

Industrial utilization of hardwood in Sweden

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Abstract

This paper is intended to provide an overview of hardwood resources and use in Sweden today. The figures presented are estimates and should be interpreted accordingly. Sweden has about 23 million hectares of productive forest land. This means that forests cover more than half of Sweden's area. Sweden is located in the northern coniferous zone; spruce and pine are the most common tree species. Sweden is an important country with respect to the production of pulp, paper and sawn softwood timber. An increased demand for hardwood by the pulp industry and new perspectives on deciduous forests, regarding them not only as a source of raw materials but also as an ecosystem with a rich biodiversity and a place for human recreation, has resulted in a growing interest in the sustainable management of deciduous forests. The total stock of wood in Sweden's forests amounts to about three billion m³sk¹. Annual growth amounts to about 100 million m³sk, while the volume harvested each year is around 85 million m³sk. The annual growth of deciduous trees is roughly 20 million m³sk. The stock of hardwood has increased from about 300 million m³sk in 1920, to roughly 500 million m³sk today. This is about 17% of the total stock of wood in Sweden. Birch is the dominant deciduous species, accounting for about 67% of the hardwood volume. Aspen accounts for 9%, alder for 8%, oak for 6% and beech for 4%. These five species together represent 94% of the total stock of hardwood. The total volume of ash, elm, maple and lime is 8 million m³sk – less than 2% of the total hardwood volume. In 2004, Sweden produced 11.6 million tonnes of paper. About 86% of this was exported. Hardwood accounts for about 15% of the wood consumption in the pulp industry. The total production of sawn wood in 2004 was 16.7 million m³ and of this, 11.2 million m³ were exported. There are about 300 sawmills in Sweden producing more than 1 000 m³ per year and about 1 600 mills producing 25-1 000 m³ per year. In the small sawmills, about 9% of the production is from hardwood, but it accounts for only about 1% in the larger mills. There are fewer than 10 hardwood sawmills in Sweden that produce more than 5 000 m³ a year. The total industrial use of hardwood in Sweden is about 7.5 million m³fub². The main consumer of birch, aspen, beech and alder is the pulp industry. Alder reaches the pulp mills in mixed hardwood assortments. Birch, beech and alder are also used, to a large degree, in the sawmill industry and for furniture. Oak and ash are used mainly in the sawmill industry. During the last 25 years there has been an increased demand for oak, ash and beech for flooring. Elm is used for exclusive furniture and parquet. The supply of maple is very small and trees seldom reach the dimensions required by the sawmill industry. A great deal of maple, in form of veneer, is imported into Sweden. Lime wood is mainly used by carpenters. The demand for ash, which is quite high, has resulted in imports from Denmark and Germany.

Introduction

This paper is intended to provide an overview of the resources and use of hardwood in Sweden today. Our sources of information are official statistics from, for example, the National Forest Survey, SDC, The Swedish Forest Industries, and The 2000 Sawmill Inventory. Since the statistics for hardwood are not often presented with reference to individual species, we also talked to representatives of sawmills and other industries that use hardwood as a raw material in order to get a more complete picture. The figures presented are estimates and should, therefore, be used with discretion.

The Swedish forest

When considering deciduous species it is essential to examine the situation in Swedish forestry as a whole.

Sweden has about 23 million hectares of productive forest land. This means that forests cover more than half of Sweden's area. About half of the Swedish forest area is owned by individuals or families. In all, some 350 000 people own forests in Sweden. The average area of privately owned properties is just less than 50 hectares. Forest companies, such as Bergvik Skog, SCA and Holmen, own about one quarter of Sweden's forests. Approximately 18% of Sweden's forest land is owned by the state, including the large forestry company Sveaskog AB. Other public bodies, such as the church, municipalities and universities own the remaining 7%.

Sweden is located in the northern coniferous zone, with spruce and pine being the most common tree species. This is one reason why research and investment during the last 100 years has almost entirely focused on the management and exploitation of coniferous forests and the industrial uses of pine and spruce. Today, Sweden is an important country with respect to the production of paper and sawn softwood. There is an increasing demand by the pulp industry for hardwood. Deciduous

¹ m³sk = cubic metres standing volume incl. bark and tops (forest cubic metre)

² m³fub = cubic metres solid wood excluding bark and tops

species have become more highly valued in the last decade, not only as a raw material for the forest industry, but also in forests used for recreation and because of their importance for enhancing biodiversity.

Forest resources

Apart from a few years in the 1970s, forest growth has always exceeded the volume harvested. The total growing stock in Sweden's forests amounts to about three billion m³sk. Today, annual growth is about 100 million m³sk, whilst the volume harvested each year is around 85 million m³sk. The annual growth of hardwood is roughly 20 million m³sk.

Forests are not uniformly distributed around the world. Areas with large populations often have very few forests – and vice versa. One way of illustrating this is to compare how much forest a country has in relation to its population. In Sweden, with a population of about 9 million people, there are 327 cubic metres of wood per inhabitant. A comparison with conditions in other European countries shows that only Finland, with 374 cubic metres per inhabitant has more wood per capita. In France and Germany there are only 50 and 35 cubic metres per capita, respectively. In Great Britain the figure is as low as 6 cubic metres per inhabitant.

Deciduous forests are not very common in Sweden and most of the deciduous trees are naturally interspersed within the coniferous forests. The most common deciduous species are birch, aspen and alder. In recent years, deciduous species have increased within the Swedish forests.

The growing stock of deciduous trees has increased from about 300 million m³sk in the 1920s to 500 million m³sk today. Deciduous trees account for 17% of the total standing volume (Figure 1).

The total stock of wood by species and diameter is presented in Table 1.

Birch is the dominant hardwood species, accounting for about 67% of the hardwood volume. Aspen accounts for 9%, alder 8%, oak 6% and beech 4%. These five species together represent 94% of the total stock of hardwood.

Birch, aspen and alder can be found across the whole country, while most of the other hardwood species grow only in the southern regions.

The forest industry

International trade in forest products generates a large

export surplus for Sweden. In 2004, forest products worth 110 billion SEK were exported, while imports of forest products amounted to only 25 billion SEK, resulting in a surplus on the trade in forest products of 85 billion SEK (exports less imports of pulp, paper, sawn timber products, waste paper, wood, joinery products etc.).

Forest products accounted for 12% of the total value of exports in 2004. Paper and paper products account for the greater part of Sweden's forest product exports. In 2004, Sweden produced 11.6 million tonnes of paper and, of this, 10 million tonnes were exported. The production of sawn wood in 2003 was 16.7 million m³ and 11.2 million m³ were exported.

About 300 sawmills in Sweden produce more than 1 000 m³ per year and about 1 600 mills have a production volume of 25-1 000 m³ per year. In 2000 the small sawmills (25-1 000 m³ sawn wood) together produced 325 000 m³, of which 9% was hardwood. The percentage of hardwood processed by larger sawmills was less than 2%. There are fewer than 10 hardwood sawmills in Sweden that produce more than 5 000 m³ a year.

The industrial consumption of wood in Sweden in 2003 is shown in Figure 2.

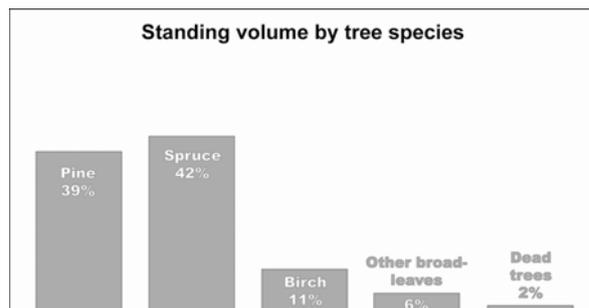


Figure 1. Standing volume by tree species. *Source: Swedish National Forest Inventory 1998-2002 (Anon. 2005).*

Slightly less than one fifth, or about 11 million m³sub (2004), of the total wood used is imported, mainly from Russia and the Baltic countries. About 40% of the imported roundwood is hardwood. Birch is the dominant deciduous species, but aspen and eucalyptus are also imported. In addition to the traditional industrial consumption of wood as a raw material, it is increasingly used for fuel.

In 2002 the percentage of softwood and hardwood (roundwood and chips) consumed in the pulp industry was about 85% and 15%, respectively. The hardwood roundwood consumption accounted for approximately

Table 1. Standing volume (*million m³sk*) on all land- use classes, by species and diameter. *Source: Swedish National Forest Inventory, 1998-2002 (Anon. 2005).*

Tree species	Diameter (cm) at breast height				Total	Percentage of all species (%)
	0-14	15-24	25-34	35+		
Scots pine	177.7	434.0	378.0	192.5	1182.2	38.7
Norway spruce	49.6	479.2	361.8	188.5	1279.1	41.9
Lodgepole pine	8.5	2.9	0.1	0.0	11.5	0.4
Larch	0.1	0.3	0.3	0.5	1.2	0.0
Birch	158.2	118.3	46.6	18.1	341.2	11.2
Aspen	7.8	12.7	13.0	11.7	45.1	1.5
Alder	13.4	13.1	9.1	3.5	39.3	1.3
Oak	3.6	5.4	7.2	15.1	31.2	1.0
Beech	0.9	2.3	3.6	11.2	18.1	0.6
Sallow	5.1	5.2	2.8	1.9	14.9	0.5
Rowan tree	4.1	1.6	0.4	0.1	6.1	0.2
Ash	0.8	1.0	0.9	1.8	4.4	0.1
Elm	0.1	0.2	0.3	0.7	1.3	0.0
Maple	0.4	0.3	0.3	0.2	1.2	0.0
Lime	0.2	0.2	0.2	0.5	1.1	0.0
Hornbeam	0.3	0.3	0.1	0.0	0.7	0.0
Cherry	0.2	0.2	0.2	0.0	0.6	0.0
Other broadleaved species	1.4	0.6	0.5	0.2	2.8	0.1
Dead trees	25.0	24.4	14.0	7.4	70.8	2.3
All	657.2	1102.3	839.3	453.8	3052.5	100.0

20% or about 6.7 million m³fub and, of this, 80% was birch, 10% aspen, 7% beech and 2% alder. Sweden imports large volumes of pulpwood. About 3.2 million m³fub of birch pulpwood comes from Russia and the Baltic countries. Most of the beech used for pulp and paper, approximately 75%, is also imported, mainly from Germany and Poland. In addition, an increasing amount of aspen is imported from Russia.

The sawmill industry produces about 16.7 million m³ of sawn wood and, of this, about 200 000 m³ are hardwood. The dominant species are birch, beech and oak. The consumption of hardwood saw timber during the last 50 years is presented in Figure 3.

The changes over the period are probably related to market forces. The peak in consumption in 1973 is, to

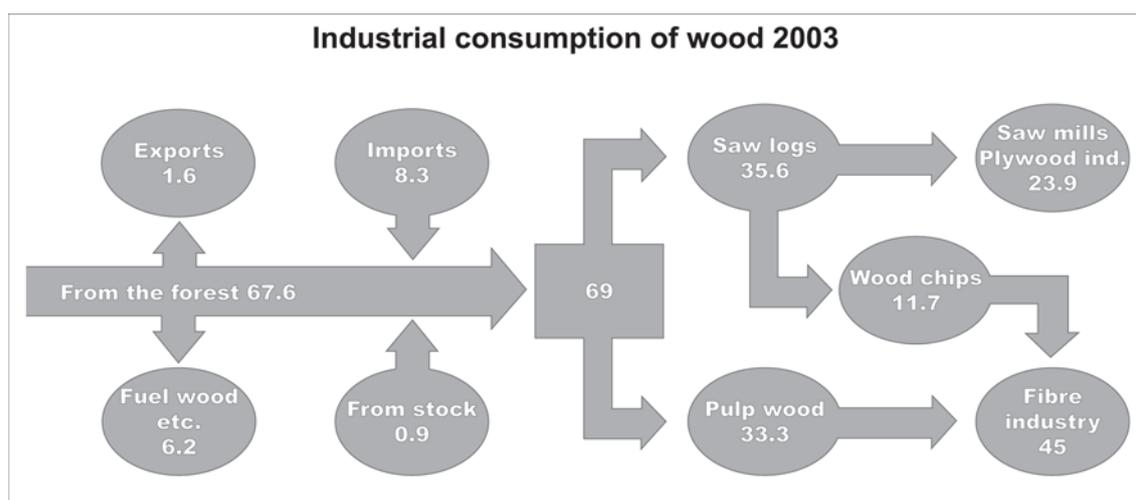


Figure 2. Industrial consumption of wood in 2003 (*million m³fub*). *Source: SDC, The timber measurement council (Anon. 2004).*

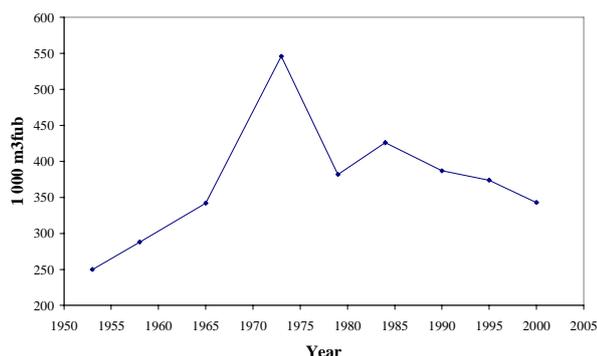


Figure 3. Consumption of hardwood saw timber over the last 50 years. *Source: The 2000 Sawmill Inventory (Staland et al. 2003).*

some extent, related to an overall increase in production for the whole sawmill industry.

Of the total industrial consumption, pulpwood accounts for about 90% and saw timber for 10%. Logs for veneer and other uses (excluding fuel wood) represent less than 1% of the total consumption of roundwood; these industries use softwood almost exclusively as their raw material.

In 2002, the use of wood fuels in district heating plants amounted to 18.4 TWh. Of this, short rotation energy forest (*Salix* spp.) accounted for about 0.2 TWh. The use of wood fuels in one- and two-household dwellings was 9.9 TWh. With an efficiency of 80% it amounts to 23.0 TWh and 12.3 TWh, respectively, of unprocessed raw material. The wood fuel supplied to district heating plants is in the form of whole tree chips from forest residues derived from clearcuts, bark, sawdust and chips from sawmills as well as roundwood of insufficient quality to be used for pulpwood. The percentage of hardwood used is assumed to be a little less than the standing stock of hardwood, around 15%. The amount of hardwood in wood fuels in one- and two-household dwellings is assumed to be 50%, because hardwood in thinnings and final fellings is often used as this sort of fuel. Assuming that the conversion for pine and spruce is 2.0 MWh/m³ and for birch is 2.5-2.7 MWh/m³, the volume of fuel wood amounts to about 14.5 million m³. Hardwood is also used as fuel in the forest industry, for instance, bark from beech pulpwood and bark, chips and sawdust produced in sawmills are all used as fuel. We estimate that the true figure for the amount of hardwood used for fuel is probably between 3.5 and 6.5

Table 2. Consumption of hardwood as a raw material in different industrial sectors (volume in 1 000 m³fub, fuel wood in 1 000 m³fub³). *Source: Ekström 1987, Anon. 2004 and Staland et al. 2002.*

Industrial branch	Consumption	
	1984-86	2002
Pulp mills	5 600	7 023
Sawmills	400	410 ⁴
Fuel wood	5 400	3 500-6 500

million m³. Consumption of hardwood is shown in Tables 2 and 3.

Uses of the dominant hardwoods in Sweden

Birch (Betula pubescens and Betula pendula)

In Sweden, birch is used mainly by the pulp and paper industry. Today, 5.3-5.8 million m³fub are used in the sulphate process. The pulp and paper industry imports about 3.2 million m³fub of birch pulpwood annually from Russia and the Baltic countries. The consumption of saw logs is about 120 000 m³fub. Total production of sawn birch has decreased by 45% over the last five years. Most of the sawn wood is used for flooring and furniture. The veneer industry is estimated to use about 2 000 m³fub.

Curly birch (*Betula pendula* var. *carelia*) has a wood that differs from the common silver birch. The wood has a wavy grain and is used for exclusive furniture. Currently, the volume produced of this type of wood is very small, but a new breeding technique has increased

Table 3. Estimated total annual consumption of roundwood from deciduous trees in Sweden during 2000-2004 (fuel wood excluded).

Tree species	Consumption	
	Volume (1000 m ³ fub)	Import (%)
Birch	5 700-6 000	60-75
Aspen	600-800	40-50
Beech	500-600	60-75
Oak	200-250	10-25
Alder	50-70	< 1
Ash	12-15	10-30
Maple	4-5	70-90
Elm	1-3	< 1
Lime	0.4-0.6	< 1
Cherry	< 0.2	< 1
Hornbeam	< 0.1	< 1
Other species	0.5-1.5	< 1
Total	7 100-7 800	55-75

³ m³fub = cubic metres solid wood including bark

⁴ This figure refers to the year 2000

the area of plantation. The value per m³ of sawn wood from curly birch is more than 200 times that of birch pulp wood.

Aspen (*Populus tremula*)

Swedish sawmills use between 2 000 and 4 000 m³fub of roundwood per year. The consumption for matches is about 40 000 m³fub, of which 50% is imported. Today there is just one mill in Sweden that produces matches. At the beginning of the 1900s matches were manufactured by 170 companies. Aspen is also the classic timber used for sauna benches in Scandinavia. During recent years the pulp and paper industry has increased its use of aspen as a raw material. Aspen is used in the CTMP-process, but also increasingly in the sulphate and sulphite processes. The total consumption of pulpwood is between 600 000 and 800 000 m³fub per year, of which about 50% is imported. Most of the imported wood comes from Russia and the Baltic countries.

Alder (*Alnus glutinosa* and *Alnus incana*)

In 2004 about 8 000 m³ of sawn wood was produced in the sawmill industry. The production reflects an estimated roundwood consumption of 14 000 m³fub. Most of the sawn wood is used for furniture and alder is becoming increasingly popular for interior decoration. Other uses include clog-making and moulds for the metal- and glass-industry.

Alder is used, to some extent, in the pulp and paper industry as it arrives at pulp mills in the mixed hardwood assortments. The volume of alder pulpwood is estimated to be 50 000 m³fub per year.

Beech (*Fagus sylvatica*)

About 500 000 m³fub of beech is used annually in the production of pulp and paper in Sweden. Almost all of the beech pulpwood is bought by a single mill: Nymölla in southern Sweden, owned by StoraEnso. The mill has two production lines; one based on softwood and one based on hardwood. The hardwood line is dominated by beech, but imported eucalyptus and aspen are also used. Most of the beech, approximately 75%, is imported, mainly from Germany and Poland. The products derived from the hardwood pulp are multicopy and envelope paper.

During 2004, Swedish sawmills used about 55 000 m³fub of beech. Consumption of beech for saw timber has decreased by 60% during the last five years. The sawn wood is mainly used for flooring/parquet and furniture. Production of beech veneer in Sweden is

negligible. Beech is also used as a fuel wood and is a good raw material for toys, wood turning and lollipop sticks.

Oak (*Quercus robur* and *Quercus petraea*)

About 123 000 m³ sawn oak was produced by the sawmill industry during 2004. Based on an estimated yield of 60%, the roundwood consumption is about 175 000 m³fub. This makes it the most common hardwood used for saw timber in Sweden. The volume for sawn timber has decreased by 20% during the last five years. The use of oak for flooring and furniture has, however, increased based on imported sawn wood. Most of the sawn wood is used for parquet and furniture. The veneer industry in Sweden only uses a small amount, less than 2 000 m³fub, of oak, but quite a large quantity of oak is used as fuel. About 60 000 m³fub per year of the lowest quality oak is chipped and exported to Norway for use in manufacturing Bauxite.

Oak is imported from other European countries and from the USA. The volume imported is estimated to be 30-40 000 m³fub of roundwood per year. Of this, red oak (*Quercus rubra*) accounts for about 15 000 m³fub.

Ash (*Fraxinus excelsior*)

Between 12 000 and 15 000 m³fub was used by the Swedish sawmill industry in 2004. Most of the wood is used for flooring and furniture. The Swedish ash is said to have darker heartwood than ash grown in Denmark or Germany. However, darker ash is becoming more acceptable, since it can be used for design features in, for example, furniture and floors.

Elm (*Ulmus glabra*)

Elm is used for exclusive furniture and parquet. The amount of roundwood used is estimated to be around 2 000 m³fub per year. However, many elm trees are dying as a result of Dutch elm disease and the supply of Swedish grown elm is limited.

Lime (*Tilia cordata*)

Wood from the lime tree is mainly used by carpenters and roundwood consumption is estimated to be less than 500 m³fub per year. Most of the wood comes from avenues and city parks and from scattered trees in hardwood forests.

Maple (*Acer platanoides*)

The demand for veneer made from maple has increased during the last 10 to 20 years. The veneer is used for

furniture, and for cabinet doors in fitted kitchens. In 2004, about 4 500 m³fub of maple roundwood was used in Sweden, of which roughly 90% was imported from Germany. Swedish maples seldom reach the dimensions demanded by the sawmill industry. Maple is also used for flooring, produced from imported sawn wood from Germany or North America.

Cherry (*Prunus avium*)

The volume of cherry used by industry is very small, less than 200 m³fub per year. However, wild cherry is a very popular hardwood species to plant, especially on former arable land. Cherry has a special value since it could be used in the same way as many of the imported tropical hardwoods.

Hornbeam (*Carpinus betulus*)

The roundwood consumption of hornbeam is estimated to be less than 100 m³fub per year. The wood is used for hand tools, such as planes and mallets. Other uses include rollers, cogs, piano keys and hammers, butchers benches and shoemakers' lasts.

Other species

Other hardwood species that can be found in Sweden are rowan (*Sorbus aucuparia*), whitebeam (*Sorbus intermedia*) and different species of willow (*Salix* spp.). None of these species account for industrial use of more than 100 m³fub a year.

Discussion

Despite an increase in the growing stock of deciduous trees, the demand from the Swedish market exceeds supply and the industry imports between 4-6 million m³fub of roundwood each year. Sawn wood is also imported, in particular oak for the furniture industry. It is, therefore, possible that there is potential to increase the profit derived from deciduous forests. In addition, the increasing non-industrial value of forests (human recreation, biodiversity etc.) contribute to this.

If it may be possible to combine intensive management of urban and recreation forests with the production of high quality wood, the rotation time for valuable hardwoods such as oak, ash, beech and maple could be increased to 150-200 years. In this way, dimensions and quality could reach the same levels as those achieved in central Europe.

The pulp industry today imports large volumes of hardwood as a raw material for the production of short fibre

pulp. In addition, wood is required for use as a fuel. Small-diameter wood from cleanings and thinnings, or wood of insufficient quality for use by sawmills could, therefore, find a market. What is currently imported could, perhaps, be produced in deciduous forests in Sweden. There are reasons to expect an increased demand for hardwood for the production of paper products from short fibres and an increase in the use of wood fuel. This means there is the potential for forest owners to achieve an increased economic return on essential silvicultural activities, which currently usually only generate costs. A profit could be made by selling small dimension wood for pulp or fuel.

Today a great deal of high quality hardwood does not reach the sawmills, instead it is mixed with pulp- or fuel wood. One reason is that, in Sweden, deciduous trees often grow interspersed within the coniferous forests and the small volumes of hardwood harvested together with the coniferous trees make it very costly to extract and deliver these logs to the hardwood sawmills. There is a significant logistical problem to be solved. A greater number of pure deciduous stands or a higher percentage of deciduous trees in the coniferous stands would probably result in better and more economic use of the wood from deciduous trees.

The fact that, in Sweden, the production of sawn timber from some deciduous species has decreased does not necessarily mean that consumption is lower than before. In fact, users such as furniture and floor manufacturers import increasing amounts of sawn timber and components. This means that the Swedish furniture industry imports raw materials and exports the finished products. In the long run this is likely to become uneconomical as the cost of labour and capital investments will become standardised across Europe.

As discussed, Sweden imports a large volume of pulpwood. Most of this originates from the Baltic countries and Russia. It is not certain whether such imports will be available in the future, nor is it clear what influence transport costs will have on their economic viability.

When choosing which species to grow, one has to make guesses about factors such as the risk from storms, future markets for the wood and the development of new products. There are many opportunities to spread the risk by diversifying the range of forest stands and, as the saying goes, to "not put all your eggs in one basket".

Acknowledgements

During the work on this paper we have been provided with valuable information and insight by representatives of sawmills, pulpmills, veneer industries, forest companies and by members of research institutes and forest organisations. We wish to thank all those who have helped us. We would also like to thank The Broadleaf Program, which sponsored this work.

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Personal Communication

Data have also been collected by personal communication with representatives of sawmills and other industries using hardwood as a raw material.