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The Usage Value of Non Native Trees

ALPTREES REPORT

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from local autochthonous native trees and non-native trees

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Preface

By Gian Antonio Battistel and Hoffmann Christian [1]

Various scenario calculations show that climate and other environmental changes significantly affect the ecosystems of Alpine forests, and the composition of native trees and animal species. Their distribution and silvicultural use depend on the national forest regulations and strategies. But above all, it is up to the decision of private forest owners or managers of national state forests how they make use of the non-native tree species (NNT) to adapt the Alpine Forests to the consequences of climate change. They have the operational capacity to raise awareness of adaptation needs among actors in the timber value chains, to supply markets with timber products and for maintaining the traditional business models, typical of rural and socio-economically marginal mountain areas.

Although NNT products are already widely used in Europe, they have not received attention in the New EU Forestry Strategy agenda. Accordingly, the ALPTREES project has the merit of promoting the added value of NNTs for Europe´s forests and related value chains. The authors also open the debate on the existing and potential markets of NNT assortments and create more confidence in their current and future use. The document can be seen as a first attempt to raise awareness among customers and decision makers about the use of NNT wood. In a compact format, the report summarizes the practical scientific findings on the most important NNT species for the timber market. The report also provides a preliminary outlook on the economic value of NNTs wood products along the timber value chains of some Alpine countries. Furthermore, it illustrates in a simple and intuitive way some valuable experiences made by companies active in the Alpine Space.

Actors of the forest-wood value chains have the opportunity to share knowledge as well as experiences among communities in rural and metropolitan areas within the Alpine Space. Students, freelancers and companies can find ideas and inspiration for the design and development of products made from NNT wood in sawmills, timber processing plants, carpentry, joinery, furniture factories and engineering offices. Bringing together these types of skills and value chains' actors is fundamental to achieving sustainable rural and urban areas and enhancing the dialogue between sustainable forest and timber value chains and sustainable cities.

1 Coordinators of EUSALP Task Force „Multifunctional Forests and Sustainable Use of Timber"
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The EUSALP Task Force on „Multifunctional Forests and Sustainable Use of Timber“ (TF-MFSUT) is looking with interest at the ALPTREES initiative and its impulse to the discussion on the sustainable future of forests and timber value chains. The mandate of the TF-MFSUT foresees the fostering a smooth exchange of information among the involved AGs (see AG, 2, 6, 7, 8, 9, participating in initiatives that support common interests and can be exploited at policy level.

TF-MFSUT appreciates the findings of ALPTREES that could contribute to the EUSALP Strategic Priority „Innovation Hub for Green Business“ for the period 2021-2022. The TF_MFSUT is convinced that the “ALPTREES Knowledge Hub” might thereby feed into the major topic on „Forest and timber value chains˝. Moreover, TF-MFSUT sees ALPTREES „Knowledge Hub“ as a valuable partner to drive the design and implementation of the key actions in which it is involved. To this end, TF-MFSUT encourages the authors to continue on the path outlined in this document by addressing the contribution of NNTs to the circular and bioeconomy, innovative business models and climate action to reduce the world’s carbon and material footprint, for achieving climate neutrality.

Figure 1: Area of the EUSALP, Alpine Space Programme and Alpine Convention

More information:

- Alpine Space Programme https://www.alpine-space.eu/
- Eusalp Programme https://www.alpine-region.eu
- Alpine Convention https://www.alpconv.org/en/home/convention/framework-convention/

1. Introduction

Austria, France, Germany, Italy, Liechtenstein, Slovenia and Switzerland are part of the Alpine space (Figure 1) and the presence of non-native tree (NNT) species has been a reality in the region and in the wider European area for some time. During last hundred years, NNT species have been promoted in forest and urban areas due to their characteristics, as some non-native tree species have higher yield, higher timber value, high esthetic value, etc. Many NNT are already introduced in forests and forestry, but relatively few species have major importance in terms of area. Those are situated mainly in western European countries (Pötzelsberger et al. 2020). According to Pötzelsberger (2018) the share of NNT ranges from less than 1% in the Baltic states and in some south-eastern European countries to over 60% in Ireland and Scotland. On average it is an estimation that NNT cover about 4% of European forests.

Some NNTs came to our area unintentionally or spontaneously. Many have not established themselves in the Alpine region at all. Some have become more competitive and invasive in the new situation, also due to the fact that climatic conditions have changed since the first attempts of introduction and promotion NNT species in our forests and urban areas. During the ALPTREES project we were able to identify 135 native tree species and 633 non-native tree species in the forests and urban areas of Alpine space. Majority of these NNTs can be found only in the urban areas, fulfilling different ecosystem services than those from forests.

Pötzelsberger et al. (2020) correctly stated that NNT raise a range of different associations and emotions—to many citizens they are just exotic trees in parks, to many nature conservationists they are an evil to native ecosystems that should be eradicated, to a rising group of foresters they are part of the solution to climate change and an increasing timber demand. Nevertheless, certain NNT species can no longer be avoided and must be accepted and managed systematically and placed in suitable habitats. Research shows that certain NNT may be more suitable for changing climatic conditions and therefore have to take their presence into account. A careful integration of a range of tested NNT into future forest management planning shows a high potential for climate change adaptation and mitigation (Pötzelsberger et al. 2020). We anticipate that the share of these species will increase in the future, thus forming certain market values of their assortments. Currently, the timber market for these species is still in its infancy and poorly developed. Sometimes higher quality assortments of NNT appear at auctions and submissions where they fetch high prices.

Although NNT constitute a very small portion of the standing tree biomass, it certainly has a high use value for specialty applications as well as for high value timber uses. Lower quality timber can be generally used for the similar applications than equivalently suitable native tree species and in an equivalent price range as native timber species. For energy use no differences between NNT and native species could be found.

Regarding the usage value, NNTs are often reported together with native genera. This is considered in the analysis at hand since in equivalent use cases (i.e. similar value and/or

similar use). It is important to know the value of NNT timber and it is necessary for the NNT market to develop with all its laws. Primarily, maybe even more important, is to know the usage value of NNT wood and timber. Once the usage value is defined, also the market prices can be formed.

Our report is an attempt to outline the current situation in the field of the most important and common NNT in the Alpine region. We wanted to give an information on the topic, which NNT species are currently most important in the region, what is their use value, what are they useful for and what is their value on the timber market. As we wrote in the report, the timber market for any given NNT species is currently small and focused on high-value timber with some use cases for specialty applications. For lower value wood, the distinction between NNT and native trees is not important, e.g. use for biomass, for energy production or for use as pulpwood.

2. Survey of literature and secondary data

Two main contributions to the assessment on the usage value of NNTs were made through the Interreg Alpine Space Project CaSCo (Bruckner and Strohmeier, 2017) and through the Cost Project Action NNEXT (Hasenauer et al., 2017). Sapsford et al. (2020) lists some ranges for some NNT species potentially relevant for further examining the marketable value of NNT timber and lists sources where to find further information for other species.

Table 1: NNTs identified either in value wood auctions or as use cases during expert interviews (expert interviews not included in the report at hand). Species in red are not mentioned in the NNT monographs.

NNT name	Value wood	Use cases	English
Abies grandis		X	Giant fir, grand fir
A. nordmanniana/bornmuelleriana		X	Nordman fir, caucasian fir
Abies procera		X	Noble fir
Acer negundo		X	Box elder
Acer opalus	X		Italian maple
Aesculus hippocastanum	X	X	Horse chestnut
Ailanthus altissima	X	X	Tree of heaven
Carya illinoinensis		X	Pecan nut
Carya spp	X		Hickory
Catalpa bignonioides	X	X	Indian bean tree, Southern catalpa
Cedrus atlantica		X	Atlas cedar
Cedrus spp.	X		Cedars
Celtis australis	X		European nettle tree
Chamaecyparis lawsoniana	X		Lawson cypress
Cupressus spp.	X		Cypresses
Cryptomeria japonica	X		Japanese cedar, Japanese redwood
Cydonia oblonga	X		Quince
Ginkgo biloba	X		Gingko
Gleditsia triacanthos	X	X	Honey locust, thorny locust
Juglans nigra	X	X	Black walnut
Liquidambar styraciflua		X	American sweetgum
Liriodendron tulipifera	X		Tulip tree
Metasequoia glyptostroboides	X		Dawn redwood
Morus alba	X		White mulberry
Morus nigra	X		Black mulberry
Morus spp.	X		Mulberry
Paulownia tomentosa	X	X	Princess tree,
Picea omorica			Serbian spruce
Picea sitchensis		X	Sitka spruce
Pinus nigra	X	X	Austrian pine, black pine
Pinus strobus	X	X	White pine
Pinus wallichiana		X	Himalayan pine

NNT name	Value wood	Use cases	English
Platanus spp.	X		Planes
Populus x canadensis	X	X	Hybrid poplar
Prunus cerasifera		X	Cherry plum
Pseudotsuga menziesii	X	X	Douglas fir
Quercus canariensis		X	Algerian oak
Quercus pubescens		X	Pubescent oak
Quercus rubra	X	X	Northern red oak
Rhus typhina		X	staghorn sumac
Robinia pseudoacacia	X	X	Black locust
Sequoiadendron giganteum		X	Giant sequoia
Styphnolobium japonicum	X		Japanese pagoda tree
Thuja occidentalis	X		Northern white cedar
Thuja plicata	X	X	Western red cedar

Due to the global pandemic, interviews are delayed and were not considered in the report at hand.

3. Survey on wood submissions in the Alpine Space

In Austria, Germany, Slovenia, and Switzerland high-value timber is sold at timber submissions. Timber submissions are forestry sales procedures in a high-value and comparatively low volume market in which timber is sold to the highest bidding party of interest. Usually, such submission doesn´t take place in the form of a public auction, but in the form of written offers with the highest written offer being selected for subsequent transaction (however, everyone can examine the timber at the submission site during the submission event; sometimes these offers can be also made in person at the submission site). It depends on the organising entity if submission events are allowing all tree species to be submitted. Sometimes there are events only for deciduous or only for coniferous timber. In some cases, it is specified which species can be submitted. These events address veneer wood buyers, value wood traders, instrument makers, carpenters, furniture makers, shingle wood producers, barrel makers (esp. oak wood) and other interested parties.

Wood submissions are interregional marketplaces where forest owners can sell high-quality timber for high prices. On one side the interregional connectedness gives sellers the opportunity to select from a range of submission evens and choose events specific for the type of wood they intend to sell, on the other side provenances are not always considered (although in many cases wood certification is a requirement). According to the Austrian forest owner associations especially hardwood was sometimes sold as fuelwood before sellers were made aware of the possibility to sell at submission events giving them the opportunity to sell at a higher value. With regard to quality, veneer wood and saw logs of quality classes A and B are usually submitted and preregistration is required. Wood submission events are also an opportunity for networking and exchanging information on specific recommendations for selecting appropriate seedlings and managing forests regarding the overall event focus. Often there are side-events with lectures enabling expanding the knowledge base for or exchanging know-how amongst prospective buyers including adaptive and climate-sensitive forest management. Since timber submissions offer the highest-value trading of roundwood these are also the events with the most specialised applications for NNT.

- In Germany high-value timber submissions relevant for the Alpine space are in Bavaria (Holzkirchen, Litzendorf, Sailershausen, Himmelkron/Fichtelberg) and in Baden-Württemberg (Ortenau, Bopfingen, Otting/Waging am See).
- In Austria forest owner associations are organising value wood submissions in Lower Austria (Heiligenkreuz), Upper Austria (St. Florian bei Linz), Styria (Großwilfersdorf), Tyrol (Weer, Vomp), and Vorarlberg (Feldkirch). In Tyrol and Vorarlberg native coniferous trees are sold (Spruce, Larch, Fir, Swiss stone pine). Tyrol allowed listing of non-coniferous trees since 2020 (where only yew was offered in addition to the “traditional” trees).
- In Slovenia wood submissions are organised in Slovenj Gradec.
- Lower Austria and Upper Austria specialise on hardwood trees
- In Switzerland submission data was considered for Sankt Gallen (Buchs, Henau, Kaltbrunn), Thurgau (Güttingen, Neuwilen, previously also in Tägerwilen), in Luzern (Horw), Zürich (Regensdorf and Winterthur), Bern (Grafenried, Büren) and Neuchâtel (Colombier), Aargau (Rheinfelden) Beyond the regions mentioned here, wood from the Alpine space is also

offered at submission events in other federal States and provinces of the Alpine space countries showing the interconnectedness regarding specific trading places for specific wood assortments.

In Italy most transactions for wood seem to be conducted through electronic auctions, e.g. in the provinces of Trento and Friuli Venezia Giulia several websites offering public auctions, private bidding and private contracts were examined. An important marketplace is portale del legno trentino, but it is specialised on transactions of larger quantities of native timber. No timber of non-native trees was advertised for the recent years to the knowledge of the author. Moreover, there are wood auctions similar to submissions held in the regions of Friuli Venezia Giulia (Tolmezzo and Ampezzo, since 2015), in Trentino (Trento, since 2012), in Lombardy (Erba, since 2019) where the first valuable wood auction was held as part of the 10th wood energy exhibition. For NNT species in wood auctions in Italy no further information on results or on subsequent auctions could be found within the reporting period for the report at hand. It does not seem that results for submission-style auctions are published. Furthermore, there are also sales for lots of standing timber in the regions Bolzano/South Tyrol, Trento, Lombardy and Piemonte. NNT occurrence is rather uncommon for forest plot auctions but between 2015 and 2020 there were occasional offers of *Pinus strobus* and *Pinus nigra*. Until 2005 timber from public forests was sold through auctions. About 40% of sold timber came from public forests.

In France, most transactions seem to be conducted either with the help of electronic auctions or through supply contracts negotiated in advance. It seems that it is necessary to be registered as seller or trader to access more specific information. Information on value wood submissions could not be found. Due to language and time constraints, it is likely that information about wood submissions and auctions in the Italian and French speaking Alpine Space is missing.

4. Tree profiles regarding use value

Douglas fir (*Pseudotsuga menziesii*)

Its wood has relatively good strength. It is moderately heavy and durable (similar to larch). The wood of European Douglas-fir cultivars is reddish brown (red fir) in contrast to wood from cultivars of the American native range (yellow fir). It is a high-quality lumber but can also be used as sliced or rotary cut veneer (Sauter and Becker, 1996). Douglas fir can also be used for decorative boughs (Golonska, 1991). The wood is easy to dry and process. It dries and processes well. Heartwood: very poor. It is a popular tree for use as building and construction timber with a recommendation of about 200 target trees/ha with max. 50 cm at breast height. For a higher value use for interior fittings and the furniture industry about 80-90 target trees/ha are recommended. Douglas fir produces quality wood with high strength values, good weather resistance and good processing properties. The sapwood and heartwood of the Douglas fir differ significantly and are very similar to those of the larch. Depending on the location and growing conditions, the appearance of the wood and its properties can vary greatly. Fine annual rings, few knots and low resin content are general characteristics of good wood properties (Ruhm and Schönauer, 2015).

photo: Aleksander Marinšek

photo: Eric Meier, www.wood-database.com

Figure 2:
left - Douglas fir (Pseudotsuga menziesii) in the forest stand and its needles and cone
right - veneer sample of Douglas fir

Red oak (*Quercus rubra*)

The wood of Red oak (*Quercus rubra*) has good mechanical strength and is of medium hardness. It is used, among other things, for flooring, windows, furniture, railroad sleepers, industrial and firewood. The wood can be stained and matted well, but before varnishing it is necessary to fill the pores. The gluing is satisfactory. Surface treatment in exterior construction is difficult. Impregnability: sapwood = good, heartwood = good.

Its wood is used in a similar way as the native pedunculate and sessile oaks. The heart is reddish brown with light sapwood. The wood is not weather-resistant but can be impregnated well. It is used indoors and impregnated outdoors. Red oak is used as parquet wood, for staircase construction and for making windows and doors. Red oak wood is more elastic and almost as hard as pedunculate or sessile oak. It is superior to the domestic oaks in bending and compressive strength.

photo: Anja Müller-Meißner

photo: Eric Meier, www.wood-database.com

Figure 3:
left - Red oak (Quercus rubra) in the forest stand,
right - veneer sample of its wood

Black walnut (*Juglans nigra*)

Its wood is moderately heavy, hard, strong, and durable. It is used as sliced face veneer, solid for furniture making but also for rifle stocks and as turnery (Sauter et al., 1995). The wood is easy to work, stains well, varnishes very well, glues well, dries well but slowly. The black walnut is also one of the most sought-after hardwoods in its home country. The sapwood is whitish to light brown, the heartwood chocolate to violet-brownish. The wood is hard, heavy, elastic, shrinks only moderately, can be worked well with tools, but is not resistant to fungus and insect attack without impregnation. It is comparable to walnut (*Juglans regia*), therefore very valuable and is used for veneer, furniture, panelling, parquet, and as special wood for turning and carving (Reautschnigg, 1998).

photo: Lado Kutnar

photo: Eric Meier, www.wood-database.com

Figure 5: Left - Black walnut (Juglans nigra) in the forest stand, right - veneer sample of its wood

Weymouth pine (*Pinus strobus*)

The wood of Weymouth pine (*Pinus strobus*) is light, soft and of medium elasticity. It is easy to work with hand and machine tools. It hardly works and cracks. In cabinet making it is used as a substitute for pine (healthy-asthenic, upper part of the trunk). The lower part of the trunk can be used as a construction timber (Stratmann, 1988).

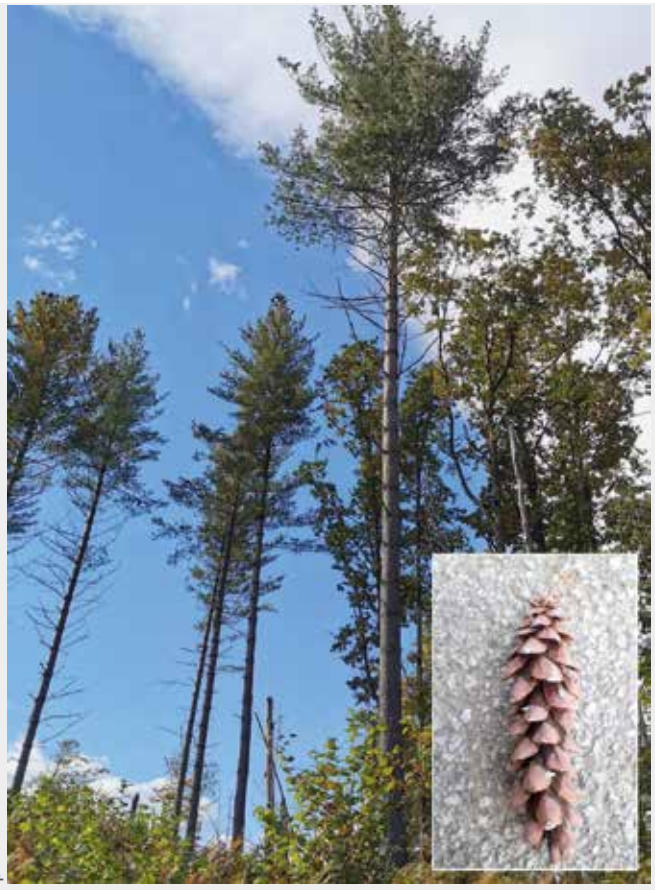

photo: Aleksander Marinšek

photo: Eric Meier, www.wood-database.com

Figure 6: Left - Weymouth pine (Pinus strobus) in the forest stand and its cone, right - veneer sample of its wood

Black locust (*Robinia pseudoacacia*)

The black locust is a very vigorous pioneer tree species and is characterized by a high stocking capacity, which makes it very suitable for coppice management and thus for fuelwood use (Leibundgut, 1984). Robinia produces a very hard, durable, elastic wood. For example, its bending strength is well above that of oak (Sell, 1989). Black locust is used in earthworks, hydraulic engineering, and mining, as well as in temporary avalanche control (Brändli, 1996). In wine-growing areas it is also used for vine stakes. Other uses include: carpentry wood, parquet flooring, gymnastic equipment, tool handles. It was recommended as energy wood by Müller (1991) because of its high calorific value. In addition, acacia blossom honey enjoys growing popularity in Central Europe; furthermore, the beekeeper considers black locust a valuable bee pasture (Müller, 1991). The wood must be dried very carefully, as it tends to crack and deform. Despite its hardness, it can be worked satisfactorily and is good for turning and carving. Impregnability: very poor.

photo: Aleksander Marinšek

photo: Eric Meier, www.wood-database.com

Figure 7: Left - trunk and leaves of Black locust (Robinia pseudoacacia), right - veneer sample of its wood

Sequoia trees (*Sequoia* spp.**, representative for subfamily** *Sequoioideae***)**

Sequoia sempervirens wood is soft, splinters easily, is weak but very resistant to decay and decomposition (Olson et al., 1990; Person and Hallin, 1942). The wood is used for shingles and for squared lumber. To date it is one of the most valuable timber species in its native California (Metcalf, 1924). Young wood of *Sequoiadendron giganteum* has favourable wood properties. It is very resistant to decomposition (Piirto, 1986) and can be used as dimensional lumber, as well as veneer and plywood (Piirto, 1986). Old-growth wood of giant sequoia is brittle and has low tensile strength, making it unusable for most structural purposes (Hartesveldt et al., 1975).

photo: Aleksander Marinšek

photo: Eric Meier, www.wood-database.com

Figure 8: Left - two trees of Sequoia sempervirens in the forest stand, right - veneer sample of its wood

Poplar hybrids (summarised under *Populus* spp.)

Poplar hybrids are not distinguished in value wood auctions from native poplars. Because use cases are similar. It was assumed that prices are generally comparable to native poplars if not slightly lower, since *Populus nigra* seems to be the most popular Populus tree in the value wood auctions.

Figure 9: Stand of Populus x canadensis trees in a plantation

photos: Lado Kutnar and Matjaž Mastnak

Plane trees, sycamore trees (*Platanus* spp.)

Plane trees are valuable timber trees. Their wood is hard, the grain of the wood is coarse and twisted, but not very strong. Plane tree´s wood can be worked easily with hand and machine tools. Tear-out can sometimes occur in the rays of quarter sawn sections during planning. The wood turns, glues and finishes well. Some *Platanus* species are reported to respond poorly to steam bending.

photo: Aleksander Marinšek

photo: Eric Meier, www.wood-database.com

Figure 10: Left - trunk and leaves of London plane tree (Platanus × acerifolia), right - veneer sample of its wood

Cedar trees (*Thuja* spp.)

Thuja tree wood consists of multiple varieties with different uses but are often not differentiated in wood submissions. The most relevant species for value wood in the Alpine region seem to be the western red cedar (*Thuja plicata*) and northern white cedar (*Thuja occidentalis*). In its native region *Thuja plicata* is very popular for the production of decking, siding, shingles and outdoor structures because it has a high decay resistance and hydrophobic properties. Its low density and light weight enables easy processing and shaping. The heartwood has a consistent reddish-brown tone, and the sapwood is whiteish with little decay resistance. The latter usually gets milled away during processing. *Thuja occidentalis* is similarly resistant to decay and insect infestation making it also suitable for outdoor applications such as shingles, posts and decking. It is also a popular wood for canoe building in its native region. It is less dense than *Thuja plicata* and tends to be brittle, easily tearing out without adequate tools (Wood magazine, 2016).

photo: Aleksander Marinšek

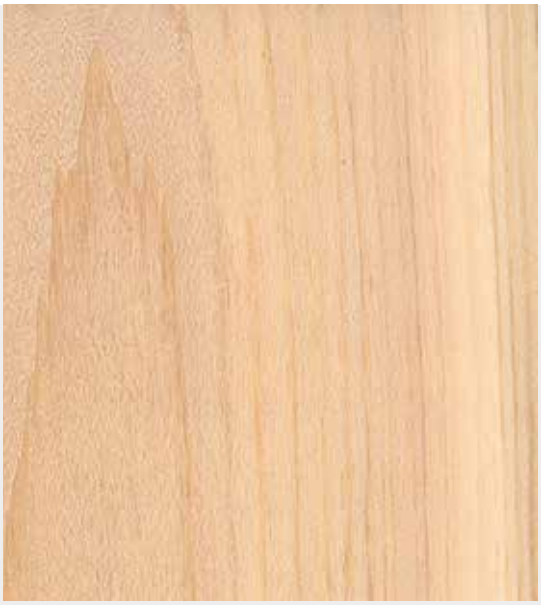

photo: Eric Meier, www.wood-database.com

Figure 11: Left – trunk, leaves and cones of Northern White Cedar (Thuja occidentalis), right - veneer sample of its wood

Thuja plicata can be cultivated in pure stands as well as in mixed crops. Because of its shade tolerance, it is well suited for regeneration under canopy. Otherwise, the natural regeneration is difficult due to high seedling mortality. For the production of valuable timber, value pruning is indispensable and is recommended. The wood is characterized by good strength, is light and does not resinify. It has poorer mechanical properties (compression, tensile and bending strength, modulus of elasticity) than other conifers (e.g., *Picea abies* and *Pseudotsuga menziesii*), but a markedly high natural durability in outdoor applications (Vor, 2015). Especially the heartwood is very durable (Reautschnigg, 1998). There are various exterior applications

(e.g., facades, outdoor furniture, boats), and it is suitable for veneering, although taper has to be considered. The wood is not suitable for the pulp and paper industry due to its constituents. The wood dries well, glues well, stains and varnishes well. In the Northwest of the United States, *Thuja plicata* is one of the important tree species for forestry. The wood is traded under the name Red Cedar, it is particularly durable, but soft, brittle, coarse-fibred and very light, 350 to 400 kilograms per cubic metre when air-dry. It has a pleasant aromatic smell and is very resistant to insect and fungal attack. It can be processed and glued well. The yellowish-brown or reddish-brown core is surrounded by a narrow white sapwood, there are no resin channels in the wood.

Horse chestnut (*Aesculus hippocastanum*)

Horse chestnut has a low density and interlocked grain. It is easy to work/process but can lead to fuzzy surfaces due to its low density and interlocked grain. It has poor decay resistance. The heartwood is creamy white to yellowish brown while the sapwood is white. It is commonly used for veneer and furniture production, as plywood and for wood turning objects (Meier, 2020). A decoction of the bark and leaves is also used in folk medicine of Albania, Kosovo, and Central Italy to treat circulatory and rheumatic disease. The seeds are traditionally used as a therapy for chronic venous inefficiency and is thus of interest for the pharmaceutical industry. The ripe seed is also used for horse feeding (Ravazzi and Caudullo, 2016)

John Ruter, University of Georgia, Bugwood.org

photo: Eric Meier, www.wood-database.com

Figure 12: Left – Leaves and fruits of Horse chestnut (Aesculus hippocastanum), right - veneer sample of its wood

Cypress trees (*Cupressus* spp.**)**

Its wood have a fine structure with a homogenous grain. The heartwood is yellowish-brown to reddish and mostly light while the sapwood is white to yellowish. The timber has an insect-repellent aromatic smell. Cypress wood in general is very resistant and durable and is therefore popular for uses as construction wood, for outdoor furniture, for shipbuilding and for coffin production. Furthermore, it is used for furniture production as well as for windows and doors. It has an easy workability making and it is also suitable for turning work (Georges, 2020b).

photo: Lado Kutnar

photo: Eric Meier, www.wood-database.com

Figure 13: Left - Cypress tree (Cupressus sempervirens), right - veneer sample of its wood

Hickory trees (*Carya* spp.)

According to Cassens (2007a), they belong to the most dense and the strongest north American hardwood lumber category. Because these woods are impact resistant it is traditionally used for tool handles such as sledgehammers, axes, picks, and hammers in its area of origin. Another application is the use for long handles e.g., for shovels and forks. Further uses are drumsticks, ladder rungs and the like. *Carya illinoinensis* is the largest and fastest growing hickory but its wood is inferior to that of other hickories and is not commercially important.

photo: Rob Routledge, www.forestryimages.org

photo: Eric Meier, www.wood-database.com

Figure 14: Left – trunk and leaves of Shagbark hickory (Carya ovata), right - veneer sample of its wood

Tree of heaven (*Ailanthus altissima*)

Its wood has a long use history as technical timber in China. Ailanthus wood is light and resistant. In Slovenia it was reported to be used as support for growing vegetables (e.g. beans). Higher value uses include cabinetry and turned objects. For other production know-how for processing is not very established. Due to its low calorific value and low combustibility, it is not appropriate for fuelwood use (Georges, 2020c).

photo: Lado Kutnar

photo: Eric Meier, www.wood-database.com

Figure 15: Left – a habitus of Tree of heaven (Ailanthus altissima), right - veneer sample of its wood

Lawson cypress (*Chamaecyparis lawsoniana*)

Stratmann (1988) reports "excellent height growth" in southwestern Germany, while the experimental plantations in Austria show only little height growth or strength development. In the literature it is described as a typical mixed tree species and often forms the secondary stand under Douglas fir or Sitka spruce. When establishing a stand, a coniferous pre-planting is necessary (Mayer, 1992). It supplies wood for veneers, hydraulic engineering and carpentry. The wood is also used for matches and pencil production. It is light and due to its ingredients very resistant to fungal and insect infestation.

photo: Robert Brus

photo: Eric Meier, www.wood-database.com

Figure 16: Left - Lawson cypress (Chamaecyparis lawsoniana), right - veneer sample of its wood

Honey locust (*Gleditsia triacanthos*)

It is a moderately fast-growing tree which is very hardy and tolerant of draught and salinity. In the US it is therefore planted for windbreaks and erosion control. In Europe it is winter hardy and a popular tree for parks and recreational areas. For urban trees usually a thornless and pod-less variety is planted. Because it is relatively undemanding with regard to soil conditions it is occasionally also used as a street tree (Schimann, 2015). The wood is dense, hard and durable, but splinters easily. According to Cassens (2007) the lumber is similar to oak and could be sold for a comparable price or as a higher priced value-wood item.

photo: Aleksander Marinšek

photo: Eric Meier, www.wood-database.com

Figure 17: Left - Honey locust (Gleditsia triacanthos), right - veneer sample of its wood

American tulip tree (*Liriodendron tulipifera*)

The wood is also sold as American whitewood or Yellow poplar. It has light and soft wood with a homogenous grain and scattered pores. Due to its softness workability of *Liriodendron tulipifera* is easy. It is suitable for the production of furniture, wall and ceiling coverings, musical instruments, turnery, sculpting and is also used as pulpwood in the paper industry (Georges, 2020).

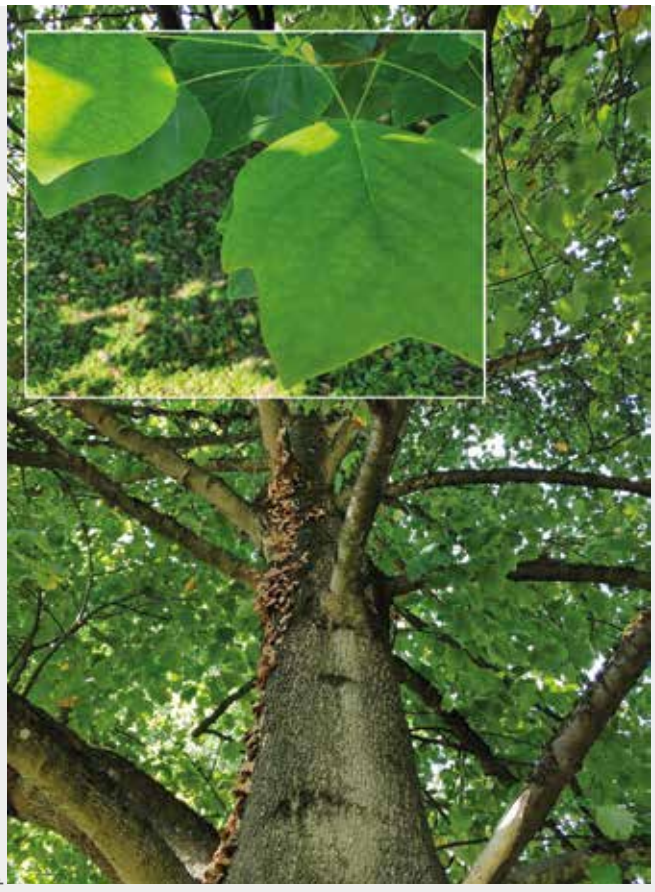

photo: Aleksander Marinšek

photo: Eric Meier, www.wood-database.com

Figure 18: Left - American tulip tree (Liriodendron tulipifera) and its leaves, right - veneer sample of its wood

Mulberry (*Morus nigra* and *Morus alba* summarised under *Morus* spp.)

Based on interviews value-wood is popular for further use in musical instruments production.

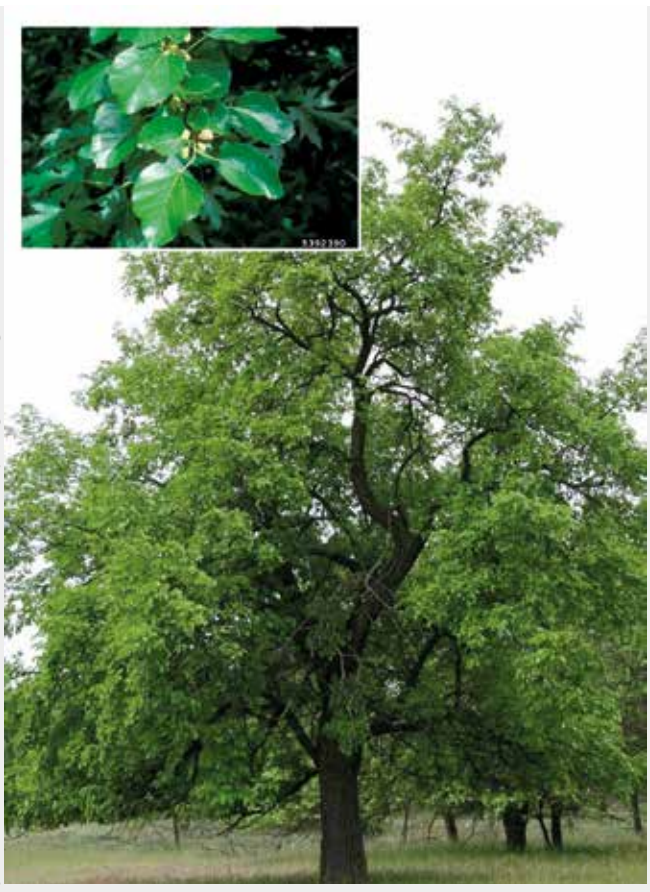

photo: John M. Randall, The Nature Conservancy, Bugwood.org

photo: Eric Meier, www.wood-database.com

Figure 19: Left – White mulberry (Morus alba) and its leaves and fruits, right - veneer sample of Red mulberry (Morus nigra wood)

Princess tree (*Paulownia tomentosa*)

It is cultivated for value timber productions in some countries in Europe. Its wood is very light with a straight grain and low shrinkage. It can be easily worked without splitting or warping. Due to its lightness, it is popular for furniture, model aircraft and gliders as well as airplane, ship and vehicle interiors. It is sometimes used for crafting musical instruments (Georges 2020d).

photo: Aleksander Marinšek

photo: Eric Meier, www.wood-database.com

Figure 20: Left - Princess tree (Paulownia tomentosa) and its leaves, right - veneer sample of its wood

Black pine (*Pinus nigra*)

The wood of Black pine is similar to that of Scots pine - moderately hard and straight-grained - but rougher, softer and with lower tensile strength. In the Mediterranean, black pine is mainly used for construction or as fuel wood (van Haverbeke, 1990).

photo: Aleksander Marinšek

photo: Eric Meier, www.wood-database.com

Figure 21: Left – a habitus of Black pine (Pinus nigra), right - veneer sample of its wood

5. Economic evaluation of the current use of NNT in the Alpine region

5.1 The value wood

The timber market for a specific NNT species is small, focused on high-value wood with some use cases for specialty applications. For lower value timber the distinction between NNT and native trees is not important e.g., for the use for biomass-for-energy use or for uses as pulpwood.

The economically most relevant NNT sold by volume is the Douglas fir (Table 2). It is an important tree in value-wood submissions. Due to its compatibility in processing softwood, it can be used as substitute for traditional Spruce-based value chains.

Rank	Species	Sales count
1	*Pseudotsuga menziesii*	48
2	*Quercus rubra*	35
3	*Robinia pseudoacacia*	21
4	*Juglans nigra*	20
5	*Pinus strobus*	13
6	*Thuja* spp.	11
7	*Cupressus* spp.	8
8	*Platanus* spp.	8
9	*Aesculus hippocastanum*	5

Table 2: Ten most important NNT ranked by sales count (min. one transaction occurred in a submission = 1) in the period 2015-2020 for Austria, Germany, Slovenia, and Switzerland (only auctions in the regions mentioned above were considered)

Regarding sales volumes, the most traded NNTs were *Pseudotsuga menziesii*, *Quercus rubra*, and *Juglans nigra* (all >= 100 m^3 sold in the period 2015-2020, Figure 22) with the latter being a NNT fetching the highest prices in value-wood submissions regardless of place. Rather popular trees (10-100 m^3 sold in the period 2015-2020, Figure 22) were *Pinus strobus, Robinia pseudoacacia, Sequoia* spp., *Populus* spp., *Platanus* spp., *Thuja* spp., *Cedrus* spp., *Hippocastanum* spp., and *Cupressus* spp. Trees with rather low volumes in trade (1-10m^3 sold in the period 2015-2020, Figure 22) are *Carya* spp., *Ailanthus altissima, Chamaecyparis lawsoniana, Gleditsia triacanthos, Liriodendron tulipofera, Morus* spp., *Paulownia tomentosa,* and *Pinus nigra*. Trees traded only occasionally in wood submissions are *Acer opalus, Celtis australis, Catalpa bignonioides, Cryptomeria japonica, Styphnolobium japonicum* (syn. *Sophora japonica*) with trade volumes lower than 1 m^3 in the submissions examined between 2015 and 2020 (not depicted).

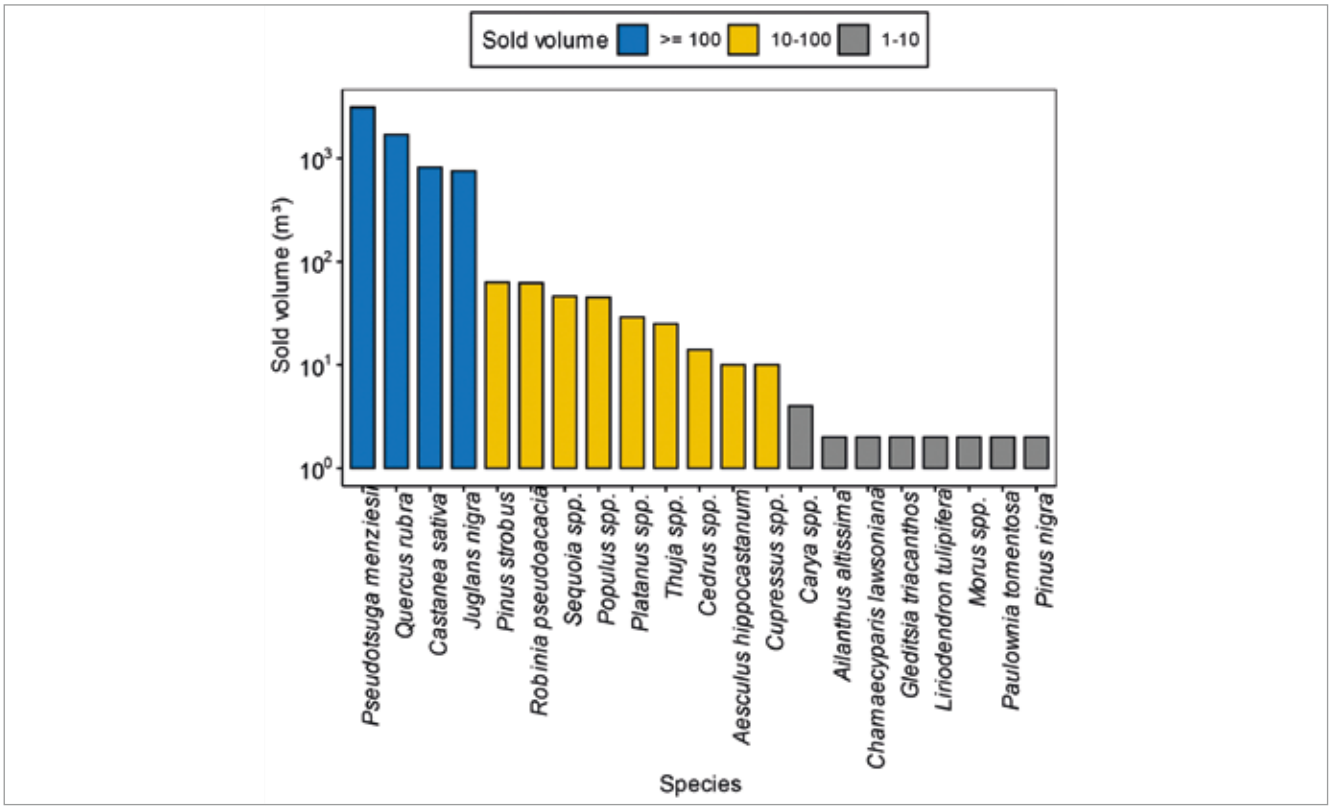

Figure 22 Sold volumes of relevant NNT (incl. aggregates with native tree species). Data from Austria, Germany, Slovenia, and Switzerland were considered.

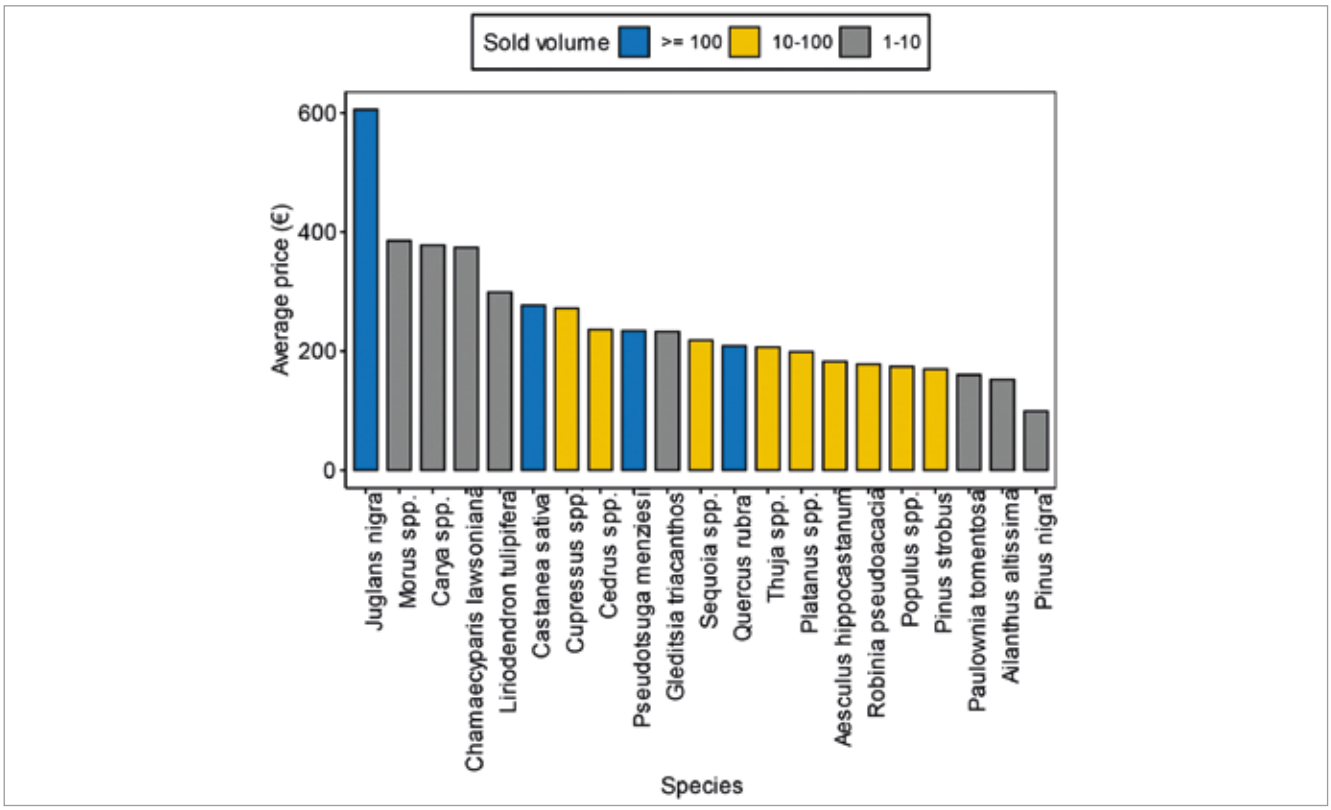

Figure 23: Average prices for NNT (incl. aggregates with native tree species) per m³ traded at wood submissions (the highest bidding prices of executed transactions). Data from Austria, Germany, Slovenia, and Switzerland were considered.

It is likely that submission results of NNTs belonging to the genera *Abies, Acer, Picea, Pinus* (except *Pinus strobus* and *Pinus nigra* which are usually mentioned explicitly), *Prunus, Quercus* (except *Quercus rubra*) are often reported together with other (native) trees of that same genus since a distinction is not useful for traders and buyers. Exceptions are mentioned above, but it is likely that distinctions are not consistent across submission places.

When analysing average prices at wood submissions *Juglans nigra* fetches by far the highest prices for value wood (Figure 23). When ranked by average price, the next four species are insignificant considering volumes sold but interesting for specific customers (cf. use cases).

Wood from *Morus* spp. Is very popular for high-value instrument production reflecting the comparatively high price in wood submissions while *Carya* spp. Seems to be popular for sports equipment. *Liriodendron tulipifera* is highly popular (amongst uses mentioned earlier) for organ production.

5.2 Value wood comparison among countries

Figure 24 shows a comparison of the average price of *Pseudotsuga menziesii* in wood submissions among three countries. In Austria, no transactions of this species of NNT were recorded between 2015 and 2020, since Lower Austria and Upper Austria specialise on hardwood trees and the other states focusing rather on native non-coniferous trees. In Slovenia only two sales were registered which were both comparatively low. Switzerland had the highest number of transactions (n = 20 events) and also the highest average price per m³ of wood. Germany had only half as many transactions as Switzerland (n = 10 events) and a significantly lower average price per m³.

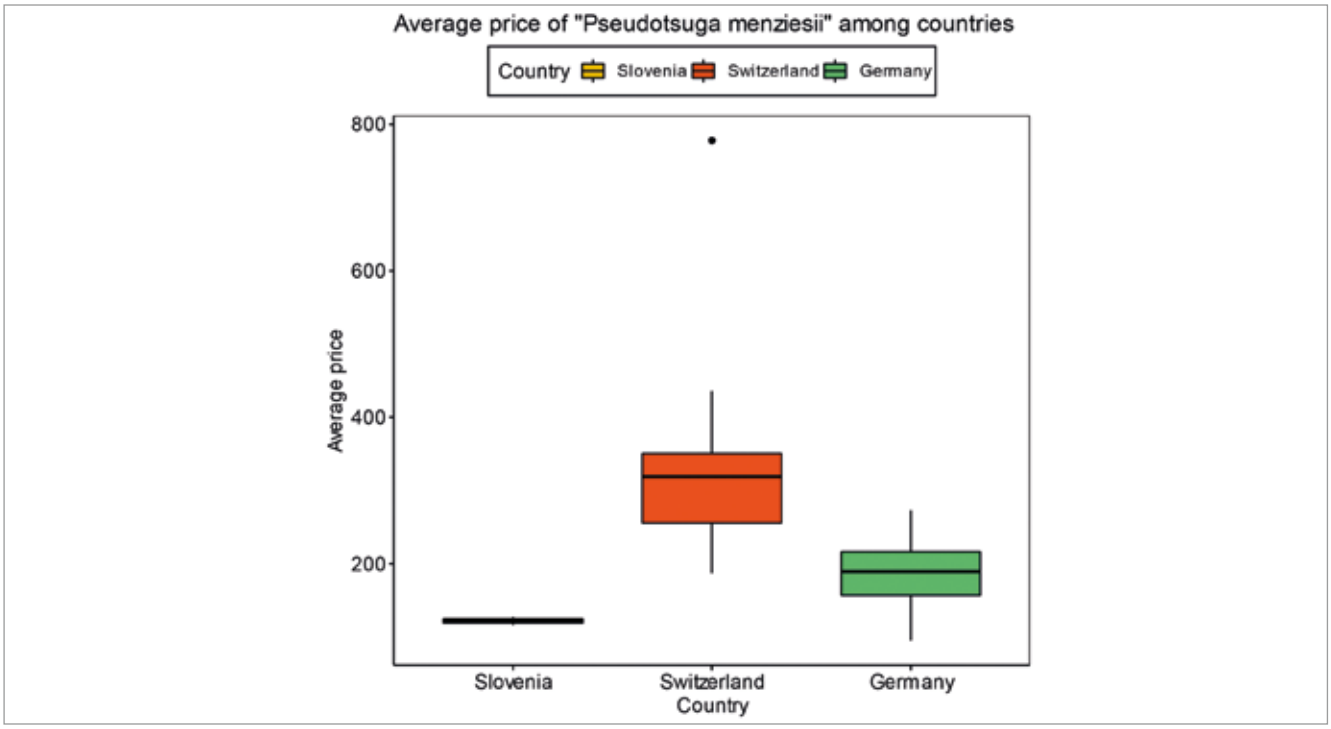

Figure 24: Differences in average submission prices per m³ for Pseudotsuga menziesii in Slovenia, Switzerland, and Germany (no Douglas fir submission sale was registered in Austria)

As a rule, *Pseudotsuga menziesii* is bought up by sawmills in Austria - usually at equivalent spruce prices or slightly higher. In Slovenia only two sales occurred at wood submissions in the last five years, while it is a highly popular wood for submission in Germany and Switzerland, fetching significantly higher prices in Switzerland.

The second-most important species in terms of quantities of value wood sold was traded in all four countries where submission data was available. Switzerland had tendentially the highest prices for *Quercus rubra* but also the highest variability at five submission events. In Germany *Quercus rubra* wood was trades at 20 submission events with a comparatively low variability in prices. Austria had somewhat a somewhat lower price range than Germany with more irregular submissions of *Quercus rubra*. The lowest submission prices were achieved in Slovenia in five submission events (i.e. each year *Quercus rubra* wood was sold except in 2017). The differences as well as the spread in average prices per m³ is shown in Figure 25.

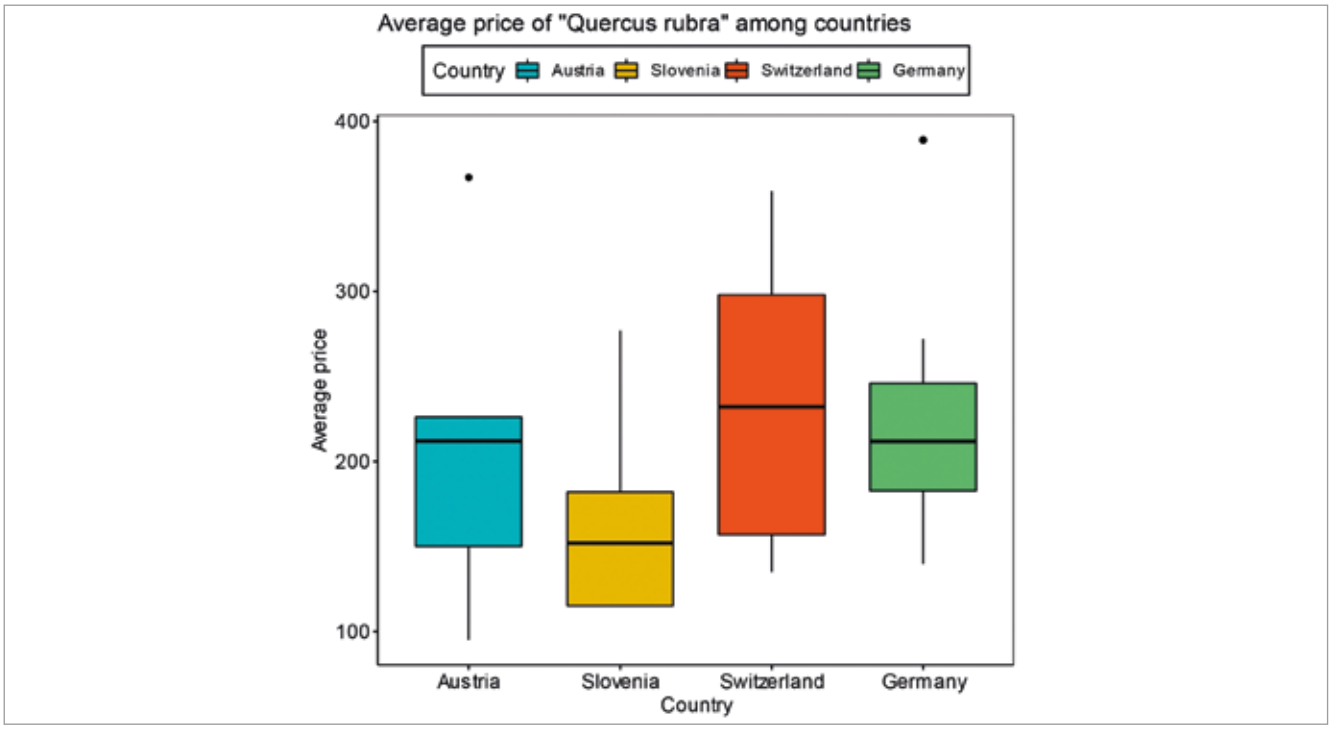

Figure 25: Differences in average submission prices per m³ for Quercus rubra in Austria, Slovenia, Switzerland, and Germany

As Figure 26 shows, *Juglans nigra* fetched by far the highest prices in each country, since *Juglans nigra* is the most popular NNT high-value wood by average value per m³. It also fetches the highest maximum bids at timber auctions in all countries examined. Austria was the most popular country for submissions of *Juglans nigra* in the last years (Figure 26).

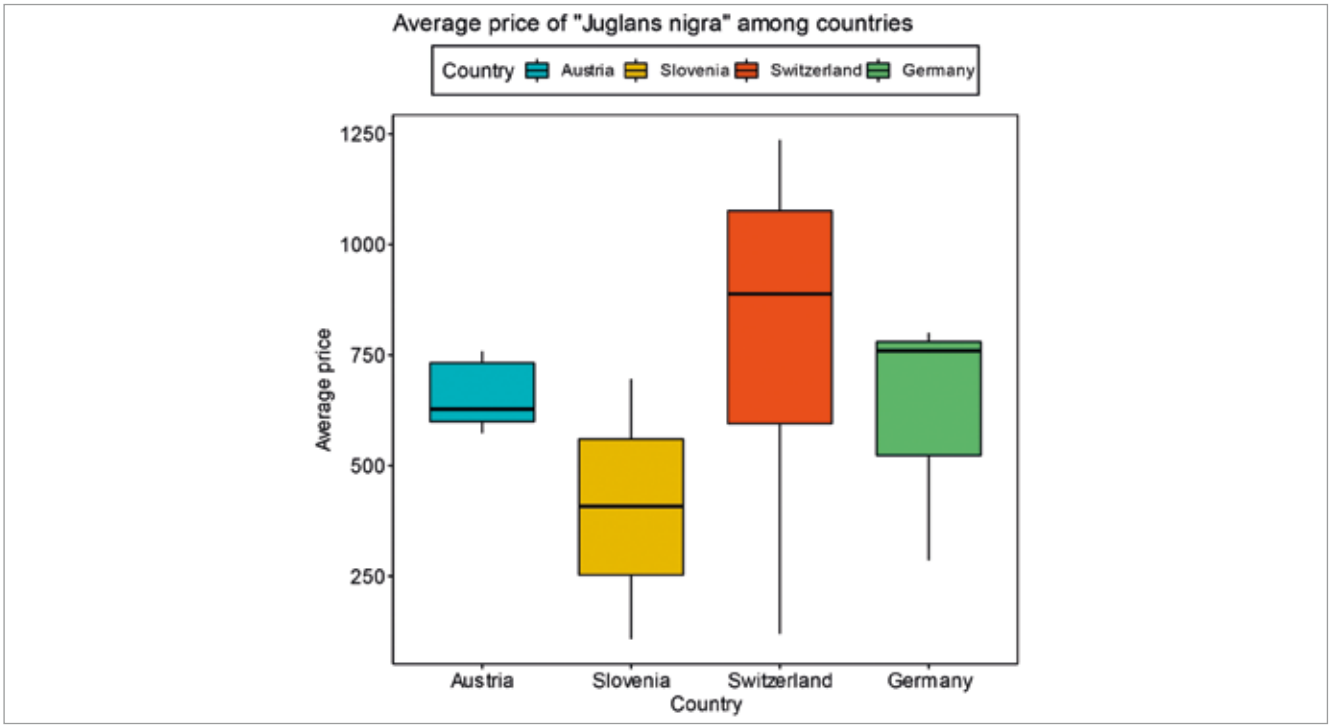

Figure 26: Differences in average submission prices per m³ for Juglans nigra in Austria, Slovenia, Switzerland, and Germany

Overall, the figures above show that Switzerland achieved the highest average prices across all four NNTs examines and Slovenia achieved the lowest average prices per m³ at wood submissions. Because of the number of transactions, it seems more likely that a country's price level is a more important determinant for NNT value-wood sales price than wood log quality itself which would explain some of the differences exhibited through the previous four figures. For Austria and Germany interconnectedness of submission events also plays a role because events in one country often recommend events in the other beforehand which is not the case between other country combinations.

5.3 Industrial roundwood

Industrial roundwood can be subdivided in sawlogs, which are used for sawnwood production as well as in pulpwood which is mainly used for pulp and paper production as well as for the production of chip- and fibreboards. In FAOSTAT, price data on the import and export values and quantities for pulpwood and sawlogs respectively are not available but only production data. Usually, when data on the value of wood is not available, the so-called unit value of a wood product is estimated from the mean of the import value per import unit and export value per export unit. To derive the unit value the aggregated category industrial roundwood (comprising of sawlogs, veneer logs and pulpwood) was thus considered instead.

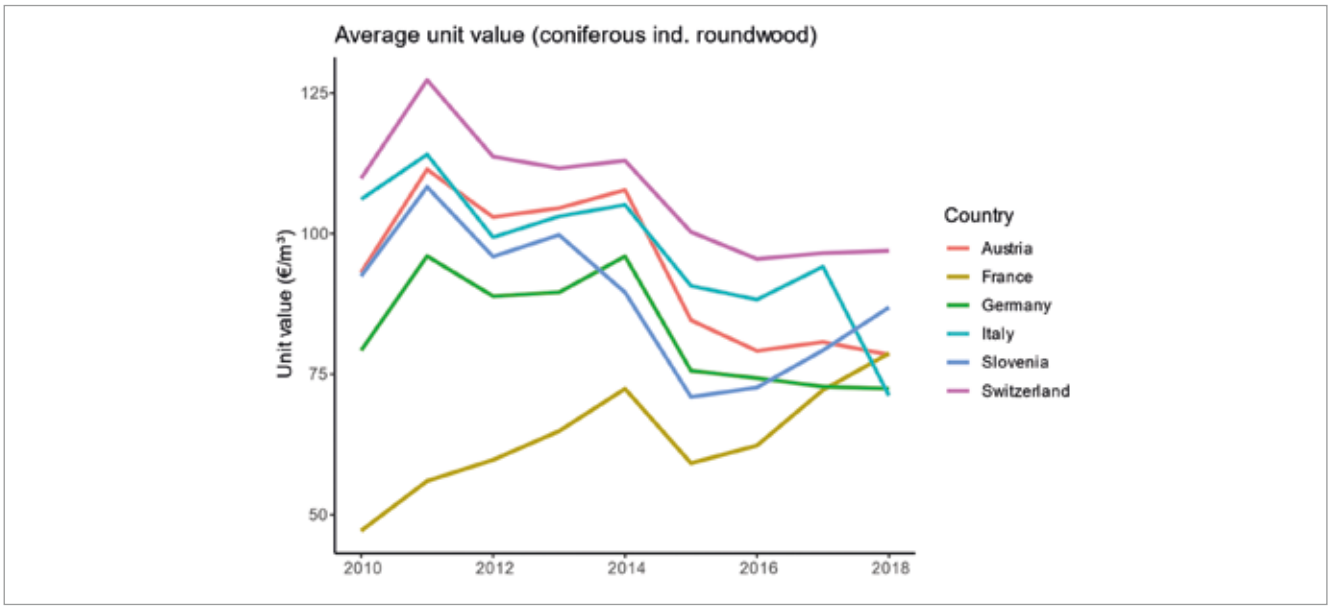

Figure 27: Average unit value per m³ of coniferous industrial roundwood in Austria, France, Germany, Italy, Slovenia and Switzerland (aggregated data for entire country, respectively; data source: FAO, 2021)

Figure 27 shows the development of indicative prices (unit values) for coniferous industrial roundwood showing marked differences between the countries of the Alpine Space. In the recent years there seems to be a convergence of the very low French prices and the comparatively high Italian prices towards price levels amongst other countries. As an exception, prices in Switzerland are still much higher than in the other five countries but also shows a decreasing trend.

For non-coniferous industrial roundwood Austria shows the lowest unit values consistently since 2010 with a decline in price since 2014. There are marked differences between Austria, France, and Germany, with Germany showing the highest prices overall. Italy experienced a strong decrease in unit values for non-coniferous industrial roundwood in the last years while the price was increasing for this category of wood in Slovenia.

Prices for log assortments for specific NNTs

According to Schuster (2016) sawlogs of *Pseudotsuga menziesii* are mostly sold according to local spruce prices in Austria. For species specific sawnwood applications, the development of US prices was suggested. In the US Douglas fir was traded for 360 - 515 US$/MBF[1] between August 2020 and December 2020 (Inland Forest Management, Inc., n.d.).

According to a presentation of the Austrian chamber of agriculture (Schuster, 2016) sawnwood from *Quercus rubra* is being sold at 20-30% lower prices than native Oak wood. *Quercus rubra* was reported from 330 €/m³ (27 mm, A/B quality) to 495 €/m³ (80 mm, A/B quality).

1 MBF = 1000 board feet

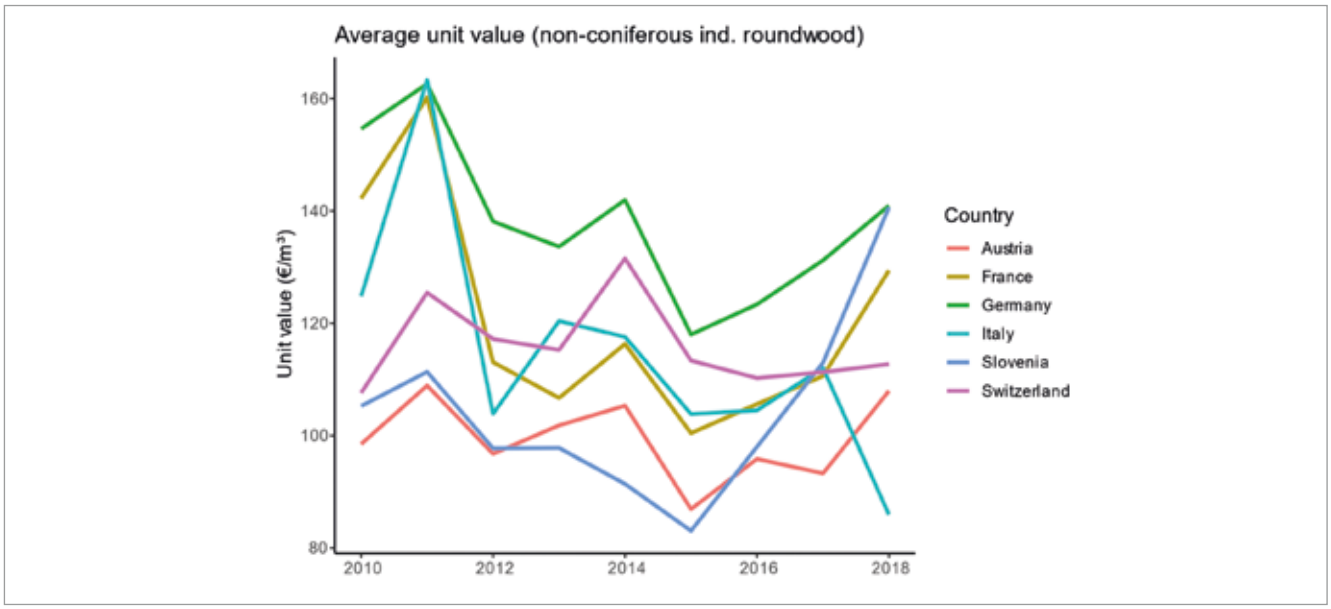

Figure 28: Average unit value per m³ of non-coniferous industrial roundwood in Austria, France, Germany, Italy, and Switzerland (aggregated data for entire country, respectively; data source: FAO, 2021)

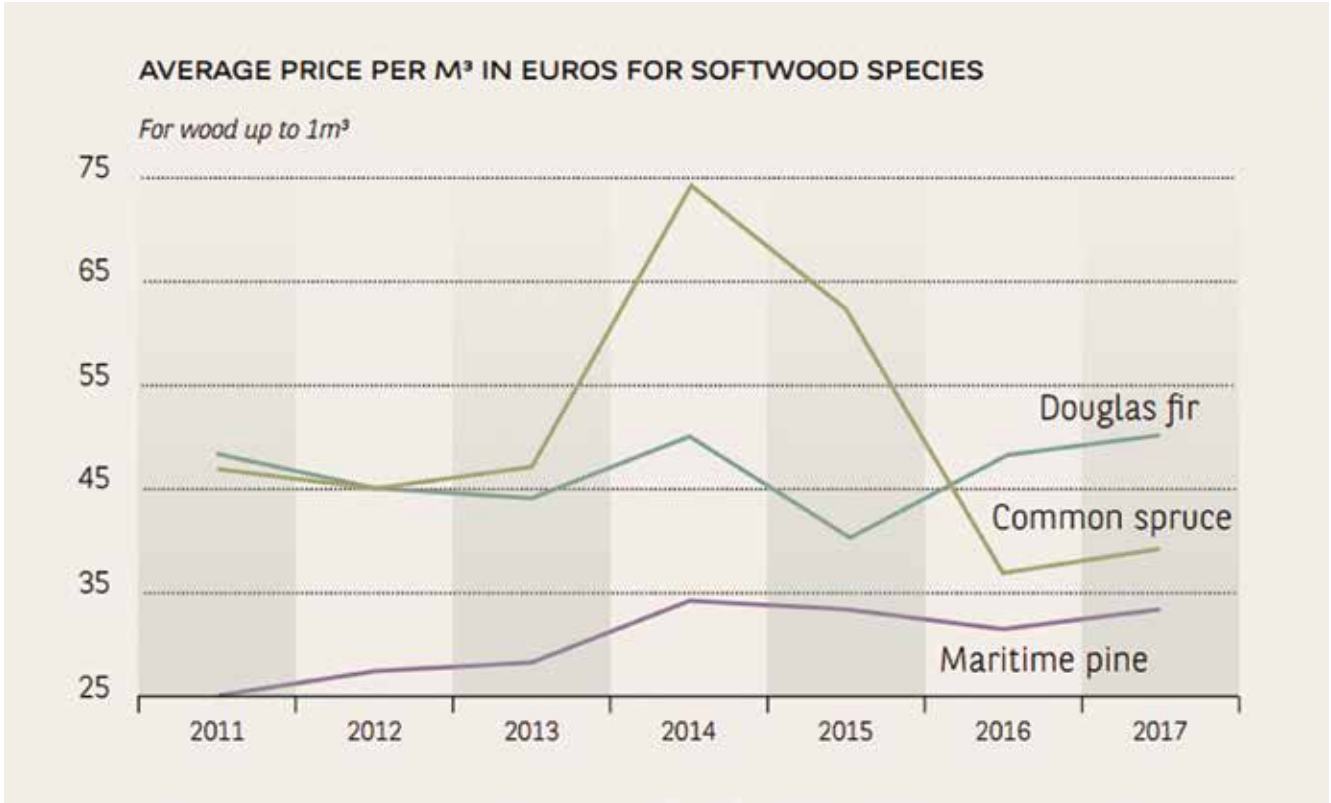

Figure 29: Average price of selected softwoods in France (Source: Experts Forestriers de France cited after BNP Paribas 2018)

It is assumed that in Germany the price relation of *Quercus rubra* to native *Quercus* is similar. Since in Austria prices for Oak are not reported separately (except some national reports), the price development for Germany is treated as indicative for the prices in Austria too. Prices for Oak roundwood in are reported as producer price index in Germany (cf. Figure 30). Better industrial roundwood data for Austria is not available since only the most important Austrian tree species are reported (i.e., Spruce/Fir and Beech).

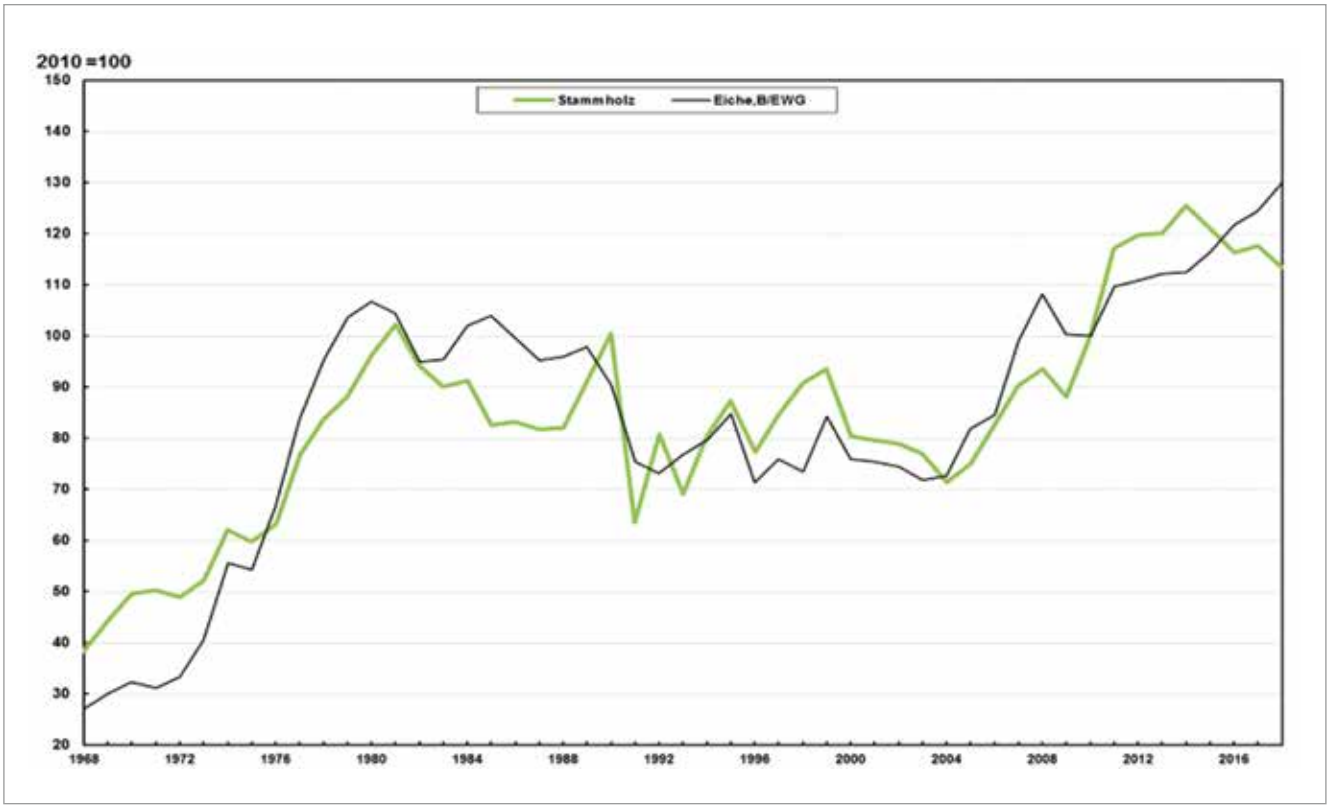

Figure 30: Producer price index for Oak roundwood (black) compared to average roundwood among all species (green) in the period 1968-2017 (2010 = 100; source: BMEL; 2019)

In France, price for Oak (as an indicator for *Quercus rubra*) is reported as annual average price in m^3 (Figure 31). Also, for Poplar hybrids the general price for native Poplars is a good data source (Figure 31).

For all other NNTs it must be assumed that they are represented within the respective average softwood or hardwood price. There is regionally available data for more specific native NNT-equivalent or NNT-proxy species but due to the heterogenous nature of reporting and language requirements such an analysis is beyond the scope of the report at hand.

Poplar hybrids in France can be well represented by the price for native Poplar in general Figure 31).

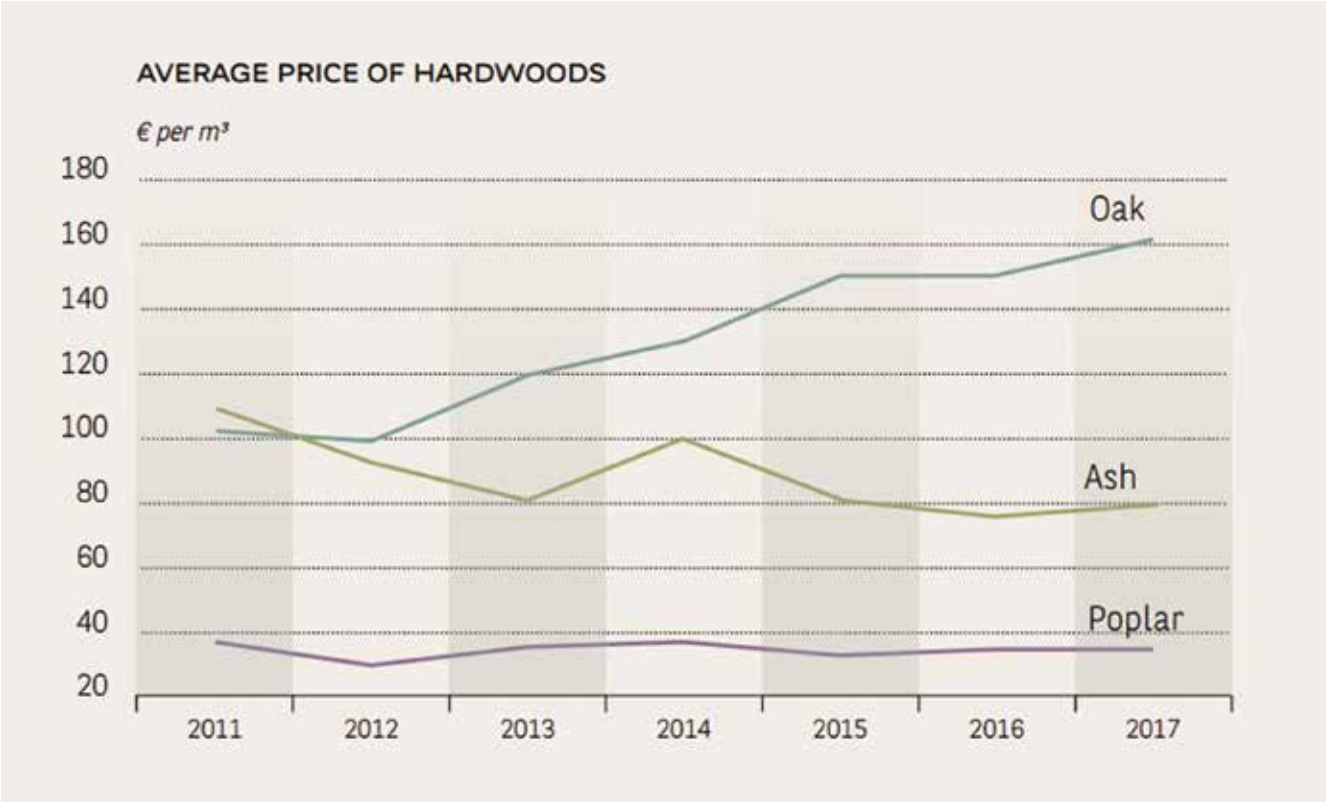

Figure 31: Average price of selected hardwoods in France (Source: Experts Forestriers de France cited after BNP Paribas 2018)

5.4 Sawnwood

If NNTs are marketed as sawnwood they are usually seen as substitute for native wood thus following similar price trends and having similar price levels than native wood. Thus, the price developments for coniferous and non-coniferous sawnwood in general were examined.

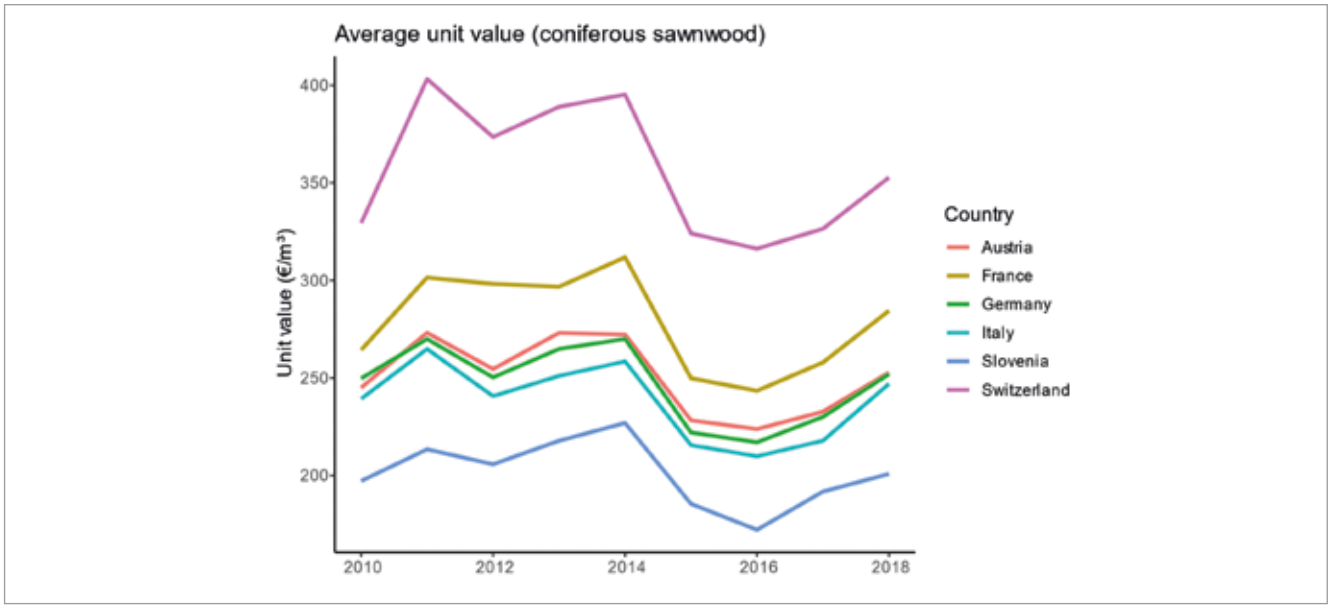

Figure 32: Average unit value for coniferous sawnwood (data source: FAO, 2021)

Figure 32 shows the development of the unit value for coniferous sawnwood for six countries of interest (values for Liechtenstein were not available). While there are marked differences in coniferous sawnwood price among countries with the cheapest unit value in Slovenia and the most expensive unit value in Switzerland all prices follow similar trends. Thus, differences are likely to occur due to different price levels in the respective countries.

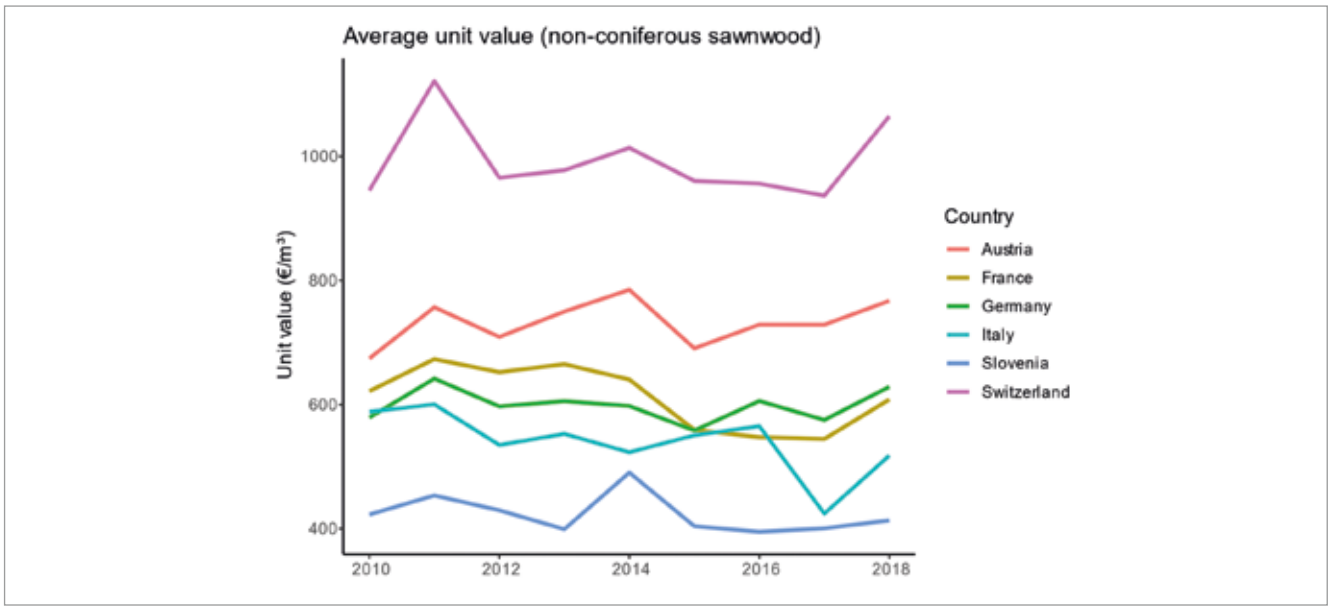

Figure 33: Average unit value for non-coniferous sawnwood (data source: FAO, 2021)

Figure 33 shows aggregated unit values for non-coniferous sawnwood species, as Slovenia having the lowest and Switzerland the highest price level. Here the comparative price level is somewhat lower for France in relation to other countries while it is comparatively higher for Austria.

While in Austria, the German Alpine space and Slovenia mainly softwoods seem to be of interest, *Quercus rubra* seems to be used together with native *Quercus* sawnwood in France which was about 904 €/m³ in the period 2015-2018 according to UNECE/FAO (UNECE/FAO, 2020).

UNECE/FAO also publishes unit value price tables (UNECE/FAO, 2010) including industrial roundwood as well as sawlog prices for selected coniferous (fir/spruce, pine) and non-coniferous (oak, beech, poplar, birch, maple, cherry, ash) species which could be used as proxy prices, but these would require further analysis to possibly make statements about relevance in the NNT-context since more investigation of regionally available data would be necessary.

5.5 Wood fuels

Recent prices in France for wood chips and particles were reported to be 44.60 €/m³. Slovenian fuelwood is reported to be 44,60 €/m³ (roadside, average) for the same period.

Average pellets prices in France were 270,1 €/t (Based on 1t of wood pellets in bulk), in Austria it was about 238 €/t, while in Switzerland it was about 365 €/t (5000 kg bulk price incl. VAT; UNECE/FAO, 2020). Additionally, Figure 34 shows the development of pellets prices for a selection of European Union member states (including the countries of interest: IT = Italy, DE = Germany, FR = France, AT = Austria), while for Switzerland no information was reported (Calderón, 2019).

Since pellet prices are not species specific, it can be assumed that palletisation of NNT would yield the same prices as shown in Figure 34.

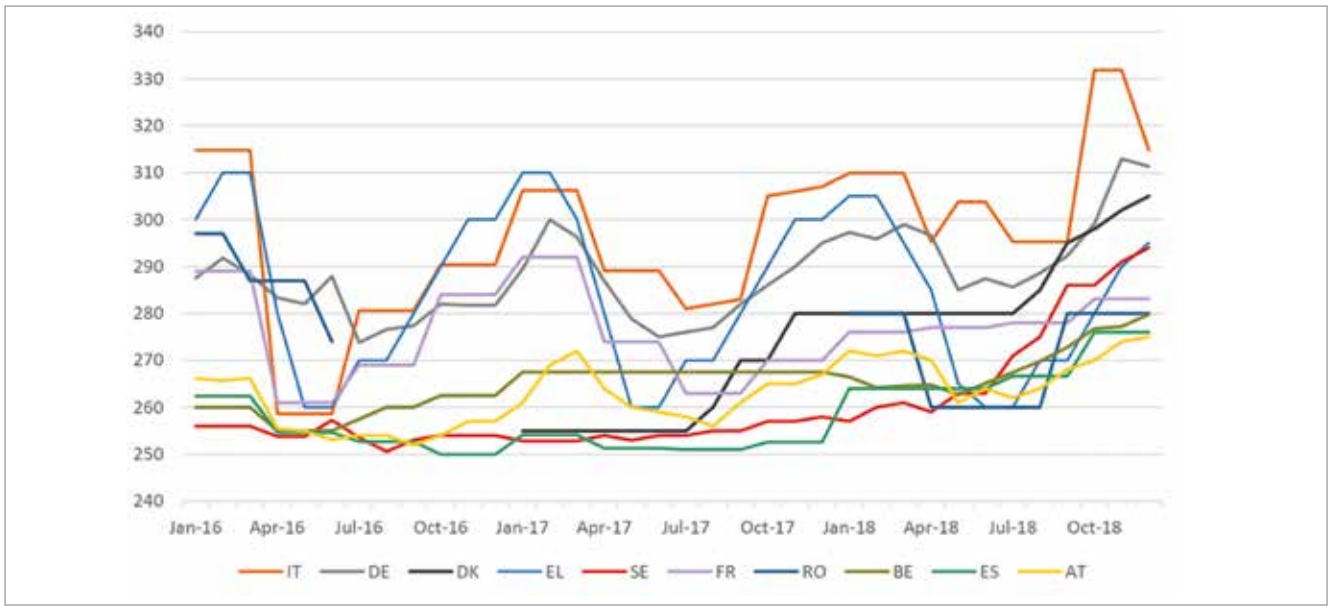

Figure 34: Bagged pellet prices in European countries (retail price, 1 pallet in €/t incl. VAT; source: Calderón, 2019)

6. Current and potential future use cases for selected NNTs with regional relevance

This section presents quotes from preliminary research resulting from expert interviews and context analysis as well as prominent mentions of NNTs in secondary literature.

6.1 *Pseudotsuga menziesii*

"*Because of its success on the market and in the context of climate change, it would be interesting to test Douglas in the Alpine mountains on appropriate sites… to define. The Alpine convention does not allow plantations for production (or, to be more precise, don't allow public subsidies for those plantations) but experimental ones are possible. Some actors (FCBA, Private forest owner organisations, sawmill association…) would like to investigate Douglas behaviour on „new" locations*"
– South-eastern France

Douglas fir has popular applications in outdoor furniture and raised beds and has very good stiffness ratings (Borůvka et al., 2015, Hasenauer et al., 2017) which makes it a promising raw material specifically as construction timber in the future.

6.2 *Quercus rubra*

As already stated in the timber profiles red oak seems to be popular for flooring, windows, furniture, and railroad sleepers. In Austria and Germany it is also used as fuelwood. In the future the use for parquet wood, staircase construction as well as for windows and doors could be expanded.

6.3 *Robinia pseudoacacia*

"*Among non-native species, the most important in Piemonte (Italy) is Robinia pseudoacacia (Black locust). Farmers surely like Robinia because it is easy to manage and it provide income streams. Robinia pseudoacacia is used for industrial use, for furniture and sometimes for floors.*"
–Piemonte, Italy

Figure 35: Robinia parquet flooring. Advertised with children's toys to illustrate its durability, Weitzer, Austria

Since *Robinia pseudoacacia* is one of the most durable NNT (Hasenauer et al., 2017), it is also a popular tree for the construction of playground equipment, tree houses and railings. On the one hand, Robinia wood is flexible and strong, and on the other hand it has a low tendency to splinter. Thicker Robinia trunks over 15 cm can be also inserted directly into the ground as unpeeled or milled round trunks without prior drying. However, metal post shoes are usually used for safety.

In France thin Robinia roundwood is sold for use as vine stakes or fence posts (about 13 to 27 €/pc). In the German-speaking areas wood for fence posts was in a range from 3 to 20 €/pc depending on length and diameter (e.g. Robinia24.de, 2020; Ruhdorfer Naturholz GmbH, 2020).

Higher value applications include use for parquet flooring (e.g. Weitzer GmbH) and stairs, panelling, use as garden and outdoor furniture, or raised beds (Silberholz e.U.) with prices of 40-80 €/m³. Due to its resistance to decomposition, it also has popular applications for raised beds, terraces and playground equipment (Robin - Georg Moravec e.U., 2020).

It is used for soil-bioengineering and temporary avalanche control which are also suitable use cases for the future next to the high-value applications.

6.4 *Juglans nigra*

The wood of *Juglans nigra* is highly sought after for its heartwood. Currently it is popular for cabinet making, wooden sculptures, fine carpentry, gunstocks, parquet flooring, oars, and coffins. Because it is rather rare it is also very popular for veneer production.

The nuts are popular in the United States, although less than the walnut (*Juglans regia*) because of more difficult extraction. The shells of black walnut seed can be ground: in the United States there are used for dyes for wool and handicraft applications.

According to CRPF (2014) black walnut is less popular in France than common walnut because of its darker, purplish-brown colour. Main sales markets are Switzerland, Germany, Sweden and Italy. The market seems to be very specialised, and the quality of the log is highly influencing the price. Consumer preference seems to be different among Alpine Space regions due to an increasing popularity in darker wood products - especially flooring - e.g. in Austria. For timber for slicing and veneering the price in France was reported to be between 700 and 1400 € in 2014 and more while for sawmilling, cabinet making and woodworking it was stated to be between 200 and 500 €/m³ (CRPF Rhône-Alpes, 2014).

Future use cases are equivalent to current ones, since this is a highly popular high-value NNT.

6.5 *Paulownia tomentosa*

In Italy, *Paulownia tomentosa* is used e.g. for manufacture for smartphones as a design accessorise.
"*[...] the danger, in the end, is not as big as the advantages. I think that if you manage well, you*

can get more benefits than if you just try to manage the native species and expect them to naturally succeed under climate change conditions. Sometimes it's harder."
–Veneto, Italy
"*For me, the wood is really good. The problem is the carpenters and woodworkers´ acceptance. They are used to work with the traditional wood species and are conservative regarding new uses. It will take some time for the mentality to change. But it will certainly change in the future*"
–Brescia, Italy

Figure 36: Paulownia beehive, Tomasoni, Italy

Figure 37: Paulownia smartphone speaker amplifiers, Tomasoni, Italy

Next to fashionable wood products *Paulownia tomentosa* has promising future application for lightweight applications and acoustic use, e.g. for musical instruments.

6.6 *Thuja* spp.

With regard to furniture there are large differences regarding execution, quality of manufacturing and wood species or type of wood used. In the Alpine space *Thuja* has a popular use case as lightweight wood for furniture production. Besides that, is also marketed as barbeque wood, which is a higher value fuelwood application (Schuster, 2016).

Wood of *Thuja plicata* is a very popular raw material for the production of shingles in the United States (50% of all shingles in the United States are made of *Thuja plicata*) but is also used as construction timber for interior and exterior use (facades) as well as for windows and for doors. These are also possible use cases in the Alpine space. Despite its good wood properties, the use of this tree is very limited due to the very low supply of *Thuja* roundwood in the Alpine region. Sale and utilisation are subject to many coincidences in supply and production can therefore be hardly optimised. There are currently no known specialty uses for *Thuja plicata* or *Thuja* spp. in general.

6.7 *Gleditsia triacanthos*

According to Cassens (2007b) the wood of *Gleditsia triacanthos* has a good higher value use for custom-made furniture, cabinets, and millwork or for parquet floors because of the attractive grain and colour, stating "*Honey locust is a beautiful wood that deserves more attention*" (Cassens 2007b, 2).

6.8 *Sequoia* spp.

Sequoia sempervirens wood has popular applications for construction lumber and shingles. Its burls can be used for the production of veneers, turned goods and tabletops (Olson et al., 1990). *Sequoiadendron giganteum* is being used as dimensional lumber, as well as for as veneer and plywood in its native region (Piirto, 1986). Historically Giant sequoia was commercially exploited since the 1850s until the mid-1950s. It was mostly used for fenceposts, grape stakes, shingles, patio furniture and for pencil production (Hartesveldt et al., 1975) providing potential applications for Sequoia-wood in the Alpine space.

6.9 NNT in general

"*We have these species here and we have to learn how to use it. In ecological terms – forest communities are constantly changing, and income of new species is somehow expected*" – Teacher at a secondary school, Slovenia

In Italy there is a project for the promotion, recovery and valorisation of wood from urban trees that have to be felled for reasons of age, instability, new territorial planning requirements or periodic renewal of urban trees. It is a circular economy project aimed at the conservation of natural capital, to preserve wood and to encourage the second life of urban trees with the creation of unique products and artefacts due to urban wood often being delivered in

Figure 38: Standing Sequoia tree (left) in Lombardy, Italy and wood of Juglans nigra (right) in Piemont, Italy. Both were offered through the Facebook marketplace of LegnoUrbano.

uncommon shapes and sizes. Because this project focuses on wood from urban trees there is also a high prevalence (LegnoUrbano, 2020)

Paulownia Italia Srl. organises a biennial forest-wood-energy fair (FORLENER, foresta-legno-energia). While it focuses on the forest-wood energy chain, a value timber auction and an "arbor show" are also part of the fair. Recently there is some cooperation with LegnoUrbano and local sawmills (Forlener, 2019).

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