Timber from **trees** and **shrubs**

Properties and historical utilization of 60 Central European wood species

“Wood that is not used for burning,
but for all kinds of other things.”

*“Holz, welches nicht zum Brennen, sondern
zu allerlei anderen Dingen verbraucht wird.”*

Krünitz 1773-1858
Oeconomische Encyclopädie

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Foreword by the author

The origin of the book
While sampling for dendrochronological dating of historical and prehistoric wood, one regularly encounters „old wood“. This connection makes it obvious that a more far-reaching examination of the comprehensive subject area of „historical wood utilisation“ is necessary. In addition to construction types and processing techniques, historical wood utilisation is primarily characterised by the question of wood species selection. Which type of wood was used for which application? This gave rise to an interest in the utilisation of various wood species.

The first steps have been taken by students (diploma theses, bachelor theses) since 2004. In a first project (Austrian Science Fund FWF TRP 21-B16 “Historische Holzverwendung in Österreich”, 2010-2013), 48 wood species were identified in Austria’s museums through extensive wood species analyses. This work was continued and deepened in a subsequent project (Austrian Federal Ministry of Science, Research and Economy, Sparkling Science, SPA04-188 “Wald-Holz-Werkstoff”, 2012-2014). At the same time, the search for historical literature was intensified. Further work by students helped to collect data - especially in the area of characterisation. A further Sparkling Science project (SPA05-013 “Wert-Holz”, 2014-2017) made it possible to merge the data sets, further expand and complete the extensive characterisations and literature analyses and initiate this book.

In 2017 the book was published in German with the publisher Kessel. From this time onwards, there was an interest to translate this book into English. Due to some support of the World Wood Day Foundation (www.worldwoodday.org) and the International Wood Culture Society (www.iwcs.com), it was possible to set up a glossary with Joe Thompson (www.holzverwendung.at).

Sparkling Science
“Sparkling Science” is a research programme of the Federal Ministry of Science, Research and Economy that promotes young scientists in a modern and unconventional way. In the “Sparkling Science” projects, scientists work side by side with pupils on current research issues. As part of the “Wert-Holz” project, 25 students were able to complete 10 Matura theses at the Higher Department of Wood Technology at the HTL Mödling and the Higher Federal College of Forestry in Bruck an der Mur. The data compiled in the theses was an important part for the completion of this book.

Acknowledgement
Many institutions, people, companies and sponsors were involved in this project - and I would like to express my sincere thanks to them (see contributors and supporters in the book’s imprint). However, I would like to emphasise and especially thank Konrad Mayer for his work in the Wert-Holz project and in the production of this book. He thankfully managed the data and is responsible for the illustrations and many of the texts. I would also like to thank Andrea Weber (née Klein) for many of the data and text modules and Sebastian Nemestothy for doing all the layout work.

I would also like to take this opportunity to thank my former supervisors and mentors for guiding and supporting me in this direction - Gottfried Halbwachs and Rupert Wimmer. I therefore dedicate this book to Friedl Halbwachs, who has unfortunately already passed away.

Michael Grabner

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Introduction

Wood was and is an elementary natural raw material - even today, the annual global demand is still increasing. For thousands of years, wood was the most important fuel, building and construction material, as well as the raw material for precursors of the chemical industry (Radkau 2007). However, the utilisation of wood also has a distinct cultural-historical dimension with great temporal depth. For over 400,000 years - since the archaeologically documented use of tools and firewood (spears from Schöningen, Germany; Thieme 1997) - wood has been one of the most important raw materials that have accompanied mankind (Begemann 1977, Ziethen 2000, Radkau 2007, Wegener 1999). Wood is only preserved as an organic material in a completely dry environment or under water over very long periods of time. Early evidence of wood utilisation is therefore relatively rare. Since time immemorial, mankind's skills have developed through working with wood (Radkau 2007, Reschreiter et al. 2013). Just a few decades ago, every child knew which wood to use to carve bows and arrows and which wood made the best pipes. Every craftsman and every farmer was an expert when it came to wood (Klein 2015). On some farms, the work of the farmer was hardly distinguishable from that of a professional craftsman due to his high level of manual skill (Moser 1949). In crafts, such as that of the miller, master craftsmen were required to be able to handle wood skilfully in order to carry out repairs themselves. Wooden tools were therefore usually made by the craftsmen who used them (Radkau and Schäfer 1987).

Iron and metals were a sign of prosperity and hardly affordable for the rural population (Blau 1917). Wood was the material that was characterised by its wide distribution and its relatively simple harvest and processing possibilities compared to other materials (Gayer 1939). People were dependent on wood to fulfil all their needs. The roof trusses and, in log construction, the walls, crockery, furniture, tools and household appliances were largely made of wood. Even devices that are made of metal today, such as machine parts, shafts, axles and cogwheels, were made of wood. This is why mechanical engineering was also considered a branch of carpentry in the 18th century (Fuchs 2012). Different parts of a device were exposed to various stresses - and the choice of wood species was just as varied. Alexander Peez mentions in 1899 that a Carinthian farmer still used at least twelve different wood species in his business (in Blau 1917) and Josef Blau even counts 27 wood species in just one Bohemian household (Blau 1917). A total of 48 wood species have been identified in Austrian museums (Klein 2015, Klein et al. 2016). Today, many of these wood species - large shrubs and small trees (such as cornelian cherry and barberry) - are no longer used. The Austrian Timber Industry Association, proHolz, lists 24 domestic wood species in its "Holzspektrum" (Fellner et al. 2006). This representation corresponds to the domestic timber traded today. However, compared to the number of tree and shrub species growing in domestic forests, this number is relatively low (Ebert 2001). Ebert (2001) describes for Germany that 6% of the tree species occupy 80% of the forest area. In Austria, spruce and beech alone account for over 60% of the forest area (Prem 2008).

As the usability of a wood species as a material depends not only on its occurrence and availability, but above all on the specific wood property, the total of all wood properties is also determined by the number of available wood species. Any reduction in the variety of wood species thus leads to a minimisation of the potential properties of wood as a material (e.g. Gayer 1939). Only by considering small trees and large shrubs can the full technological potential of wood as a material be realised. Radkau (2007) explains the recent reduction in the number of wood species used by the fact that the same importance is no longer attached to the natural differences between individual tree species as was previously the case.

Each wood species has specific properties that make it suitable for one or other application (Gayer 1939, Klein et al. 2016). The respective properties depend on the anatomical and chemical structure of the wood, the age of the tree, the trunk section and the site where the tree was growing (Gayer 1939, Zobel 1989, Grabner 2005). The assessment of the respective property depends on the specific application. Hardness, for example, is a valued property and correlates positively with density and strength (Niemz 1993). Nevertheless, it cannot generally be said that hard wood species are the better ones. If good machinability and low own weight are desired, the soft wood species the more valuable (Radkau 2007). It can be assumed that in most cases it was not just one property that was decisive for the functionality of a wooden workpiece, but the combination of two or more wood properties. Thus, a different type of wood would be favoured for a cogwheel or a carriage axle than for carving. Josef Blau (1917) emphasises that on the farms of the Bohemian Forest, each type of wood was differentiated according to its origin and properties and selected for the appropriate use.

Knowledge about the use and processing of wood has been collected over centuries and passed on orally from one generation to the next. This traditional knowledge was hardly changed for a long time (Moser 1949). For Tyrolean farmhouse furniture, for example, there is evidence that the wood joints have remained almost the same over centuries (Colleselli 1968). Wood was very valuable and was processed with as little material loss as possible (Klein et al. 2014). This can be seen, for example, in construction timber, which was generally not processed with sharp edges (Klein and Grabner 2015), or the obligation to store and reuse old timber that was no longer in use (Grabner et al. 2016). However, in furniture making and barrel stave production, the trunks were also processed in such a way that as little wood loss as possible occurred in the form of chips (Karmarsch 1841). The carpenter made sure that the width of the board corresponded to the requirements of the piece of furniture. Karmarsch (1841) writes about this (see quotation).

One of the most important methods of using wood economically and efficiently was to use each wood species correctly. Care was taken to ensure that high-quality wood was not used for purposes for which lower-quality wood was also sufficient. Regional availability as well as legal and technical accessibility also played an important role. Forests were also managed according to these principles, with concrete effects on the composition of tree species, the harvesting age and the regulation of ownership and utilisation rights (Radkau and Schäfer 1987).

„One must endeavour to cut out the necessary pieces from a given plank in such a way that as little waste as possible is produced by small, unusable pieces. For this purpose, it is essential to select a plank of suitable length, width and thickness for each case and to divide it up in the way that is most appropriate for the purpose.“

„Man muss trachten, aus einer gegebenen Bohle die erforderlichen Stücke so herauszuschneiden, dass so wenig wie möglich Abfall durch kleine, unbrauchbare Teile entsteht. Hierzu ist wesentlich, dass man für jeden Fall die Bohle von geeigneter Länge, Breite und Dicke auswählt und die Einteilung derselben dergestalt treffe, wie es dem Zwecke am angemessensten ist.“

Karmarsch 1841

Although wood has always played an important role in Austria, a great deal of knowledge and experience about the properties and processing of this unique material has already been lost (Klein 2015). Josef Blau already described this in 1917:

„The old economic and working methods, the skills, knowledge, experience and conditions that have long been passed on, and with them much necessary linguistic and cultural heritage, are moving ever higher up the forests and mountains.“

„Die alte Wirtschafts- und Arbeitsweise, die lang her vererbten Fertigkeiten, Kenntnisse, Erfahrungen und Zustände und mit ihnen viel nötiges Sprach- und Kulturgut ziehen sich immer höher die Wälder und Berge hinauf.“

Blau 1917

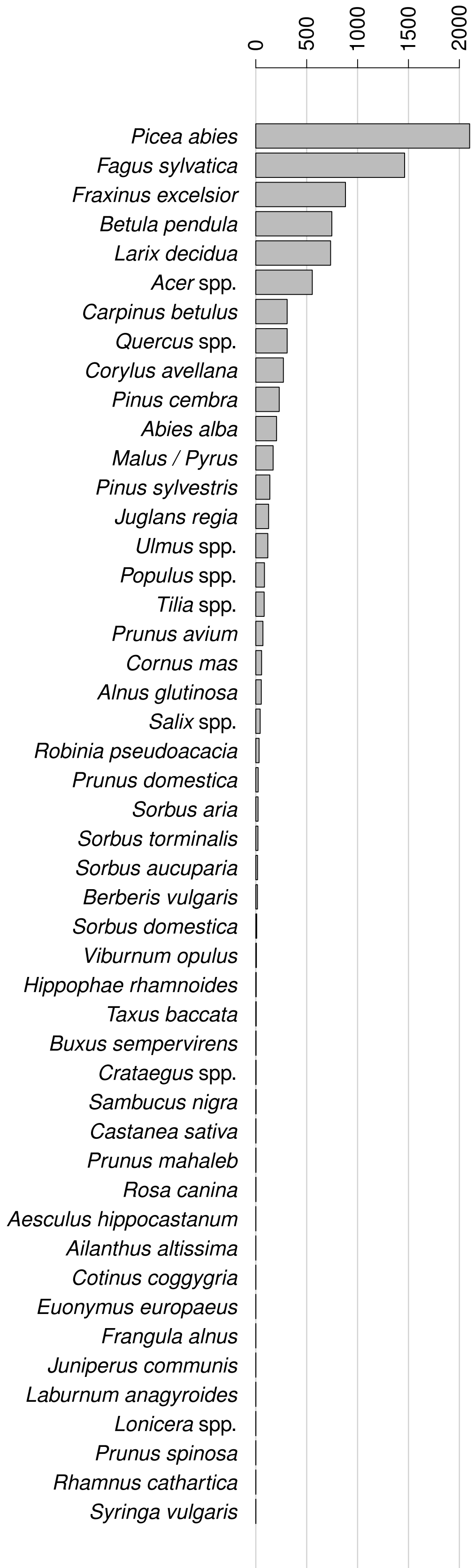

Fig. 1: Number of determinations per wood species on 8985 object parts from six Austrian museums

Aims of the book

Wood is a raw material that has not only accompanied mankind for a long time but has also characterised it. Knowledge of its properties and possible uses has developed over thousands of years. Over the last two to three centuries, much of this knowledge has been recorded in books.

The basic idea of this book was to aggregate this historical knowledge and compare it with modern parameters. In this way, wood species determinations on objects from several museums are combined with the analysis of historical literature and a comprehensive characterisation of our Central European wood species. In addition to the characteristics, this book describes the proven historical utilisation of Central European wood species. A total of 48 wood species were identified in several Austrian museums (Klein 2015, Klein et al. 2016). These were expanded to a total of 60 historically relevant wood species by frequently mentioned wood species in the literature (see Literature analysis section). The literature analysis was supplemented with ethnological references (Bockhorn 2013), which include mentions in folklore literature as well as in museum inventories. This catalogue of 60 wood species was compiled on the basis of existing standards and specially developed test specifications.

The description of historical use is intended to inspire. Based on the hypothesis that the wood species were previously used according to their properties, this list serves as a source of ideas for potential new applications and products. All the characteristic values listed are characterised by a consistent methodology. As a result, the book offers a very good opportunity to compare the various properties of different wood species. The book is intended as a reference work for academic staff, as a textbook for students and pupils, for craftsmen and women in the timber industry, as an inspiration for foresters as well as all other interested parties and hobby craftsmen and women.

Table 1: Processed wood species and number of tested individuals

Wood species	Name	Indiv.	Wood species	Name	Indiv.
Abies alba	Silver fir	3	*Picea abies*	Norway spruce	3
Acer pseudoplatanus	Sycamore maple	2	*Pinus cembra*	Stone pine	2
Aesculus hippocastanum	Horse chestnut	6	*Pinus sylvestris*	Scots pine	4
Ailanthus altissima	Tree of heaven	3	*Platanus* spp.	Plane	3
Alnus glutinosa	Alder	3	*Populus* spp.	Poplar	4
Amelanchier ovalis	Snowy mespilus	4	*Prunus armeniaca*	Apricot	2
Berberis vulgaris	Common barberry	9	*Prunus avium*	Sweet cherry	5
Betula spp.	Birch	3	*Prunus domestica*	Plum	6
Buxus sempervirens	Box wood	2	*Prunus mahaleb*	Mahaleb cherry	3
Carpinus betulus	Common hornbeam	3	*Prunus padus*	Common bird cherry	4
Castanea sativa	Sweet chestnut	2	*Prunus spinosa*	Blackthorn	11
Colutea arborescens	Com. bladder senna	4	*Pseudotsuga menziesii*	Douglas fir	3
Cornus mas	Cornelian cherry	14	*Pyrus* spp.	Pear	4
Cornus sanguinea	Bloodtwig dogwood	13	*Quercus* spp.	Oak	3
Corylus avellana	Common hazel	13	*Rhamnus cathartica*	Buckthorn	10
Crataegus spp.	Hawthorn	13	*Robinia pseudoacacia*	Black locust	3
Euonymus europaeus	Common spindle tree	15	*Rosa canina*	Dog rose	8
Fagus sylvatica	Common beech	2	*Salix* spp.	Willow	6
Frangula alnus	Alder buckthorn	7	*Sambucus nigra*	Elder	20
Fraxinus excelsior	Common ash	2	*Sorbus aria*	White beam	8
Hippophae rhamnoides	Sea buckthorn	7	*Sorbus aucuparia*	Rowan	10
Ilex aquifolium	Common holly	2	*Sorbus domestica*	True service tree	4
Juglans regia	Common walnut	4	*Sorbus torminalis*	Wild service tree	6
Juniperus communis	Common juniper	2	*Staphylea pinnata*	European bladdernut	6
Laburnum anagyroides	Common laburnum	5	*Syringa vulgaris*	Lilac	7
Larix decidua	European larch	2	*Taxus baccata*	Common yew	3
Ligustrum vulgare	Common privet	11	*Tilia* spp.	Lime	3
Lonicera spp.	Honeysuckle	3	*Ulmus* spp.	Elm	2
Malus spp.	Apple	7	*Viburnum lantana*	Wayfaring tree	7
Morus spp.	Mulberry	3	*Viburnum opulus*	Guelder rose	7

The database

Determination of wood species

In six Austrian museums (Museum of Forest Farmers - Gutenstein, Lower Austria; Austrian Open Air Museum - Stübing near Graz, Styria; Museum of Folk Culture - Spittal an der Drau, Carinthia; First Carinthia Museum on Handicraft - Baldramsdorf, Carinthia; Museum of Agriculture - Schloss Stainz, Styria; Museum of Furniture at the Probstkeusche - Malta, Carinthia), a total of 8985 object parts from a wide variety of inventories were analysed. A total of 48 different native wood species were identified (Klein 2015, Klein et al. 2016). Figure 1 shows the number of wood species determinations for these wood species: In addition to the most common (spruce and beech), hazelnut was already determined as the ninth most common shrub. Only 19 of the 48 wood species belong to the group of “main wood species”. In addition to the determination of the wood species, an estimation of the stress on these object parts was carried out. This was divided into the following areas: Strength, impact resistance, hardness, wear resistance, friction, impact absorption, splitting resistance, dimensional stability, antibacterial properties and durability (Klein 2015, Klein et al. 2016). The aim of this categorisation was to describe the wood properties based on the proven uses and the associated loads.

Literature analysis

In order to compile the existing knowledge about the properties of these wood species and their use, 122 historical books and 88 sources of ethnological literature from the fields of botany, forestry, timber industry, xylotheques and home economics were analysed (Klein 2015, Klein et al. 2016, Bockhorn 2013). These works provide an overview of wood technology knowledge in the period from 1690 to 1985. The anatomical-structural and technological descriptions and references to their use were summarised for 60 native (with a few exceptions also non-native, but cultivated for a long time - see Table 1) wood species. The description of these wood species in the historical books is in part detailed - but mostly without a comparable numerical description of the properties.

Characterisation

The 60 wood species of historical relevance were characterised using modern methods - in part based on valid standards (e.g. strength), in part using specially constructed test devices (e.g. friction) or test specifications (see Methods section).

As many of these species are no longer used and therefore not traded, they had to be found, harvested and processed. Species were identified on the basis of botanical characteristics such as leaves, cones, buds and habitus, and straight stem sections were taken from several individuals. The resulting stem sections were cut into quarter sawn boards, dried and then stored in a standardised climate (according to DIN 50014, 20°C, 65% relative humidity) and planed to a thickness of 10mm or 20mm.

Depending on the test, the required specimens were prepared from this material. The wood of the species currently used was obtained from the timber trade and comes from a smaller number of individuals. For this reason, our results do not cover the full technological range of the species (e.g. the higher values for Norway spruce or Scots pine compared to DIN 68364). The focus of this work was to characterise rarely used species. The values determined for these species are therefore much more robust than those measured for the ‘main species’. As comparative values are available in the literature for many parameters, it was possible to check for all species whether the values were within the expected variability.

Table 1 compares the scientific names with the common names, supplemented by the number of individuals of trees or shrubs processed.

Test parameters and methods

Density (wood and dry wood density)

Density is one of the most important material parameters, as it explains the variability of other material parameters to a large extent (Niemz 2008, Bosshard 1984, Niemz 1993, Kollmann 1951). Within a scattering range caused by anisotropy and inhomogeneity, properties such as strength, hardness, combustion resistance and thermal conductivity are directly proportional to density (Göhre 1961). The correlation between density and other material properties, especially strength, is described as very high (Saranpäa 2003). As with other material parameters, the density depends not only on the