of the wild service tree.

The sufficient water supply is generally found at Cambisols (59% of the analyzed localities), compared to Haplic Luvisols (6% of the analyzed localities) that have lower water supply with possibility of soil aridization. Rendzinas (35%) are mostly loose soils permeable for water. There are high losses of water caused by leaching, and thus the water supply is usually low there.

According to the obtained data, it is possible to evaluate the wild service tree as a light-demanding woody plant with requirements for higher temperatures and higher contents of nutrients in soil, able to grow on drier soils with infrequent occurrence of water deficit. With regard to the expected changes of global climate, wild service tree should substitute some tender woody plants with higher sensitivity to drought in landscape as well as in forestry.

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Received for publication June 12, 2007
Accepted after corrections July 11, 2007

Ekológia a rozšírenie jarabiny brekyňovej *Sorbus torminalis* (L.) Crantz. na Slovensku

ABSTRAKT: Jarabina brekyňová patrí medzi zriedkavé druhy drevín tolerujúce vyššie teploty a nízku pôdnu vlhkosť. V príspevku sú analyzované údaje z 34 lokalít jarabiny brekyňovej na Slovensku. Väčšina skúmaných lokalít (70 %) bola na južne exponovaných stanovištiach (JV, J, JZ), 97 % lokalít bolo v nadmorských výškach do 600 m. Brekyňa uprednostňuje biotopy dubovo-hrabových lesov. Najhojnejší výskyt sa zaznamenal v skupine lesných typov *Fageto-Quercetum.* Podľa príslušnosti k lesným vegetačným stupňom bola väčšina stanovíšť s brekyňou (85 %) v 3. a 2. lesnom vegetačnom stupni, kde potenciálna evapotranspirácia prevláda nad úhrnom zrážok. Od marca do septembra je vodný deficit približne 100–150 mm. Najfrekventovanejšie sú stanovištia s horskou klímou (62 %) s prevahou subtypu mierne teplej (38 %) a teplej (15 %) klímy. Brekyňa rastie prevažne na pôdach sorpčne nasýtených s priaznivými fyzikálnymi charakteristikami (65 % stanovíšť). Pôdy sú úrodné, dobre zásobené živinami (hnedozeme, kambizeme). Niektoré lokality (35 %) majú pôdy minerálne bohaté, ale pre jednostranný chemizmus sú väčšinou málo úrodné (rendziny). Pokiaľ ide o obsah vody v pôde, dostatočné zásoby vody všeobecne majú kambizeme. Hnedozeme majú nižší obsah vody v pôde s možnosťou presýchania. Rendziny sú zväčša kypré, dobre priepustné pre vodu, vzhľadom na plytký profil a tým aj nízku dažďovú kapacitu zásoby vody mávajú nízke. Na základe získaných údajov je možné jarabinu brekyňovú hodnotiť ako svetlomilnú drevinu s vyššími nárokmi na teplo a obsah živín v pôde, schopnú rásť na suchších pôdach s občasným vodným deficitom. Vzhľadom k predpokladaným zmenám globálnej klímy by jarabina brekyňová mohla nahradiť na sucho citlivejšie druhy drevín v krajine aj v lesnom hospodárstve.

Kľúčové slová: jarabina brekyňová; ekológia; rozšírenie; stanovište; spoločenstvo

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