Ecology and silviculture of wild service tree (*Sorbus torminalis* (L.) Crantz): A literature review

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Ökologie und Waldbau der Elsbeere (*Sorbus torminalis* (L.) Crantz): Eine Literaturübersicht

1 Introduction

The genus *Sorbus* L. comprises about 250 species widespread in the northern hemisphere (PHIPPS et al., 1990, in BEDNORZ, 2007/a). Wild service tree is one of the 18 species of *Sorbus* L. occurring in Europe (WARBURG and KÁRPÁTI, 1992). It is widely distributed across western, central and southern Europe, but also occurs in north-western Africa and south-western Asia (Figure 1).

Across this range the species occurs at elevations between 100 m (Romania – DINCĂ, 2000; Italy – RAVAGNI, 2007) and 2,200 m (Turkey – KAUSCH-BLECKEN VON SCHMELING, 1994). Wild service tree is a minor component of various oak (and less frequently pine or beech)-dominated woodlands, where it is found as individual tree or forming small groups up to 30 trees per hectare (PLEINES, 1994; DEMESURE et al., 2000; HOCHBICHLER, 2003; ODDOU-MURATORIO et al., 2001, both in HOEBEE et al., 2006; RAVAGNI, 2007). HOCHBICHLER (2003) counted up to 850 trees per hectare in a young stand and 36 trees per hectare (dbh > 7 cm) in an area of about 130 ha managed as coppice-with-standards. It never forms pure stands and larger populations of over 100 wild service trees are rare (PLEINES, 1994; BEDNORZ 2007/c).

Even though the species is known since the onset of Silviculture (EVELYN, 1664), interest in wild service tree has

Zusammenfassung

Das Vorkommen der Elsbeere (*Sorbus torminalis* (L.) Crantz) reicht von West-, Zentral und Südeuropa bis nach Nordwestafrika und Südwestasien. Ihre Seltenheit und Wertholzfähigkeit, ihre Bedeutung hinsichtlich Boden- und Biodiversitätsschutzes sowie hinsichtlich des Landschaftswertes und machen die Elsbeere mit ihrer hohen ökologischer Plastizität zu einer bedeutenden Edellaubbaumart der Gegenwart und für die Zukunft. Besonders in den letzten vier Dezennien wurde in vielen europäischen Ländern das Interesse an der Ökologie und dem Waldbau mit Elsbeere verstärkt, welches zu zahlreichen Publikationen führte. Diese Arbeit fasst die wichtigsten deutschsprachigen, französischen, englischen, italienischen, spanischen und rumänischen Bücher, Artikel und Berichte zusammen und gibt einen Überblick über die relevantesten waldbaulichen Empfehlungen für die praktische Bewirtschaftung der Elsbeere.

Schlagworte: Elsbeere, natürliche Verbreitung, Ökologie, Wachstum, Waldbau.

Summary

Wild service tree (*Sorbus torminalis* (L.) Crantz) is distributed across western, central and southern Europe as well as north-west of Africa and south-west of Asia. Its scarcity and very valuable timber, its value regarding soil and biodiversity protection, landscape values and ecological plasticity, make wild service tree interesting as a valuable broadleaved tree species for the present and future. Especially in the last four decades, most European countries became interested in wild service tree ecology and silviculture and many research findings have been published across our continent. This paper summarizes the most important books, papers and articles, published in German, French, English, Italian, Spanish, and Romanian and provides an overview of the most relevant recommendations for the best practise in wild service tree silviculture.

Key words: Wild service tree, natural range, ecology, growth, silviculture.

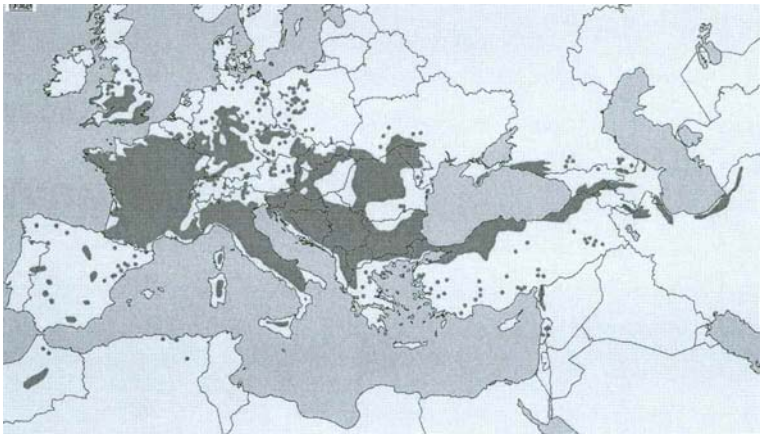

Figure 1: Distribution map of *Sorbus torminalis* (L.) Crantz (after DEMESURE-MUSCH and ODDOU-MURATORIO, 2004)
Abbildung 1: Verbreitungsgebiet der Elsbeere (*Sorbus torminalis* (L.) Crantz) (nach DEMESURE-MUSCH und ODDOU-MURATORIO, 2004)

grown especially in the last four decades in countries like Germany (ROHRIG, 1972; KAUSCH-BLECKEN VON SCHMELING, 1980; MEYER, 1980, all in MAURANGES, 1981), France (MAURANGES, 1981), Switzerland (PLEINES, 1981, in MAURANGES, 1981), Romania (DINCĂ and DINCĂ, 1996) or Italy (PELLERI and FERRETTI, 2003). Such interest in a companion tree species arises from its rarity, its spectacular yellow autumn colour but especially from its very valuable timber highly recommended for the furniture and veneer industry, turnery, construction of musical and measuring instruments, etc.

2 Site requirements

2.1 Climate

Throughout Europe wild service tree is found especially in plain and hilly areas, being considered a *submediterranean* species (RAMEAU et al., 1989; MÁJOVSKY, 1992, in PAGANOVA 2007). It requires warm climates (*sub-mesotherm* species – ŞOFLETEA and CURTU, 2001, 2007) specific to the oak (*Quercus robur*, *Q. petraea*, *Q. cerris, Q. pubescens, Q. pyrenaica*, *Q. humilis*, *Q. faginea*)-dominated forests. It seldomly occurs in the forest steppe zone and pre-mountainous zone (pure and mixed pine or beech forests) as in Romania (NEGULESCU and SĂVULESCU, 1965; HARALAMB, 1967; STĂNESCU, 1979) and Spain (ORIA DE RUEDA et al., 2006). Being a warmth-requiring forest species wild service tree inhabits mostly horizontal terrains or sun-facing (south, south-west, and south-east) slopes (LORENTZ and PARADE, 1867; POKORNY, 1990; EWALD et al., 1994, in PAGANOVA, 2007; DINCĂ, 2000). It can tolerate low winter temperatures, spring frosts, summer droughts of up to two months (HARALAMB, 1967; MONTERO et al., 2002) as well as strong winds.

The optimum mean annual temperature for this species ranges between 10 and 17 °C (MONTERO et al., 2002); minimum annual rainfall is about 600 mm, while the optimum lies between 800 and 1,500 mm (ORIA DE RUEDA, 2002).

2.2 Soil

Wild service tree is a *very tolerant* species with regard to soil characteristics. It can grow on both acid and basic soils (from clays to limestones – JACAMON, 1987; SAVILL, 1991; GARCÍA and ALLUÉ, 2006), with a pH ranging from 3.5 to 8 (FAVRE D'ANNE, 1990; LANIER et al., 1990; SEVRIN, 1992/a) and humus types from dismoder to carbonated mull (SEVRIN, 1992/a). It is adapted to soils subjected to temporary flooding alternated with dry periods (RUIZ DE LA TORRE, 2006) and tolerates moderately rocky soils (ORIA DE RUEDA et al., 2006). However, it avoids both dry sandy soils and wet or marshy soils (LORENTZ and PARADE, 1867; RUBŢOV, 1958). At higher elevations (towards the altitudinal limit, in beech-dominated forests), the species is well adapted to dry, calcareous but nutrient-rich soils (STĂNESCU, 1979; MEYER, 1980, in SAVILL, 1991). The best soils for *Sorbus torminalis* are rich, deep and fresh, continuously supplied with water (STĂNESCU, 1979; LEBOURGEOIS, 2000; PAGANOVA, 2007). Under such conditions its trees are the tallest and show a good habit (PAGANOVA, 2007).

3 Growth pattern

3.1 Height growth

In the first years, wild service trees grow quicker in height than the associated forest species (e.g., pedunculate oak, sessile oak, hornbeam, maples, common ash, wild cherry, etc.) and reach 40–60 cm (even 100 cm) per year (CRAVE, 1985). The height growth diminishes quickly after 20–30 years of age and stops at 60–70 years (PLEINES, 1981, in FAVRE D'ANNE, 1990; NICLOUX, 1988, in LANIER et al., 1990; KAHLE, 2004). If wild service trees lack light from above and growing space from 10–20 years of age on, their height growth diminishes quickly and they remain as underwood tree species as in Austrian coppice-with-standards (HOCHBICHLER, 2003) or even bush-like as in Romania (STĂNESCU, 1979; STĂNESCU et al., 1997). KAHLE (2004) drew height growth curves based on 21 trees from a limited geographical area in Germany.

In general, *Sorbus torminalis* trees reach mean heights of 15–20 m (LORENTZ and PARADE, 1867; POSKIN, 1926; JACQUOT, 1931; HARALAMB, 1967; MAURANGES, 1981; BECKER et al., 1983; CRAVE, 1985; RAMEAU et al., 1989; PLEINES, 1981, in FAVRE-D'ANNE, 1990; HOCHBICHLER, 2003). Occasionally, under optimum site and light conditions, its height can be as high as 25 m or even 30 m (CRAVE, 1985; SAVILL, 1991; WARBURG and KÁRPÁTI, 1992; BASTIEN, 1997; ONF, 1999; SCHRÖTTER, 2001; MONTERO et al., 2002; ORIA DE RUEDA, 2002; DINCĂ and DINCĂ, 2003; KAHLE, 2004). The tallest wild service trees in some European countries are 28 m height (Romania – HARALAMB, 1967), 32 m (France – LANIER et al., 1990; SEVRIN and KELLER, 1993) and even 33 m (Germany – KAUSCH-BLECKEN VON SCHMELING, 1993).

A comparison of the height reached in late stages of development shows that wild service tree can have almost the same height as oaks, common ash and cherry on moderately productive sites. The differences are less obvious on dry sites (SCHRÖTTER, 2001; HOCHBICHLER, 2003; KAHLE, 2004).

3.2 Diameter growth

Wild service tree grows slowly in diameter; under favourable growing conditions its mean diameter growth can be as high as 5.6 to 7.4 mm per year (BASTIEN, 1997). Diameter growth starts declining at 60–70 years of age and diminishes sharply at 90–100 years (CRAVE, 1985). It accumulates no more than 1 mm per year after 120 years of age (KAUSCH-BLECKEN VON SCHMELING, 1980, in CRAVE, 1985; SAUVÉ, 1988, in FAVRE D'ANNE, 1990). Old *Sorbus torminalis* trees can reach 50–60 (even 70 or 80) cm in diameter (JACQUOT, 1931; BECKER et al., 1983; ONF, 1999). In coppice-with-standards stands of the eastern part of Austria wild service trees reach 47–67 cm in diameter in 70–180 years (HOCHBICHLER, 2003). Occasionally, under very favourable ecological conditions and when trees are free-grown as in stands managed as coppice-with-standards, wild service trees can be larger than 80 cm in diameter (89 cm in Great Britain – MITCHELL, 1978, in SAVILL, 1991; 90 cm in Germany – KAUSCH-BLECKEN VON SCHMELING, 1993; 120 cm in France – DRAPIER, 1993/a).

3.3 Crown architecture, self pruning and defects

The *crown architecture* of wild service tree is a mix of *Rauh's model* (rhythmic monopodial growth, acrotony, distal orthotropy, lateral flowering) and *Massart's model* (plagiotropy that provides an optimum exploration of growing space). At old ages the crown form is a very wide cone (ball, sphere – BASTIEN, 1997), due to the reduction of apical dominance and strong, orthotropic development of lateral branches (BARNOLA et al., 1993; DRAPIER, 1993/c; SEVRIN and KELLER, 1993) (Figure 2).

The potential of *self pruning* of wild service tree is very high (MONTERO et al., 2002, ORIA DE RUEDA et al., 2006). When wild service trees are cultivated without underwood or in widely spaced plantations, the lower dead branches remain on the trunk, which makes artificial pruning necessary in order to produce branch-free boles of high quality wood (MAURANGES, 1981; CRAVE, 1985; DRAPIER and SEVRIN, 1992; SEVRIN, 1992/a, 1992/b; DRAPIER, 1993/c; SEVRIN and KELLER, 1993). This species does not develop epicormic branches following heavy pruning or thinning (LANIER et al., 1990; DRAPIER and SEVRIN, 1992; AA.VV., 1996; BASTIEN, 1997; MONTERO et al., 2002; RAVAGNI, 2007).

A frequent defect of wild service trees is the presence of ascending branches and thus *forks*, leading to the occurrence of the *forked habit*. This is one of the three habits, along with the *forest habit* (involves a straight and unique trunk) and the *chandelier habit* (multiple forking, excessive developments of lateral shoots that compete with the terminal shoot) described for wild service tree (DRAPIER,

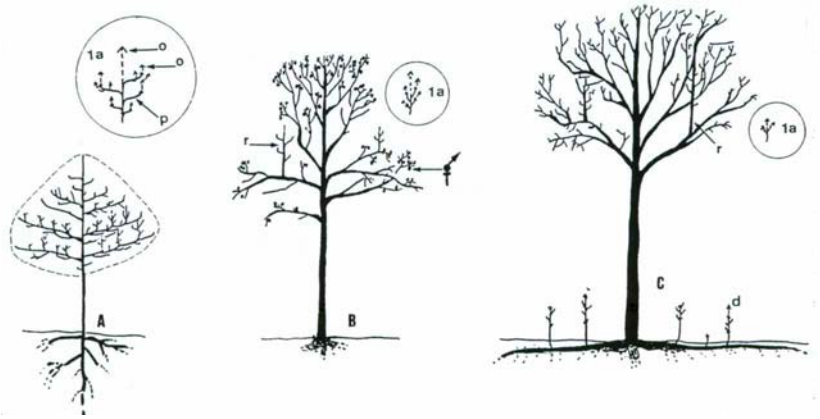

Figure 2: Hypothetical evolution of a wild service tree based on growth characteristics of an 1-year old shoot: 1a – growth acrotony of an 1-year old shoot; o – orthotropy with a temporary switch to plagiotropy; r – possibility of reiteration; d – ability to root suckering (after BARNOLA et al., 1993)

Abbildung 2: Hypothetische Entwicklung der Elsbeere basierend auf Wuchseigenschaften einjähriger Sprosse: 1a – Wachstums-Akrotonie eines einjährigen Sprosses; o – Orthotropismus mit einem temporären Wechsel zu Plagiotropismus; r – Möglichkeit der späten Umstellung der Sprossentwicklung; d – Fähigkeit zur Wurzelbrut (nach BARNOLA et al., 1993)

1993/c; SEVRIN and KELLER, 1993). The presence of forks at lower heights (less than 3 m) hinders the production of high-quality veneer logs and imposes the early application of formative pruning (DRAPIER and SEVRIN, 1992; SEVRIN, 1992/a, 1992/b; DRAPIER, 1993/c; SEVRIN and KELLER, 1993; WILHELM, 1993).

4 Longevity (life span)

The life span of wild service trees is considered as being as long as:

- between 100 and 200 years (RUBŢOV, 1958; NEGULESCU and SĂVULESCU, 1965; HARALAMB, 1967; STĂNESCU, 1979; STĂNESCU et al., 1997; ŞOFLETEA and CURTU, 2001, 2007);
- up to 200 years or even longer (LORENTZ and PARADE, 1867; MAURANGES, 1981; CRAVE, 1985; NICLOUX, 1988, in LANIER et al., 1990; DRAPIER, 1993/a; ROPER, 1993);
- between 200 and 300 (even 400) years (FAVRE-D'ANNE, 1990);
- up to 300 years (POKORNY, 1990).

However, the rotation age of wild service veneer logs is not prolonged further than 100–120 years of age because of the halt of its height growth at 60–70 years of age, combined with the insignificant diameter growth after 120 years of age (DRAPIER and SEVRIN, 1992; SEVRIN, 1992/a, 1992/b; DRAPIER, 1993/c) and the need for avoiding rotting of wood.

5 Ability to grow in mixtures

This feature is closely related to the *shade tolerance (light requirements)* of wild service tree. In this respect, the opinions are highly variable and range from *tolerant* (RUBŢOV, 1958) to *semi-tolerant* (HARALAMB, 1967; LANIER et al., 1990; FEHR, 1993; OTTO, 1994; KLUMPP and KIRISITS, 1998; SCHÜTTE, 2001; ŞOFLETEA and CURTU, 2001, 2007; RUIZ DE LA TORRE, 2006; PAGANOVA, 2007) and *intolerant (light demanding species)* (FRON, 1923; POSKIN, 1926; EVANS, 1984, 1988; DRAPIER and SEVRIN, 1992; HART, 1994; BASTIEN, 1997; LEBOURGEOIS, 2000; BEDNORZ, 2007/b, 2007/c), the latter being the most frequently expressed viewpoint. There are also evidences that this species withstands moderate shading at early ages, becoming intolerant as the tree develops, especially in cold areas (ORIA DE RUEDA et al., 2006). The intolerance to shade is confirmed by the crown architecture of *Sorbus torminalis* (mixture of Rauh's and Massart's models as described above) which evolves towards a very wide form – ball, sphere – owing to the strong development of secondary shoots.

Taking into account these aspects it is considered that wild service trees can develop *optimally* only when getting maximum light from above. They can *tolerate* quite well the stand shade if the canopy cover includes small openings providing some access of sunlight from above (DRAPIER, 1993/b). When overshaded by trees growing more rapidly, wild service trees do not die but their growth rate diminishes dramatically (*resist* shade, *vegetate but not grow*) (SEVRIN, 1992/a), form the underwood and are not able to

produce large logs for veneer production. Therefore the wild service tree is favoured when growing in coppice-with-standards woodlands, which are harvested and regenerated every 20–30 years. This is the reason why wild service tree was mostly considered a 2nd height class tree species (heights of maximum 15–20 m) in high forests, a management system which seemed not to be fully adequate to this rather slow-growing and light-demanding species that is threatened by the quicker growing and more adapted cohabitant species (GUINIER, 1947; HARALAMB, 1967; SAVILL, 1991).

The *dynamic behaviour* of wild service tree, correlated to its shade tolerance, corresponds to a *post-pioneer (nomadic)* or *early succession* species (FAVRE D'ANNE, 1990; DRAPIER, 1993/b; DEMESURE et al., 2000; LEBOURGEOIS, 2000; HOEBEE et al., 2006; ODDOU-MURATORIO et al., 2006; HOEBEE et al., 2007). It is mainly dispersed by frugivorous birds (LANIER et al., 1990; DRAPIER, 1993/b; DEMESURE et al., 2000) or small mammals (DEMESURE et al., 2000; ODDOU-MURATORIO et al., 2001, both in HOEBEE et al., 2006) and can establish itself easily only in open environments (disturbed areas outside the forest, along forest borders, in open patches or stands, etc.). Due to its shade intolerance and dynamic behaviour, *wild service tree is very sensitive to the competition in the tree stratum and can simply disappear if not favoured by silvicultural interventions* (FAVRE-D'ANNE, 1990; LANIER et al., 1990; DRAPIER and SEVRIN, 1992; DRAPIER, 1993/b; ONF, 1999; DÉMESURE *et al.,* 2000; LEBOURGEOIS, 2000; RICHTER, 2001; SCHÜTTE, 2001; HOCHBICHLER, 2003).

This conclusion is very important in practical terms because it explains the fact that wild service tree can be found in relevant proportions in *high forests* only until the pole stage (LANIER et al., 1990). After that, if no silvicultural interventions favouring its free growth (provide access to sunlight, especially from above) are performed, wild service trees remain under the canopy of cohabitant species and even die (LANIER et al., 1990; DRAPIER, 1993/2). Its high light requirements are entirely fulfilled only in *coppice-with-standards* systems where "by its high habit, its straight bole and fruits, this *excellent* species makes the "ornament" of standards, enriching the woodland" (JACQUOT, 1931). This very favourable opinion is shared by many foresters interested in wild service tree ecology and silviculture such as FRON (1923), DRĂCEA (1942), GUINIER (1947), HARALAMB (1967), BECKER et al. (1983), FAVRE-D'ANNE (1990), LANIER et al. (1990), SAVILL (1991), DRAPIER and SEVRIN (1992), DRAPIER (1993/c), RUIZ DE LA TORRE (2006).

6 Stand dynamics

Wild service tree shows a good potential for natural regeneration, both generative and vegetative. It is an insect-pollinated tree species and the average distance of pollen dispersal is about 750 m. Pollinators are mainly small flies but the flowers of wild service tree attract other generalist pollinators such as bees and beetles (ODDOU-MURATORIO et al., 2006).

The trees start fruiting early, at (10) 15–20 (seldom 30) years of age, abundantly and frequently (seed years every 2–3 years) (LORENTZ and PARADE, 1867; RUBŢOV, 1958; NEGULESCU and SĂVULESCU, 1965; HARALAMB, 1967; FAVRE-D'ANNE, 1990; SAVILL, 1991; BASTIEN, 1997). The germination capacity of *Sorbus torminalis* seeds is low. In addition, the wild service tree seeds exhibit a deep embryo dormancy, which can be overcome by various treatments which have been developed lately (MULLER and LAROPPE, 1993). Another characteristic of young seed-originating seedlings is their high light requirements: newly germinated seedlings need full overhead light, otherwise they disappear quickly (SAVILL, 1991).

Wild service tree *coppices* freely, but this regeneration potential is evaluated from *quite high (good)* (GUINIER, 1947; NEGULESCU and SĂVULESCU, 1965; STĂNESCU, 1979; EVANS, 1984; RAMEAU et al., 1989; BASTIEN, 1997; STĂNESCU et al., 1997; ŞOFLETEA and CURTU, 2001, 2007) to *low (weak)* (FRON, 1923; POSKIN, 1926; HARALAMB, 1967; BECKER et al., 1983; JACAMON, 1987; PAGANOVA, 2007). Because of this potential, wild service tree has been used for centuries in coppice woodlands. The decline of coppices, by conversion towards high forests especially in the last century, has contributed to the present rarity of the species (SAVILL, 1991; KAUSCH-BLECKEN VON SCHMELING, 1993).

The main vegetative regeneration method of wild service tree is by *root suckers*, as already mentioned over three centuries ago (EVELYN, 1664). Owing to the mixed heart-shape-tap root system of *Sorbus torminalis* (LORENTZ and PARADE, 1867; FAVRE D'ANNE, 1990; POKORNY, 1990), root suckers can be produced at long distances from the parent tree (10 m, even 20 m – FAVRE-D'ANNE, 1990; LANIER et al., 1990; DRAPIER, 1993/c), especially following the wounding of shallow roots by skidding (DRAPIER, 1993/c; WILHELM, 1993; WILHELM and DUCOS, 1996). The root suckers are more shade tolerant than the seed-originating seedlings and can easily withstand the overshade in the first years. They are preferentially browsed by deer (red, roe, fal-

low) and small rodents, so their protection by fencing may be required. The root suckers grow quickly in height in the first 10–15 years (MAURANGES, 1981; CRAVE, 1985; SAVILL, 1991). After this age, their height growth slows down and they can be overshaded and die if not fully released (*free grown*) by silvicultural interventions (SAVILL, 1991).

7 Silviculture

7.1 Target objectives

The targeted wood assortments define the silvicultural models to be applied to wild service tree. In this respect one should consider the fact that wild service trees become tradable only at diameters of minimum 15–20 cm, when they can be used for measuring and drawing instruments, snooker sticks, etc. (CRAVE, 1985; FEHR, 1993). As soon as the logs are at least 25 cm diameter they can be traded for musical instruments (inner part of string and wind instruments) (FEHR, 1993). Regarding the production of logs for veneer production (minimum 3 m long, without defects and as light-coloured as possible), they should be at least (30) 35 (even 40) cm diameter (MAURANGES, 1981; CRAVE, 1985; SEVRIN, 1992/a; FEHR, 1993). This requirement of producing logs as light-coloured as possible, which are the most required in the veneer industry, imposes the application of a silvicultural model providing wild service trees with free-growth conditions from early ages. Under such circumstances, large diameter logs can be produced quite early (rotation age of maximum 100–120 years), when logs are light-coloured and different than that of old and slow-growing trees, with a more reddish colour (DRAPIER and SEVRIN, 1992; SEVRIN, 1992/a; SEVRIN and KELLER, 1993; HOCHBICHLER, 2003). If logs also show coloured (dark red) heart, a common defect in older and slowly growing trees, the wood value is drastically reduced and its use for veneer production is excluded (DRAPIER and SEVRIN, 1992; MATHIEU, 1897, in SEVRIN, 1992/a; RAGUIN and BOULET-GERCOURT, 2000).

7.2 Plantation silviculture

In plantations – mostly for the enrichment or conversion of oak-dominated coppice-with-standards (SEVRIN, 1992/a) – wild service tree is introduced as a companion species. Pure plantations of wild service tree are excluded (SEVRIN, 1992/a). The *S. torminalis* plants are usually produced in nursery (sowing depth 2 cm, 40 seeds per m). The plants sown in the nursery field grow very slowly in the first year (5–7 cm) but develop a strong and deep taproot (RUBŢOV, 1958; HARALAMB, 1967). Subsequently the plants are usually grown 1 or 2 more years and reach 40–50 cm height (FAVRE D'ANNE, 1990). In Bavaria (Germany), 1-year old wild service tree plants are produced in recipients and have heights of 40–80 cm (RAGUIN and BOULET-GERCOURT, 2000). The plants can also be collected in forests as root suckers and then transplanted into nursery for another year (FAVRE D'ANNE, 1990). The wild service tree bare-rooted plants should be root pruned and subsequently planted irregularly in groups of 2–3 individuals. Owing to the potential browsing by deer or rodents the plants should be protected. As *Sorbus torminalis* plants are very sensitive to herbicide treatments (ORIA DE RUEDA, 2002) this intervention should be avoided.

The wild service tree has to be protected against competing and quick growing tree species by high intensity interventions (weeding, cleaning-respacing and thinning) so that their bole is laterally protected and the crown is kept in a free-grown state. When necessary, vigorous early formative and high pruning are performed for the production of straight and clean boles as required in the veneer industry (CRAVE, 1985; DRAPIER, 1993/c).

7.3 Silviculture of naturally regenerated stands

Taking into account some major characteristics of *S. torminalis* (shade intolerance; *post-pioneer (nomadic) species*, requiring *free-growth*; low propensity to produce epicormics after high intensity interventions; positive reaction to late thinning, etc.) (LANIER et al., 1990; BASTIEN, 1997), its silviculture should be *intensive, dynamic, tree-oriented*, close to the one used in case of other valuable broadleaved species but especially to wild cherry (LANIER, 1986). It involves vigorous (high intensity) *weeding* and *cleaning-respacing*, targeting the complete elimination of tall surrounding trees such as pioneer (e.g., silver birch, goat willow, aspen) as well as post-pioneer species (especially beech, but also maples or common ash) (CRAVE, 1985; LANIER, 1986; WILHELM, 1993; WILHELM and DUCOS, 1996). Shorter surrounding trees (e.g., hornbeam, field maple), that "push" the crowns of *S. torminalis* trees upwards and protect their boles laterally, should not be removed (DRAPIER, 1993/c; WILHELM, 1993). When wild service trees are as tall as 2–3 m, *forma-*

tive pruning is sometimes necessary in order to remove the forks and thick ascending branches and prevent the occurrence of the *chandelier* form (CRAVE, 1985; SEVRIN, 1992/a, 1992/b; DRAPIER, 1993/c; WILHELM, 1993). Later on, formative pruning is followed by *high pruning*, with the same recommendations as in the case of other valuable broadleaved species (HUBERT and COURRAUD, 1998), targeting the production of a branch-free bole of minimum 3 m (best 6–7 m) length (WILHELM and DUCOS, 1996; BASTIEN, 1997; HOCHBICHLER 2003).

Starting pole stage, wild service trees should grow free of any competition at crown level to avoid the death of lower branches and maximize tree growth. Such objective can be fulfilled by *early* and *heavy thinning from above*, favouring the future crop trees selected at the end of thicket stage-beginning of pole stage (LANIER, 1986; AA.VV., 1996; MÜLLER et al., 2000). At rotation ages of 100–120 years, these free-grown trees for veneer production are expected to have large diameters (at least 60 cm), strongly correlated with wide crowns (Figure 3), and regular growth rings of 2.5 to 4 mm per year (WILHELM and DUCOS, 1996; KAHLE, 2004). The existing correlation between diameter at breast height and crown width gives important support for the choice of planting design, for tending interventions and for controlling the growing space of future crop trees. However, rotation age can be reduced down to 50–60 (70) years on best sites (BASTIEN, 1997; MONTERO et al., 2002).

As soon as the large veneer logs have been produced they should be logged selectively, without any consideration to the rotation age of main species such as oaks or beech. Wild service trees should be harvested only during dormant season and logs processed immediately after removing the bark; otherwise the butt log oxidises and gets undesired colorations (LANIER et al., 1990; SEVRIN, 1992/a).

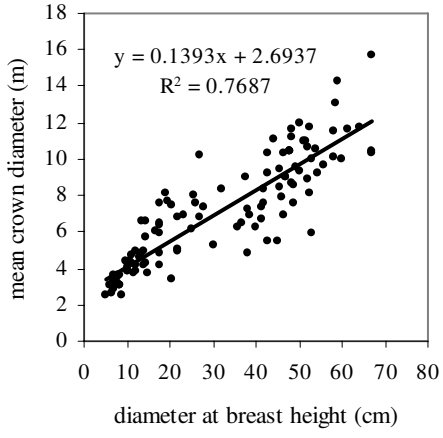

Figure 3: Correlation between diameter at breast height and mean crown diameter of wild service trees (after HOCHBICHLER et al., 2001 and NICOLESCU, 2007)

Abbildung 3: Zusammenhang zwischen Brusthöhendurchmesser und mittlerem Kronendurchmesser der Elsbeere (nach HOCHBICHLER et al., 2001 und NICOLESCU, 2007)

8 Wild service tree wood – characteristics, uses, prices

Wild service tree wood, diffuse- to slightly semi-ring-porous, is dense, heavy, fine grained and homogeneous, with no obvious colour difference between sapwood and heartwood. It is extremely appreciated since a long time ago (EVELYN, 1664; LORENTZ and PARADE, 1867; BROILLIARD, 1881; BOPPE, 1889) for turnery, carving, furniture and veneer, measuring, drawing and musical instruments construction, etc. Owing to these qualities but also to its scarcity and special interest for veneer industry wild service tree wood has attracted unbelievably high prices – thousands of Euro per cubic meter as in Germany, France, Switzerland, Austria, Spain, Romania, etc.-, overcoming all the other European forest species, since the beginning of 1990's (LANIER, 1993). However, the wild service tree wood plays a *minor (marginal) role* in the European wood market – only some thousands of cubic meters are harvested yearly – and the very important prices are "dictated" by the high demand for its veneer logs in Germany, Switzerland, France, etc.

9 Conclusions

The paper has highlighted the most relevant ecological and silvicultural characteristics of wild service tree, one of the most valuable broadleaved tree species in Europe. Its excellent wood qualities, as well as other values of *Sorbus torminalis* (ecological, ornamental, medicinal, as food product etc.) are strong arguments for its sustainable management and/or re-evaluation as producer of wood and non-wood products and services, but also for its conservation. In the latter respect, wild service tree needs *active (dynamic) conservation*, outside of the protected areas, which is the only option with positive and relevant effects (BEDNORZ, 2007/b, 2007/c). The conservation measures should try to mimic former traditional forest structures at a landscape scale (HOEBEE et al., 2007).

References

AA. VV. (1996): Les fruitiers forestiers en Bourgogne: un patrimoine à valoriser. Centre Regional de la Propriété Forestière Bourgogne.

BARNOLA, P., P. DURAND and C. PARMENTIER (1993): Recherches préliminaires sur la croissance et la morphogenèse de l'alisier torminal. Revue Forestière Française XLV (3), 261–278.

BASTIEN, Y. (1997): Sylviculture des feuillus précieux. ENGREF, Nancy.

BECKER, M., J.-F. PICARD and J. TIMBAL (1983): Les arbres. Masson, Paris-New York-Barcelone-Milan-Mexico-Sao Paulo.

BEDNORZ, L. (2007/a): Morphological variability of fruits and seeds of *Sorbus torminalis* in Poland. Dendrobiology 57, 3–14.

BEDNORZ, L. (2007/b): The wild service tree *Sorbus torminalis* (L.) Crantz in plant communities of Poland. Dendrobiology 57, 49–54.

BEDNORZ, L. (2007/c): Conservation of genetic resources of *Sorbus torminalis* in Poland. Dendrobiology 58, 3–7.

BOPPE, L. (1889): Traité de Sylviculture. Berger-Levrault & C^{ie}, Paris et Nancy.

BROILLIARD, Ch. (1881): Le traitement des bois en France à l'usage des particuliers. Berger-Levrault & C^{ie}, Paris et Nancy.

CRAVE, M.F. (1985): Un frutier meconnu: l'alisier torminal. Forêt-entreprise 28, 14–20.

DÉMESURE, B., S. ODDOU, B. LE GUERROUÉ, L. LÉVÈQUE, T. LAMANT and M. VALLANCE (2000): L'alisier torminal: une essence tropicale qui s'ignore? Bulletin technique de l'ONF 39, 51–63.

DÉMESURE-MUSCH, B. and S. ODDOU-MURATORIO (2004): EUFORGEN Technical guidelines for genetic conservation and use for wild service tree *(Sorbus torminalis)*. International Plant Genetic Resources (IPGR), Rome.

DINCĂ, M. and L. DINCĂ (1996): Sorbul terminal (*Sorbus torminalis* Crantz), o specie de mare actualitate. Revista de Silvicultura 2, 17–19.

DINCĂ, L. (2000): Elsbeere in Rumänien. Corminaria 14, 28.

DINCĂ, L. and M. DINCĂ (2003): Considerations regarding the valuable broadleaved species in Romania. Analele ICAS 46, 315–320.

DRAPIER, N. and E. SEVRIN (1992): Rapport d'étude sur l'alisier torminal *(Sorbus torminalis* (L.) Crantz*)*. ENGREF, Nancy.

DRAPIER, N. (1993/a): Les *Sorbus* en France: caractères botaniques et généralités. Revue Forestière Française XLV (3), 207–215.

DRAPIER, N. (1993/b): Écologie de l'alisier torminal *Sorbus torminalis* (L.) Crantz. Revue Forestière Française XLV (3), 229–242.

DRAPIER, N. (1993/c): Recherche d'éléments de sylviculture pour l'alisier torminal. Revue Forestière Française XLV (3), 321–334.

DRĂCEA, M.D. (1942): Curs de Silvicultura. Vol. I. Regime şi tratamente. Editura Politehnicei, Bucureşti.

EVANS, J. (1984): Silviculture of broadleaved woodland. Forestry Commission Bulletin 62, HMSO, London.

EVANS, J. (1988): Natural regeneration of broadleaves. Forestry Commission Bulletin 78, HMSO, London.

EVELYN, J. (1664): Silva: or a discourse on forest-trees and the propagation of timber in His Majesty's dominions (Internet edition, editor Guy de la Bédoyère, 1995).

FAVRE-D'ANNE, E. (1990): L'alisier torminal *(Sorbus torminalis* Crantz). Synthese bibliographique. Recherche sur la densité du bois. ENGREF, Nancy.

FEHR, R. (1993): La place de l'alisier torminal, *Sorbus torminalis* (L.) Crantz, dans la gestion d'un domaine forestier public en Suisse. Revue Forestière Française XLV (3), 371–374.

FRON, A. (1923): Sylviculture. 4ème édition. J.-B. Baillière et Fils, Paris.

GARCÍA, J. and C. ALLUÉ (2002): Flora ilustrada del Centro y Norte de la Península Ibérica – Castilla y León y Territorios Limítrofes. Junta de Castilla y León.

GUINIER, P. (1947): Technique forestière. 3ème édition. La Maison Rustique, Paris.

HARALAMB, A. (1967): Cultura speciilor forestiere. III-rd edition. Editura Agro-Silvică, Bucureşti.

HART, C. (1994): Practical forestry for the Agent and Surveyor. Alan Sutton, Stroud.

HOCHBICHLER, E., P. BELLOS and S. BIRNGRUBER (2001): Werthholzproduktion – ein Beitrag zur Edellaubholzbewirtschaftung (Esche, Bergahorn und Elsbeere). In: A. MOSER (Ed.): Beiträge zur Österreichischen Forsttagung, Universität für Bodenkultur Wien, 4–7 Juli 2001, 15–22.

HOCHBICHLER, E. (2003): Die Elsbeere (*Sorbus torminalis* Crantz) im Weinviertel (Niederösterreich). Forst und Holz 58 (21), 647–653.

HOEBEE, S.E., C. MENN, P. ROTACH, R. FINKELDEY and R. HOLDEREGGER (2006): Spatial genetic structure of *Sorbus torminalis*: The extent of clonal reproduction in natural

stands of a rare tree species with a scattered distribution. Forest Ecology and Management 226, 1–8.

HOEBEE, S.E., U. ARNOLD, C. DÜGGELIN, F. GUGERLI, S. BRODBECK, P. ROTACH and R. HOLDEREGGER (2007): Mating patters and contemporary gene flow by pollen in a large continuous and a small isolated population of the scattered forest tree *Sorbus torminalis*. Heredity 99, 47–55.

HUBERT, M. and R. COURRAUD (1998): Élagage et taille de formation des arbres forestiers. 2e édition, IDF, Paris.

JACAMON, M. (1987): Guide de Dendrologie. Tome II. Feuillus. ENGREF, Nancy.

JACQUOT, A. (1931): Sylviculture. Librairie J.-B. Baillière et Fils, Paris.

KAUSCH-BLECKEN VON SCHMELING, W. (1993): Efforts en faveur de l'alisier torminal (et du cormier) en Allemagne. Revue Forestière Française XLV (3), 357–363.

KAUSCH-BLECKEN VON SCHMELING, W. (1994): Die Elsbeere (*Sorbus torminalis* (L.) Crantz. Selbstverlag, Bovenden.

KAHLE, M. (2004): Untersuchungen zum Wachstum der Elsbeere *(Sorbus torminalis* [L.] Crantz*)* am Beispiel einiger Mischbestände in Norrhein-Westfalen. Hrsg.: Landesanstalt für Ökologie, bodenordnung und Forsten NRW, LÖBF-Schriftenreihe, Bd. 21.

KLUMPP, R. and T. KIRISITS (1998): The genus Sorbus in Austrian forestry. In: A. JACKSON and M. FLANAGAN (Eds.): The conservation status of Sorbus in the United Kingdom. Proceedings of the Workshop held at Wakehurst Place, The Royal Botanic Gardens Kew, 51–59.

LANIER, L. (1986): Précis de Sylviculture. ENGREF, Nancy.

LANIER, L., J.-C. RAMEAU, R. KELLER, H.-I. JOLY, N. DRAPIER and E. SEVRIN (1990): L'alisier torminal *Sorbus torminalis* (L.) Crantz. Revue Forestière Française XLII (1), 13–34.

LANIER, L. (1993): Le boom sur le marché de l'alisier torminal. Revue Forestière Française XLV (3), 319–320.

LEBOURGEOIS, F. (2000): Eléments d'autécologie des essences forestières. ENGREF, Nancy.

LORENTZ, M. and A. PARADE (1867): Cours élémentaire de culture des bois. 5ème édition. M^me^ V^e^ Bouchard-Huzard, Paris, Nicolas Grosjean, Nancy.

MAURANGES, P. (1981): L'alisier torminal *(Sorbus torminalis* Crantz*)*. ENGREF, Nancy.

MONTERO, G., O. CISNEROS and I. CAÑELLAS (2002): Manual de selvicultura para plantaciones de especies productoras de madera de calidad. Mundi-Prensa, Madrid.

MULLER, C. and E. LAROPPE (1993): Conservation et germination des semences. Revue Forestière Française XLV (3), 253–260.

MÜLLER, S. VON, C. AMMER. and S. NÜSSLEIN (2000): Analyses of stand structure as a tool for silvicultural decisions – a case study in a *Quercus petraea–Sorbus torminalis* stand. Forstwissenschaftliches Centralblatt 119 (1/2), 32–42.

NEGULESCU, E.G. and A.L. SĂVULESCU (1965): Dendrologie. II-nd edition. Editura Agro-Silvică, Bucureşti.

NICOLESCU, V.N. (2007): Technical and economic background of silvicultural interventions recommended to the main valuable broadleaved tree species (wild cherry, common ash, wild service tree, Norway maple and sycamore) in Romania. Research report 2005–2007. National Forest Administration-ROMSILVA, Bucuresti.

ODDOU-MURATORIO, S., E.K. KLEIN, B. DEMESURE-MUSCH and F. AUSTERLITZ (2006): Real-time patterns of pollen flow in the wild-service tree, *Sorbus torminalis* (Rosaceae). III. Mating patterns and the ecological maternal neighborhood. American Journal of Botany 93 (11), 1650–1659.

ONF (1999): Le Conservatoire Génétique des Arbres Forestiers. Bulletin technique de l'ONF 38, 9–11.

OTTO, H. J. (1994): Waldökologie. Verlag Eugen Ulmer, Stuttgart.

ORIA DE RUEDA, J.A. (2002): Guía de árboles y arbustos de Castilla y León. Junta de Castilla y León..

ORIA DE RUEDA, J.A., A. MARTINEZ DE AZAGRA and A. ALVAREZ (2006): Botánica forestal del género Sorbus en España. Investigaciones Agrarias: Sistemas y Recursos Forestales (2006) Fuera de Serie.

PAGANOVA, V. (2007): Ecology and distribution of *Sorbus torminalis* (L.) Crantz. in Slovakia. Horticultural Science 34 (4), 138–151.

PELLERI, F. and F. FERRETTI (2003): Valorizzazione delle latifoglie nobili nei cedui: un primo esempio. Sherwood Foreste e alberi oggi 93, 31–34.

PLEINES, V. (1994): Comportement écologique et sylvicole de l'alisier torminal dans quatre régions de Suisse. Revue Forestière Française 1, 59–68.

POKORNY, J. (1990): Arbres. Librairie Gründ, Paris.

POSKIN, A. (1926): Traité de Sylviculture. Jules Duculot, Gembloux, Librairie Agricole de la Maison Rustique, Paris.

RAGUIN, F. and B. BOULET-GERCOURT (2000): L'alisier torminal et le cormier en Allemagne. Forêt-entreprise 132, 17–18.

RAMEAU, J.-C., D. MANSION, G. DUMÉ, J. TIMBAL, A. LECOINTE, P. DUPONT and R. KELLER (1989): Flore Forestière Française. 1. Plaines et collines. IDF, Paris, ENGREF, Nancy.

RAVAGNI, S. (2007): Ciavardello *Sorbus torminalis* (L) Crantz. In: La selvicoltura delle specie sporadiche in Toscana. Supporti tecnici alla Legge Regionale Forestale della Toscana 3, ARSIA, Firenze, 221–232.

RICHTER, J. (2001): Eichen-Edellaubholzbestände: an der Schwelle zum Dauerwald? Forst und Holz 56, 9–11.

ROPER, P. (1993): The distribution of the wild service tree, *Sorbus torminalis* (L.) Crantz, in the British Isles. Watsonia 19, 209–229.

RUBŢOV, Şt. (1958): Cultura speciilor forestiere in pepiniere (forestiere si decorative). Editura Agro-Silvică de Stat, Bucureşti.

RUIZ DE LA TORRE, J. (2006): Flora Mayor. Organismo Autónomo Parques Nacionales, Dirección General para la Biodiversidad, Madrid.

SAVILL, P.S. (1991): The silviculture of trees used in British forestry. CAB International, Wallingford.

SEVRIN, E. (1992/a): L'alisier torminal (*Sorbus torminalis* (L.) Crantz). Qualité du bois et conditions de croissance. PhD Thesis (unpublished). ENGREF, Nancy.

SEVRIN, E. (1992/b): L'alisier torminal (*Sorbus torminalis* (L.) Crantz). Qualité du bois et conditions de croissance. Forêt-entreprise 87, 14–25.

SEVRIN, E. and R. KELLER (1993): Étude de la qualité technologique du bois d'alisier torminal: relations avec la sylviculture et le sol. Revue Forestière Française XLV (3), 299–316.

SCHRÖTTER, H. (2001): Vogelkirsche, Spitzahorn und Elsbeere: Drei wertvolle Baumarten in Mecklenburg-Vorpommenr im Abseits. Forst und Holz 56, 188–196.

SCHÜTE, G. (2001): Jungendwachstum und Schattentoleranz vegetativer Verjüngungen der Elsbeere (*Sorbus torminalis* Crantz). Forst und Holz 56, 11–15.

STĂNESCU, V. (1979): Dendrologie. Editura Didactică şi Pedagogică, Bucureşti.

STĂNESCU, V., N. ŞOFLETEA and O. POPESCU (1997): Flora forestieră lemnoasă a României. Editura Ceres, Bucureşti.

ŞOFLETEA, N. and L. CURTU (2001): Dendrologie. Vol. II. Corologia, ecologia şi însuşirile biologice ale speciilor. Editura "Pentru Viaţă", Braşov.

ŞOFLETEA, N. and L. CURTU (2007): Dendrologie. Editura Universităţii „Transilvania", Braşov.

WARBURG, E.F. and Z.E. KÁRPÁTI (1992): Sorbus L. In: T.G. TUTIN, V.H. HEYWOOd, N.A. BURGES, D.M. MOORE, D.H. VALENTINE, S.M. WALTERS and D.A. WEBB: Flora Europaea. Volume 2. Rosaceae to Umbelliferae. Cambridge University Press, Cambridge-New York-New Rochelle-Melbourne-Sydney, 67–71.

WILHELM, G.J. (1993): L'alisier torminal dans les forêts limitrophes de la Lorraine, de la Sarre et du Palatinat. Revue Forestière Française XLV (3), 364–370.

WILHELM, G.J. and Y. DUCOS (1996): Suggestions pour le traitement de l'alisier torminal en mélange dans les futaies feuillues sur les substrats argileux du nord-est de la France. Revue Forestière Française XLVIII (2), 137–143.

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