

Wood Species Selection for Musical Instruments

Seminar

Submitted by

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Abstract/Keywords

The construction of instruments is a very difficult issue, the instruments makers must know the right applications and properties of the used wood species. Only wood of high quality and with special application properties was used for the construction of musical instruments. The selection of suitable wood species for different instruments is very difficult and interrelates with the experience of the instrument maker. Wood that is used for the construction of musical instruments requires the highest quality. This quality is quite rare and difficult to detect for people who have no training and prior experience.

sound board, sound body, resonance wood, sound properties, absorbability, sound propagation

Kurzfassung/Schlüsselwörter

Der Bau von Musikinstrumenten ist ein sehr schwieriges Thema, da die Instrumentenbauer über die richtige Verwendung und die Eigenschaften der verwendeten Holzarten Bescheid wissen müssen. Nur Hölzer bester Qualität und mit besonderen Verarbeitungseigenschaften werden für den Bau von Musikinstrumenten eingesetzt. Die Wahl der passenden Holzarten für die unterschiedlichen Instrumententypen ist sehr schwer und steht im Zusammenhang mit der Erfahrung des Instrumentenbauers. Holz, das für den Bau von Instrumenten eingesetzt wird, besitzt den höchsten Standard. Diese Qualität ist ziemlich selten und sehr schwer zu erkennen für Personen, welche kein Training oder besondere Erfahrung (und Ausbildung) haben.

Resonanzböden, Resonanzkörper, Resonanzholz, Klangeigenschaften, Dämpfungseigenschaften, Schallausbreitung

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1. Introduction

Since musical instruments came into existence wood has always played an essential role in their construction. Several factors are responsible for this crucial role in the making of musical instruments (JOPPING 2003-2004). Out of all things, we can make out of wood, there is no product that requires higher quality and more careful handling of the raw material and comes in such variety as musical instruments (RICHTER 1988). There is hardly another sector in wood processing, which applies knowledge of former times like the construction of musical instruments. It would not be possible to create excellent musical instruments without acquiring profound knowledge regarding to wood species selection, handling techniques and surface treatment. For instance, the selection of wood is significant for the construction of sound boards and sound boxes. The wood species typically used for sound boards is spruce. It has perfect properties regarding the sound quality, handling and structure in this sector. Although there were attempts to replace this species with other types of wood the results were unrewarding. (RICHTER 1988).

Musical instruments made out of wood differ in many aspects from one another depending on the wood species (RICHTER 1988). This term paper provides insights into the selection of European wood species for musical instruments and their application.

2. Materials and Methods

2.1. Technical Basics

The application of different wood species for musical instruments is affected by different criteria. The selected type of wood for sound production must have special characteristics including physical and biological properties. This is reflected by the structurally heterogeneity and anatomical homogeneity in combination with certain physical properties. In addition to the acoustical function, the handling of the wood species and the aesthetic and visual function are to be considered (DAHMS 1995a).

2.1.1. *Physical parameters*

Physical parameters which influence the application of wood are the velocity of sound and the absorbability. The velocity of sound depends on the density and modulus of elasticity. At a quite small range of density the modulus of elasticity should be large. The absorbability of the different wood species shows that the sound character is different for different types of wood (RICHTER 1988).

2.1.2. Biological parameters

Biological parameters which influence the handling of wood species used in musical instruments are the width of annual rings, the percentage of late wood and growth properties. The width of annual rings affects the natural frequency and the acoustic color of the wood, e.g. wood with extremely narrow annual rings sounds hard and demure, while wood with rough and broad rings sounds flannel and hollow. The acoustic color and the tonal sound color are affected significantly by this. The late wood percentage should be between 20-25% for ideal density and mechanical stability. Regarding growth properties, eccentric growth and all disturbances of the fiber course are unacceptable, because they cause derogation of stability and sound propagation. An exception is a unique kind of European spruce, the hazelspruce (Haselfichte). Because of its wavy growth it is preferred for sound boards and sound boxes (RICHTER 1988). Wood with this growth properties has with his partly radial and partly tangential lying texture a reduction of the isotropic properties estimated. Hazelpruce needs a special care at the wood machining (RICHTER 1988, 9).

However, it is not enough to consider these parameters. The experience and intuition of the instrument maker are necessary to produce high-quality instruments (RICHTER 1988).

2.2. Classification of Musical Instruments

This part of the paper provides an insight into the classification of musical instruments. Musical instruments are grouped by the manner of sound generation, given that thereby you are able to describe the function of the used wood (DAHMS 1995c). There are several features that are important for the selection of wood used in the construction of musical instruments: favorable resonance characteristics and favorable sound characteristics beside aesthetic aspects and workability.

Musical instruments are divided into:

- Wind instruments
- Stringed and keyboard instruments
- Percussion instruments
- Utensils for instruments

2.2.1. Wind instruments (aerophones)

This group includes recorders, flutes, pipes, clarinets, saxophones, bassoons, oboes and also organs. Wood is not only used for the functional efficiency of wind instruments, but also for shaping (DAHMS 1995c). Wood is mainly used as material for wind instruments and has no direct influence on sound generation. However, it appears that wind instruments made out of different wood species generate dissimilar sounds. The quality depends on handling, physical-mechanical properties, density, hardness, surface density, wood structure (structure, ingredients) and growth quality (RICHTER 1988).

Further criteria, which influence the selection of wood species are aesthetic considerations like primary color, color variation and grain (Richter 1988). For this instruments you can use a variety of wood species. The selection is not restricted to certain properties, but also affected by optical characteristics (RICHTER1988).

2.2.2. Stringed instruments (chordophones)

This group includes musical instruments with one or more stretched strings between two fixed points. The sound is created by vibration of the strings caused by rubbing, plucking or striking. Stringed instruments are e.g. harps, guitars, violins, cellos, string basses and zithers. Mainly wood species with very good resonance properties e.g. Spruce and Maple are used for this instruments (DAHMS 1995d). The quality of the instrument is determined by properties of the material and the quality of the wood species which is responsible for the quality of the sound body (RICHTER 1988).

Keyboard instruments like pianos and harpsichords are also considered part of this group. Pianos create the sound by a hammer striking the strings (e. g. pianos) while harpsichords rather pluck the strings (DAHMS 1995d & RICHTER 1988).

Only wood species with suitable sound properties were used for sound boards of these instruments. The wood species required has to have an ideal balance between weight and stability, adequate size accuracy and good machinability (RICHTER 1988).

2.2.3. Percussion instruments (membranophones, idiophones)

This group contains the subgroups of membranophones as well as idiophones.

Idiophones generate sound by vibrating as a whole. They are constructed mainly out of native materials and there are different ways of sound production (DAHMS 1995c). The xylophone is the most famous instrument of this group. Wooden bars are hit with

a wooden mallet. Only wood species with a high absorbability resulting in a lower acoustic emission are suitable for these instruments. Hence mainly hardwoods are used for the bars (RICHTER 1988).

The second subgroup are membranophones, e.g. drums, timbals, bongos etc. The sound is mainly generated by striking a stick on a membrane causing vibration. Today these instruments are made out of plywood or laminated wood and rarely out of solid wood (RICHTER 1988).

Both subgroups use sticks and the instruments have to suffer a very high flexural impact stress. The sticks need to be both sturdy and lightweight. These requirements only have a little value of wood species (RICHTER 1988).

2.2.4. Utensils for instruments

The selection of wood for bows for stringed instruments is a delicate matter, because the wood has to possess special features. The machinability, the position of the pieces in the trunk, the uniformity and straightness of the fibers, the size and position of faults and especially the spring core (Federung) must be taken into consideration (RICHTER 1988).

3. Results

In this section, the European wood species used for musical instruments are presented. Some are still used today, but many have been replaced by other materials. The traditional fields of application are listed and explained in detail.

3.1. Wood Species Traditionally Used for the Construction of Musical Instruments

Maple – Ahorn (Ger); *Acer pseudoplatanus*, *Acer* spp. – Aceraceae

Application: Bow instruments, plucking instruments, wind instruments batons

In bow and plucking instruments Maple is mainly used as resonance wood, but also side parts, ribs, necks and bridge are made out of Maple. It is crucial to use only impeccable wood with narrow annual rings. For this purpose, Maple is one of the best native wood species. At wind instruments, other than Pear, Maple is the main kind of wood used for recorders. It has good but not perfect sound characteristics because of the biological structure (RICHTER 1988, 18; DAHMS 1995d; GROSSER 1977, 78; HOPFINGER; FUCHS 2012; FUNKE 1800; GROSSMANN 1916; MAYR und GAYER 1903; WALTHER 1802; ANDREAE 1790; LEONHARDI 1792; MEDICUS 1802; VON KEESS, EDLEM 1823; STRUBE 1791; WALTHER 1787).

European birch – Birke (Ger); *Betula verrucosa*, *Betula* spp. – Betulaceae

Application: Bow instruments, keyboard instruments, percussion instruments

In keyboard instruments Birch is used for the body housing building with middle contamination and especially it is used for the piano hammer. Regarding percussion instruments, it is used for the resonator and sometimes for batons and drumsticks. In bow instruments it is mainly used for side parts, ribs, necks and bridges. It is not used for sound boards (RICHTER 1988, 34; DAHMS 1995d; GROSSER 1977, 90; HOLZ 1995-2001;).

Pear – Birnbaum (Ger); *Pirus communis*, *Pirus* spp. – Rosaceae

Application: Wind instruments (recorders (Bockflöten), organ pipe), bow instruments, plucking instruments, piano hammer, black keys

Pear is mainly suitable for the construction of recorders and organ pipes. In addition, it is used for small components of bow and plucking instruments. In pianos it is used for the hammers and the black keys, because Pear is a rather hard and sturdy type

of wood (RICHTER 1988, 20; DAHMS 1995d; GROSSER 1977, 168; HOPFINGER; NÖRDLINGER 1874; VON KEESS, EDLEM 1823).

Beech – Buche (Ger) *Fagus sylvatica* – Fagaceae

Application: Bow instruments, keyboard instruments (mechanics), curved surfaces and formed components, drumsticks, percussion instruments, violin bow

Beech is mainly used for laminated wood and curved surfaces in instruments (case, sound post). Solid Beech is used for hammers, mechanically stressed pieces and as sound box of percussion instruments. In the past Beech was also used for violin bows. However, today other materials are used for this purpose (RICHTER 1988, 34; DAHMS 1995d, GROSSER 1977, 122; MAYER und GAYER 1903) .

Box – Buchsbaum (Ger); *Buxus sempervirens* – Buxaceae

Application: Stringed instruments, woodwind instruments (recorders, oboe, clarinet), keyboard instruments

Box is traditionally used in stringed instruments for small pieces like pegs and the chin rest but it was also used for wind instruments. In the past clarinets, oboes, transverse flutes and later also recorders were made out of Box wood. Box is a very slow growing wood with narrow annual rings and therefore a very hard and durable material for mechanical pieces in keyboard instruments. Today it is no longer used for musical instruments (RICHTER 1988, 24; DAHMS 1995d; GROSSER 1977, 94; HOPFINGER; VON KEESS, EDLEM 1823).

Douglas fir – Douglasie (Ger); *Pseudotsuga menziesii* – Pinaceae

Application: Stringed instruments

European Douglas fir grows fast and has wide rings and therefore it is not suitable for the construction of musical instruments. Wood from an old population which has narrow rings, like the Douglas fir of North America, was used for sound boards of harpsichords, the European type of Douglas fir has not the anatomical characteristics and it is not typically used for the construction of musical instruments (RICHTER 1988, 11; GROSSER 1977, 72).

Yew – Eibe (Ger); *Taxus baccata* – Taxaceae

Application: Sound boards, flutes, wind instruments, lutes

Yew is a very slow grown wood and very hard, it is mainly used for sound boards for stringed instruments. In former times Yew was used for different types of flutes because of its sound characteristics (DAHMS 1995d; GROSSER 1977, 74; HOPFINGER; STUBENRAUCH 1771; GAYER 1939; PRINTZ 1908; PRINTZ 1884; HILDT 1798; BECHSTEIN 1812; HARTIG 1851; STÜBLING 1896; SCHAFFLÜTZEL 1974; FUCHS 2012).

Oak – Eiche (Ger); *Quercus* spp. – Fagaceae

Application: Drumsticks, percussion instruments, mechanics in piano construction

Oak is mainly used for drumsticks and sometimes also for solid parts in pianos. It is characterized by its stability (DAHMS1995d; GROSSER 1977, 124; RICHTER 1988, 37).

Ash – Esche (Ger); *Fraxinus excelsior* – Oleaceae

Application: Percussion instruments, keyboard instruments, organs

Ash is not commonly used for musical instruments, but rather for drumsticks and sometimes for veneered visible surfaces of keyboard instruments. In addition, it is used for mechanically stressed components in organs (RICHTER 1988, 36; DAHMS 1995d; GROSSER 1977, 148; HOPFINGER).

Spruce – Fichte (Ger); *Picea abies* – Pinaceae

Application: Sound boards

In Europe, Spruce is the most commonly used wood for the construction of outstanding stringed instruments. Only flawless wood with quite narrow annual rings and steady growth is processed. Spruce of highest quality is the best material for sound boards and ensures excellent sound characteristics. It is used for sound boards of violins and guitars and for the interior of pianos (RICHTER 1988, 19; DAHMS 1995d; GROSSER 1977, 66; ILLE 1975; HOPFNER; MEDICUS 1802; VON KEESS, EDLEM 1823; GAYER 1928; GAYER 1939; SCHWANKL 1951; DOPF 1949; HUFNAGL 1920; SCHÖNWIESE 1911; LARIS 1910; HUNZIKER 1916; PRINTZ 1908; HILDT 1798; BECHSTEIN 1812; HARTIG 1851).

European hornbeam (White) – Hainbuche (Ger); *Carpinus betulus* – Corylaceae

Application: Keyboard instruments

Hornbeam is frequently used for mechanically stressed parts of musical instruments, mechanics (hammer) and as support for sound posts in keyboard instruments (RICHTER 1988, 35; DAHMS 1995d; GROSSER 1977, 110).

Elder, Elderberry, Black Elder – Hollunder (Ger); *Sambucus nigra* – Caprifoliaceae

Application: Pipe stems, organ pipes

In the past Elder wood was used for pipe stems, but today it is no longer used for modern pipe constructions (GROSSER 1977, 98; MEDICUS 1802).

Honeysuckle – Heckenkirsche (Ger); *Lonicera* spp. – Caprifoliaceae

Application: Pipe stems, organ-pipes

Honeysuckle has the same range of use as Elder. Like Elder it is rarely used for musical instruments today (GROSSER 1977, 96; MEDICUS 1802).

Pine – Kiefer (Ger); *Pinus silvestris* – Pinaceae

Application: Sound boards, organs, bow instruments

Pine is and was used for sound boards and all other parts of bow instruments of lower quality, because this type of wood is too soft and insufficiently elastic and therefore difficult to process. It is a cheap substitute for Spruce (RICHTER 1988, 11; DAHMS 1995d; GROSSER 1977, 70; ILLE 1975; WALTHER 1787).

Cherrytree – Kirsche (Ger); *Prunus avium* – Spiaedoideae

Application: Woodwind instruments

This wood species is mainly used for woodwind instruments because of the good machining. Cherrytree is very similar to plum (GROSSER 1977, 166; HOPFINGER; VON KEES, EDLEM 1823).

Basswood – Linde (Ger); *Tilia* spp.– Malvaceae

Application: Organ pipes, keyboard instruments

Basswood is used for organ pipes due to processability. It is also used for parts in keyboard instruments. Basswood is rarely used for musical instruments (GROSSER 1977, 190; MAYER und GAYER 1903).

Whitebeam – Mehlbeere (Ger); *Sorbus aria* – Rosaceae

Application: Violin bows

Whitebeam is used for violin bows, because it possesses special properties, which are necessary for this specific purpose like the bending of the bow. The construction of violins requires premium quality lumber (MEDICUS 1802).

Olivewood – Olive (Ger); *Olea europea* – Olaceae

Application: Recorders, guitars, lutes

Olivewood is used for high-quality recorders. Recorders constructed out of this material have a slight responsiveness (Ansprechen) and a solid and warm sound. In addition, some parts of guitars and lutes which have special characteristics are made out of Olivewood (RICHTER 1988, 23; DAHMS 1995d).

Poplar – Pappel (Ger); *Populus tremula*, *Populus* spp. – Salicaceae

Application: Keyboard instruments, stringed instruments

It is commonly used for laminary elements which have no mechanical strain on them like harpsichord lids. Sometimes this type of wood is also used for top plates, back plates and ribs of stringed instruments. It was used for small parts on the inside because it is very light and you can handle it clean (RICHTER 1988, 34; DAHMS 1995d; GROSSER 1977, 176; HOPFINGER; MAYR und GAYER 1903; VON KEESS, EDLEM 1823).

Plum – Zwetschke (Ger). *Prunus domestica* – Rosaceae

Application: Wind instruments (woodwind instruments)

Plum is mainly used for woodwind instruments, especially recorders. It has the same properties like Cherrytree like the hardness and the handling and is also mostly used

for woodwind instruments. When it comes to sound characteristics, this heavy type of wood seems Plump and creates overtones (RICHTER 1988, 20; DAHMS 1995d).

Platane – Platane (Ger); Platanus spp. – Platanaceae

Application: Bow instruments, plucking instruments, wind instruments batons

At musical instrument constructions has Platane the same characteristics and application like Maple. In bow and plucking instruments it is mainly used as resonance wood, but also side parts, ribs, necks and bridge are made out of it (GROSSER 1977, 154;LEO 1805).

Wayfaring tree – Wolliger Schneeball (Ger); Virburnum lantana – Caprifoliaceae

Application: Pipe stems, organ pipes

The wood of the Wayfaring tree was used for pipe stems, but today it is no longer processed in modern pipe construction (GROSSER 1977, 100; MEDICUS 1802).

Spindle, European spindle – Spindelbaum (Ger); Euronymus europaeus – Celastraceae

Application: Pianos, organs

In the past Spindle was utilized for piano parts und organ pipes. Today it is very difficult to get high quality Spindle and therefore it is rarely used for musical instruments (GROSSER 1977 104; WALTHER 1787).

Fir – Tanne (Ger); Abies alba – Pinaceae

Application: Sound boards

Fir has quite the same characteristics as Spruce, therefore it is also mainly used for sound boards of stringed instruments. This wood is predominantly used for instruments with a lower frequency range (RICHTER 1988, 11; DAHMS 1995d; GROSSER 1977, 62; WALTHER 1787; PFEIL 1831).

Juniper – Wacholder (Ger); Juniperus communis – Cupressaceae

Application: Flutes

Juniper is used for one special part of flutes: the block. It is a light and medium heavy wood with moderate dwindling and a lazy water absorption (RICHTER 1988, 40; GROSSER 1977,60).

Willow – Weide (Ger); Salix spp. – Salicaceae

Application: bow instruments

Willow is essentially suitable for ribs, floor and other constructive fractions at bow instruments, it is rarely used for sounding boards (DAHMS 1995d; GROSSER 1977, 178).

3.1.1. Summary of Wood Species for Musical Instruments

Table 1 shows a summary of the main used European wood species for musical instruments and their main application.

Wood species		Application
Maple	Acer spp.	Bow instruments, plucking instruments, wind instruments
European birch	Betula spp.	Bow instruments, keyboard instruments, percussion instruments
Pear	Pirus spp.	Wind instruments, bow instruments, plucking instruments
Beech	Fagus sylvatica	Bow instruments, keyboard instruments, drumsticks, percussion instruments, violin bow
Box	Buxus sempervirens	Stringed instruments, woodwind instruments, keyboard instruments
Douglas fir	Pseudotsuga menziesii	Stringed instruments
Yew	Taxus baccata	Sound boards, flutes
Oak	Quercus spp	Drumsticks, percussion instruments, mechanics in piano construction
Ash	Fraxinus excelsior	Percussion instruments, keyboard instruments
Spruce	Picea abies	Sound boards
European hornbeam	Carpinus betulus	Keyboard instruments
Elder	Sambucus nigra	Pipe stems, organ pipes
Honeysuckle	Lonicera spp.	Pipe stems, organ pipes
Pine	Pinus silvestris	Sound boards, organs, bow instruments
Cherrytree	Prunus avium	Woodwind instruments
Basswood	Tilia spp.	Organ pipes, pianos
Whitebeam	Sorbus aria	Violin bows
Olivewood	Olea europea	Recorders, guitars, lutes
Poplar	Populus spp.	Keyboard instruments, stringed instruments
Plum	Prunus domestica	woodwind instruments
Platane	Platanus spp.	
Wayfaring tree	Virburnum lantana	Pipe stems, organ pipes
Spindle	Euronymus europaeus	Pianos, organs
Fir	Abies alba	Sound boards
Juniper	Juniperus communis	Flutes
Willow	Salix spp.	Bow instruments

Table 1

4. Discussion and Conclusion

The section "Results" summarizes different fields of application regarding wood species for musical instruments. There are certain parts that can only be made out of a small number of wood species, e.g. sound boards. Sound boards are mainly made out of spruce, pine, fir or maple, because these materials have special properties which provide premium sound quality. In addition, the biological parameters and biological characteristics influence the selection of lumber for musical instruments.

The list of suitable European wood species shows that also non-typical ones are used for specific musical instruments instead of materials that are traditionally used for this purpose. In conclusion, it is not possible to determine one specific wood species for each type of musical instrument. The selection is widely influenced by the development, know-how, and habitability of the instrument maker. It is not possible to classify wood species for musical instruments in a complete and satisfying manner. Nevertheless, a rough classification regarding the typical fields of application is feasible as shown in section 3 of this paper.

The main wood species, which are used for stringed instruments, are Maple, European birch, Pear, Box, Douglas fir, Yew, Spruce, Pine, Olivewood, Poplar, Fir and Willow. These wood species are used for soundboards, side parts and other elements of the stringed instruments. Wood species with the best resonance characteristics which are used for sound boards are Hazelspruce and Maple.

Very hard wood species are used for heavy mechanical stressed pieces or percussion instruments and utensils for instruments. Wood species, which have these characteristics, are Beech, Oak and Ash.

Wood, which is used for woodwind instruments, is rather hard, fine growth annual rings and a uniform structure. The used wood species for woodwind instruments are Maple, Pear, Box, Yew, Elder, Honeysuckle, Pine, Cherry tree, Basswood, Olivewood, Plum Wayfaring tree, Spindle and Juniper.

5. Summary

As long as musical instruments exist, wood act a part in their construction as an essential material. Several factors are responsible that wood plays an important role at musical instrument-construction. Out of all things we can make out of wood, no category has the highest requirements relating to quality, handling and variety to the raw material like musical instruments.

The selection is influenced by physical and biological parameters. Physical parameters, which are influence the application of wood are the velocity of sound and the absorbability. Biological parameters, which influence the handling of wood species used in musical instruments, are the ratio of late wood, the growth-properties and the structure. The selection is also influence by the type of musical instrument. The musical instruments are grouped by the kind of sound generation, given that thereby you are able to describe the function of the used wood. At musical instruments, you have to differ between wood with good resonance characteristics and wood with good sound characteristics. The resonance characteristics decrease when the density increase, Hazelspruce is the best resonance wood. All other wood species which are not used as resonance wood are sound wood like wood for wind instruments, percussion instruments and pieces but for sound boards and sound elements of Pianos and stringed instruments.

Musical instruments may grouped in:

- Wind instruments
- Stringed and keyboard instruments
- Percussion instruments
- Utensils for instruments

It is not possible that you can exactly fix the use of the different wood species for the different types of musical instruments. The selection is very influenced by the development, know-how, and habituality of the musical maker. You can only make a rough classification for typical applications. Musical instruments made out of wood differ in many aspects from one another depending on the wood species. This term paper provides insights into the selection of European wood species for musical instruments and their application

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7. Tables

Table 1 – Summary of the wood species used for musical instruments