THE NATURAL DURABILITY OF WOOD

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The **natural durability of wood** is defined as its intrinsic capacity to resist **biological degradation agents** without any preservation or conservation treatment designed to improve its performance. This property is specific to each **wood species.**

Standard NF ISO 15686-1 (July 2011)[1], which governs design in relation to the **service life of constructions,** defines durability as the **ability of a product to fulfill its functions** (structural safety, functionality, aesthetics) over a **given period**, under the influence of degradation agents present in its environment of use. The notion of time is important to consider when talking about natural durability.

The main agents **of biological degradation are :**

- **Lignivorous fungi,**
- **Wood-eating insects,**
- **termites**
- **Marine terebrants** (worms and perforating molluscs).

The natural durability of wood is assessed in the laboratory according to a standardized protocol (NF EN 350, October 2016[2]). There are several durability classes depending on the agents of degradation:

Tests are carried out on duraminized wood[3]; unless specifically mentioned in relation to sapwood, the wood durability characteristics mentioned in the technical documents only concern the heartwood of mature wood.

Durability against wood-eating fungi:

5 classification levels:

Durability class	Description
DC1	Very durable
DC2	Durable
DC3	Moderately sustainable
DC4	Weakly sustainable
DC5	Non-sustainable

1. AFNOR, 2011. NF ISO 15686-1. Buildings and built assets - Life-cycle design - Part 1: General principles and framework. 35 p.
2. AFNOR, 2016. NF EN 350. Durability of wood and wood-based materials - Methods for testing and classifying the durability against biological agents of wood and wood-based materials.
3. Wood is made up of two parts: the sapwood (in which the raw sap rises) and the heartwood. The heartwood is the result of a metabolic process inherent in the growth of the species which, when mature, gives it its natural durability. On some species, the difference between these two parts is clearly visible (sapwood is generally lighter), while on others they are indistinguishable.

Sustainability against wood-boring insects :

DC S = Sensitive	DC D = Durable

Durability against termites :

DC S = Sensitive	DC M = Moderately durable	DC D = Durable

Durability against marine termites :

DC S = Sensitive	DC M = Moderately durable	DC D = Durable

Impregnability: this characteristic refers to the ability to impregnate wood with a wood preservative. A species with an impregnability of 4 is called a refractory species.

1 = impregnable	2 = moderately impregnable	3 = poorly impregnable	4 = not impregnable

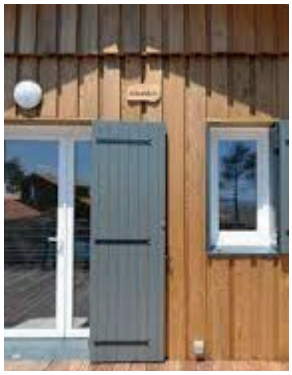
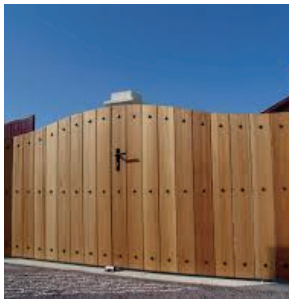
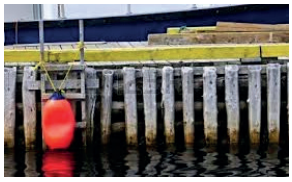
Appendix 2 contains a list of species with their intrinsic properties. Not all species are listed in standard NF EN 350, but the information available can be found in CIRAD's TROPIX data sheets[4].
Note: to determine the durability of wood against termites, the standardized test consists of placing termites in the presence of a sample of the wood to be tested. This type of test does not take into account the notion of wood palatability, which governs termite attacks on wooden structures in real-life conditions.

USE CLASSES

Use classes are situations of use for wood. They are defined in standard NF EN 335[5].

Use class 1: Wood is sheltered, fully protected from the elements and not exposed to humidification. Risks are limited to wood-boring insects and termites. Examples: parquet flooring, furniture, panelling, etc.	
Use class 2: Situation in which the wood is sheltered, fully protected from the weather, but where high ambient humidity may lead to occasional, non-persistent wetting. Risks are limited to wood-boring insects and termites. The risk of fungi is not totally excluded, but remains limited to the surface of the rooms. Examples: frameworks, roofing elements, framing, etc.	

4. https://tropix.cirad.fr/fiches-disponibles
5. AFNOR, 2013. NF EN 335. Durability of wood and wood-based materials - Use classes: definitions, application to solid wood and wood-based materials.

Use class 3.1: Situation in which the wood is outdoors without contact with the ground. It is exposed to the elements for short periods, due to rapid drying or a design that favors water evacuation. Risk of fungus and rot on structures maintained at over 20% humidity. For xylophagous insects, it depends on the specifications of the work and the geographical area. Examples: exterior joinery (windows), exterior cladding (siding), etc.	
Use class 3.2 : Situation in which the wood is outdoors without contact with the ground, with frequent humidification over long but non-continuous periods. Water can accumulate and the wood dries more slowly after humidification. Biological risks are similar to those of use class 3.1. Examples: joinery, exterior cladding (exposed to the elements), etc.	
Use class 4: Situation in which wood is in contact with the ground or support subject to recurrent wetting or immersion in fresh water. The design includes water traps and very pronounced humification. Biological risks include all decay fungi and xylophagous insects (along with termites). Examples: fences, posts, terraces, etc.	
Use class 5 : Situation where wood is in permanent contact with seawater. Biological risks include marine termites. Examples: jetties, pontoons, etc.	

In these classes of use, the service life of a species is not precisely defined. It is important to note that these classes illustrate the conditions under which the structure will be exposed. Thus, the choice of a species for a given use class will depend on its ability to withstand the specific conditions of use. The intrinsic properties of a wood species determine whether it can ensure a long service life under these conditions.

If the expected service life is defined, it is possible to establish a relationship between use class and species (NF EN 460, February 2023[6]).

Note: Use classes 1 to 4 are classified in ascending order of exposure to biotic and abiotic degradation agents: the higher the class, the more favorable the conditions for the development of these agents. Use class 5, on the other hand, stands out as it relates specifically to conditions in marine environments.

6. AFNOR, 2023. NF EN 460. Durability of wood and wood-based materials - Guide for determining performance. 28 p.

For example: **Basralocus**[7] can be used in use class 5, as it is highly resistant to marine borers, but is not recommended for use class 4, as fungi easily degrade it when it comes into contact with the soil. It can be used in classes 1, 2, 3.1, 3.2 or 5, but not 4.

THE RIGHT WOOD IN THE RIGHT PLACE

In addition to use classes, it is important to define in detail the environment in which the species is found, taking into account the following aspects in particular:

- climate (see Appendix 1) ;
- local conditions (coastal zone, valley bottom not exposed to sunlight, proximity to a source of humidity generating recurrent periods of mist or fog, etc.);
- the type of design (flow and desorption conditions[8] of rainwater have a direct influence on the durability of the part of the structure in question with regard to fungal risk[9]);
- massiveness (the more solid the wood, the more limited its desorption capacity);
- exposure to the prevailing wind.

When the use class is correctly defined, the choice of wood can be based on the expected service life of the structure.

L3 : Longevity in excess of 100 years;
L2 : Lifespan of between 50 and 100 years in the originally intended use;
L1 : Lifespan between approximately 10 and 50 years in the originally intended use;
N : Longevity uncertain and in all cases less than 10 years (solutions not to be recommended for building applications).

A very durable wood, classified as durability 1, can be used with good longevity even in an environment favorable to biological degradation agents, i.e. in use class 4. Conversely, low-durability woods (durability class 5) can be used in use class 1, provided that the risks of degradation by wood-eating insects and termites are not overlooked.

In France, these parameters are listed in fascicule de documentation FD P 20-651 (June 2011).[10]

7. Angelica, Guiana wood.
8. Desorption is the opposite of adsorption.
9. Relating to fungi...
10. AFNOR, 2011. FD P 20-651. Durability of wooden elements and structures

CHOOSING A SPECIES FOR YOUR WOOD STRUCTURE

Choosing the right species for your wood structure involves all the criteria outlined above. The diagram below illustrates the various stages involved in choosing a wood species according to the conditions of use. (A reference to quote for the method?)

Step 1: Define your project

This first step consists in identifying the type of work to be carried out, in order to determine the initial conditions of use. Is the structure more or less exposed to biotic and abiotic degradation agents? Is it an exterior construction cladding (cladding, decking, etc.), a landscaping element (street furniture, etc.), or a structural element?

Step 2: parameters influencing the behavior of the structure

Depending on its exposure, biotic and abiotic agents have a degree of presence that will influence the use class of the structure. Here are the most influential parameters:

- Geographical zone (tropical, Mediterranean, continental...) cf appendix 3
- Local conditions
- Type of design
- Wood mass

Step 3: Define use class

The previous 2 steps enable you to identify the most appropriate use class for your project.

Step 4: Select wood species

Natural durability is an intrinsic property of the species. The choice of species will therefore depend on the conditions defined in the previous steps. Beyond natural durability, the choice of a species can be made with the addition of a wood preservation treatment (conferred durability). The choice will then depend on several criteria:

- Technical criteria (machining, mechanical and chemical behavior, etc.)
- Economic criteria (price)
- Commercial criteria (species availability, location...)

Step 5.1: Naturally sustainable species

The species requires no treatment and can be used as is.

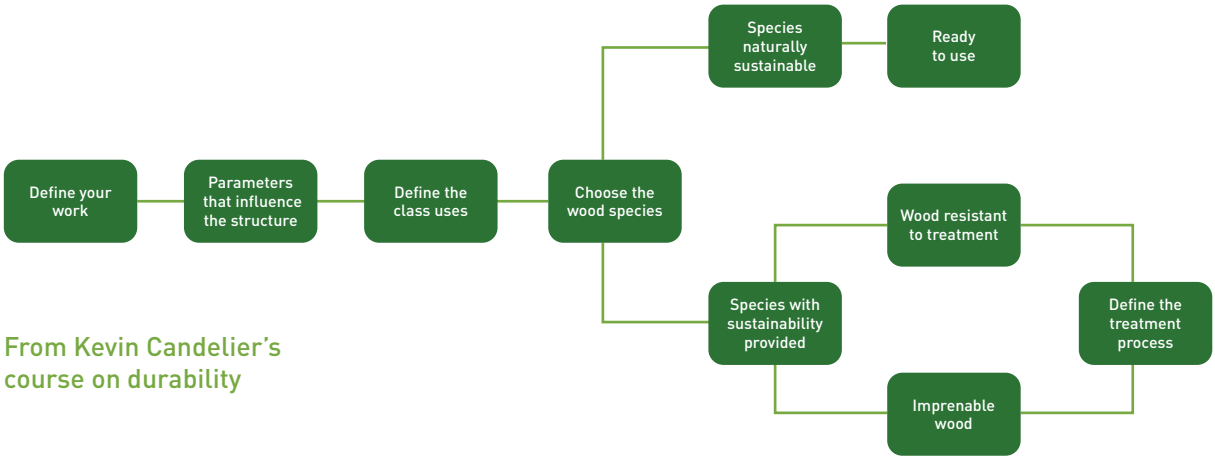
In the tropics, a significant number of wood species have a natural durability that enables them to be used in use class 4, and some even in use class 5. You can consult additional documents on the use of these tropical woods on the CIRAD and ATIBT websites.

Step 5.2: Species with conferred durability

When a species is not sufficiently durable, a preservative treatment must be applied according to the intended use class. It is then important to identify the impregnability of the species, as this has an impact on the choice of wood.

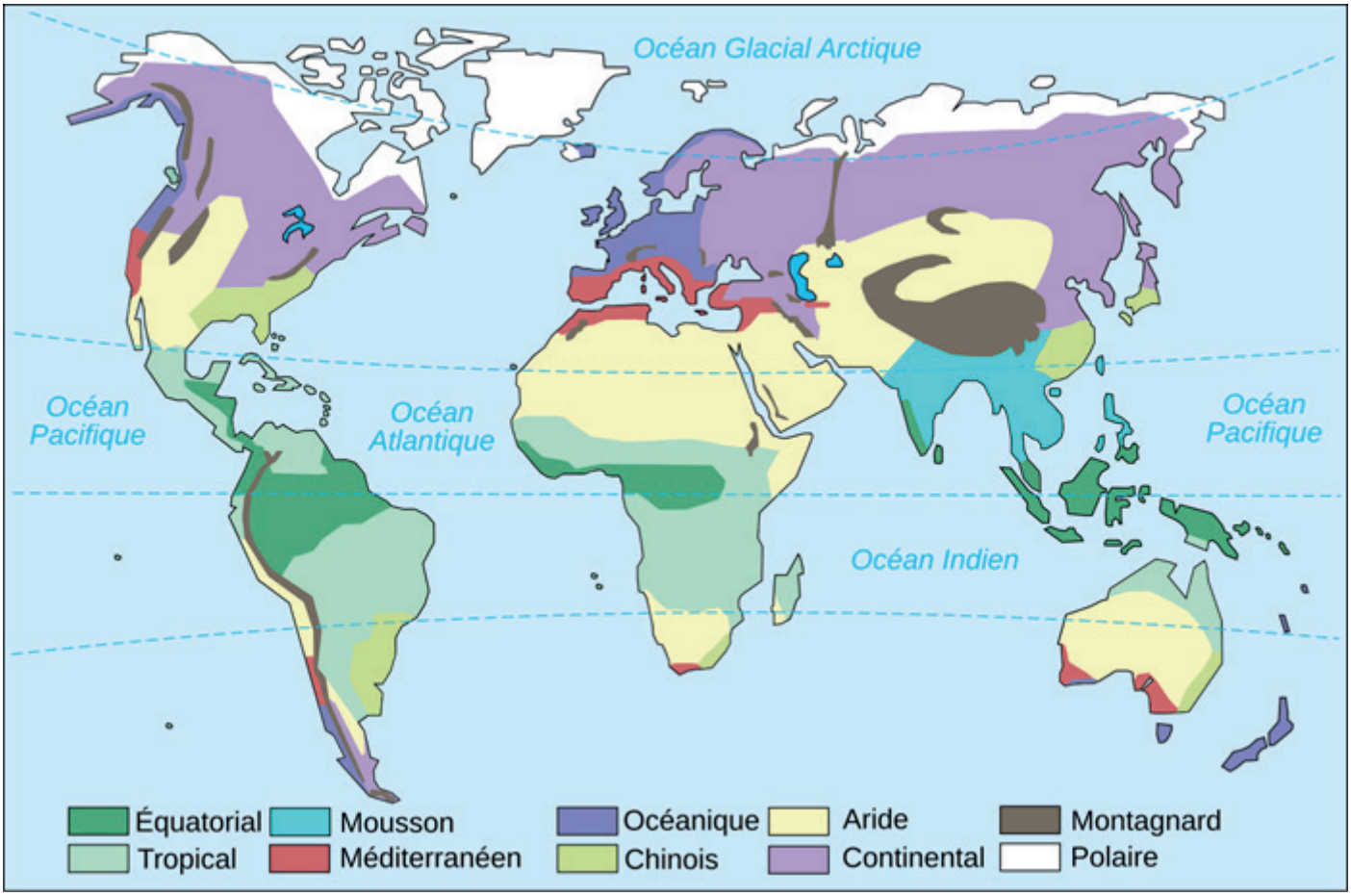
Step 6.1 : Impregnable species
Definition page 8

Step 6.2: Refractory species
Definition page 8



From Kevin Candelier's course on durability

APPENDIX 1



simplified map of world climates

ANNEXE 2

SOFTWOODS

French name	MV min kg/m³	MV kg/ m³	MV max kg/m³	Mushroom	Hylotrupes	Anobium	Termites	Impregnability	Sapwood	Sapwood width	Marine termites
Agathis	430	490	530	3_4	S	S	S	3	nd	x	
Douglas fir	510	530	550	3	S	S	S	4	3	f	
Douglas fir	470	510	520	3_4	S	S	S	4	2_3	f	
Spruce	440	460	470	4	SH	SH	S	3_4	3v	x	
If	650	690	800	2	S	S	nd	3	2	tf	
Larch	470	600	650	3_4	S	S	S	4	2v	f	
Caribbean pine	710	750	770	3	S	S	M_S	4	1	m	
Laricio pine	510	580	650	4v	S	S	S	4v	1	m_l	
Maritime pine	530	540	550	3_4	S	S	S	4	1	l	
Parana pine	500	540	600	4_5	D	S	S	2	1	l	
Radiata pine	420	470	500	4_5	S	SH	S	2_3	1	l	
Scots pine	500	520	540	3_4	S	S	S	3_4	1	f_m	
Weymouth pine	400	410	420	4	S	SH	S	2	1	l	
Pitchpin	650	660	670	3	S	S	M_S	3_4	1	m	
Cultivated pitchpin	400	450	500	4	S	S	S	3	1	m	
Lodgepole pine	430	460	470	3_4	S	S	S	3_4	1	m	
Fir	440	460	480	4	SH	SH	S	2_3	2v	x	
Sitka	400	440	450	4_5	S	SH	S	3	2_3	(x)	
Sugi (Cryptomeria)	280	340	400	5	D	nd	S	3	1	f	
Western red cedar	330	370	390	2	S	S	S	3_4	3	f	
Western red cedar	330	370	390	3	S	S	S	3_4	3	f	
Western hemlock	470	490	510	4	S	SH	S	3	2	x	
Western hemlock	470	490	510	4	S	SH	S	2	1	x	
Yellow Cedar	430	480	530	2_3	S	S	S	3	1	f	

HARDWOOD

French name	MV min kg/m³	MV kg/ m³	MV max kg/m³	Mushroom	Hylotrupes	Anobium	Termites	Impregnability	Sapwood	Sapwood width	Marine termites
Abura	550	560	600	5		nd	S	2	1	m	
African mahogany	490	520	530	3		nd	S	4	2	f	
Afrormosia	680	690	710	1_2		nd	D	4	1	tf	M
Aiélé	490	500	530	5		nd	S	4	1	m	
Ako	430	450	460	5		nd	S	1	1	x	
Amaranth	830	860	880	2_3		nd	D	4	1	f	
Andiroba	610	620	640	3_4		nd	M	3	nd	f	
Aniégré	540	580	630	4_5		nd	S	1	1	x	
Alder	500	530	550	5		S	S	1	1	x	
Avodire	540	550	560	4		nd	S	4	1	x	
Ayous	370	390	400	5		nd	S	3	1	x	
Azobe	950	1060	1100	2v		nd	D	4	2	f	M
Bangkirai	700	930	1150	2		nd	D	4	1_2	f	
Basralocus	720	750	790	2v		nd	M	4	2	f	D
Bilinga	740	750	780	1		nd	D	2	1	f	M
Bintangor	630	660	690	3		nd	M	4	2	f	
Blue Gum	700	750	800	5		nd	S	3	1	f	
Birch	640	660	670	5		S	S	1_2	1_2	x	
American yellow birch	550	670	710	5		S	S	1_2	1_2	x	
Paper birch	580	620	740	5		S	S	1_2	1_2	x	
Light embossed	570	580	630	2v		nd	S	4	1	m	
Dark moss	600	690	850	2		nd	S	4	1	m	
Bubinga	700	830	910	2		nd	D	4	1	f	
Cedro	450	490	600	2		nd	M	3_4	1_2	f	
Cerejeira	550	600	650	3		nd	M	2	2	m	
Hornbeam	750	800	850	5		nd	S	1	1	x	
Chestnut	540	590	650	2		S	M	4	2	f	
Hairy oak	710	770	860	3		nd	M	4	1	l	
Sessile oak	670	710	760	2		S	M	4	1	f	
American white oak	670	730	770	2_3		S	M	4	2	f	

French name	MV min kg/m³	MV kg/ m³	MV max kg/m³	Mushroom	Hylotrupes	Anobium	Termites	Impregnability	Sapwood	Sapwood width	Marine termites
American red oak	650	700	790	4		nd	S	2_3	1	f	
Dibétou	520	550	590	3_4		nd	S	3_4	2	f	
Doussié	730	800	830	1		nd	D	4	2	f	
Sycamore maple	610	640	680	5		S	S	1	1	x	
Eyong	700	730	800	4		nd	S	3_4	1	x	
Faro	480	490	510	4_5		nd	S	2_3	1	l	
Framiré	520	550	560	2_3		nd	S	4	2	(x)	
Freijo	520	540	550	2		nd	M	3	1	f	
Ash	680	700	750	5		S	S	2	2	(x)	
Fromager	290	320	350	5		nd	S	1	1	x	
Greenheart	980	1030	1150	1		nd	D	4	2	f	D
Beech	690	710	750	5		S	S	1_(4)	1	x	
Hickory	790	800	830	4		nd	S	2	1	x	
Ilomba	440	480	510	5		nd	S	1	1	x	
Iroko	630	650	670	1_2j		nd	D	4	1	m	
Jarrah	790	830	900	1		nd	M	4	1	f	
Kapur	630	700	790	1_2		nd	M	4	1	m	
Karri	800	880	900	2		nd	nd	4	1	f	
Kasai	650	710	750	3		nd	M	3_4	2	m	
Kempas	850	860	880	2		nd	S	3	1_2	f	
Keruing	740	750	780	3v		nd	S	3v	2	f	
Kondroti	470	480	490	5		nd	S	1	1	l	
Kosipo	640	670	720	2_3		nd	M	3	1	f	
Kotibé	710	730	760	3v		nd	M	3_4	1_2	f	
Koto	510	560	630	5		nd	S	1	1	x	
Lati	730	750	770	3		nd	M	4	2	m	
Lenga	530	540	550	5		nd	S	4	nd	f	
Limba	550	560	600	4		nd	S	2	1	(x)	
Longhi	700	730	800	4		nd	M	2	1	x	
Louro vermelho	600	620	650	2		nd	D	4	2	m	
Mahogany	510	550	580	2		nd	S	4	2_3	m	
Makoré	620	660	720	1		nd	D	4	2	m	

French name	MV min kg/m³	MV kg/ m³	MV max kg/m³	Mushroom	Hylotrupes	Anobium	Termites	Impregnability	Sapwood	Sapwood width	Marine termites
Mansonia	610	620	630	1		nd	D	4	1	f	
Horse chestnut	500	540	590	5		SH	S	1	1	x	
Mengkulang	680	710	720	4		nd	S	3	2	f	
Meranti Dark red	600	680	730	2_4		nd	M	4v	2	f	
Meranti Light red	490	520	550	3_4		nd	S	4v	2	m	
Meranti Yellow	560	630	660	4		nd	S	3_4	2	m	
Meranti White	600	630	670	5		nd	S	3v	2	f	
Merbau	730	800	830	1_2		nd	M	4	nd	m	
Mersawa	520	650	740	4		nd	M	3_4	nd	x	
Moabi	770	800	830	1		nd	D	3_4	nd	m	
Moral	750	890	960	1		nd	D	3_4	nd	f	
Movingui	690	710	740	3		nd	M	4	nd	f	
Muhuhu	830	910	960	1		nd	S	4	nd	f	
Mutenyé	760	820	880	3		nd	M	3_4	2	f	
Niangon	670	680	710	3		nd	M	4	3	m	
Walnut	630	670	680	3		S	S	3	1	f	
American walnut	550	620	660	3		nd	nd	3_4	1	f	
Okan	850	920	960	1		nd	D	4	3	f	
Okoumé	430	440	450	4		nd	S	3	nd	f	
Olon	500	550	640	3		nd	M	2_3	2_3	x	
Elm	630	650	680	4		S	S	2_3	1	f	
Ovengkol	720	780	820	2		nd	D	3	1	m	
Padouk	720	740	820	1		nd	D	2	nd	m	
Pau Amarello	730	770	810	1		nd	D	3_4	nd	x	
Peroba rosa	650	750	800	3v		nd	S	3	1	f	
Poplar	420	440	480	5		S	S	3v	1v	x	
Quaruba	450	490	510	4		nd	S	3	2	m	
Ramin	560	630	670	5		nd	S	1	1	x	
Rauli	530	580	610	4		nd	S	2	2	f	
Red Balau	750	800	900	3_4		nd	M	4v	2	f	
Robinia	720	740	800	1_2		S	D	4	1	tf	
Sapelli	640	650	700	3		nd	M	3	2	m	M

French name	MV min kg/m³	MV kg/ m³	MV max kg/m³	Mushroom	Hylotrupes	Anobium	Termites	Impregnability	Sapwood	Sapwood width	Marine termites
Sepetir	650	660	670	2		nd	S	4	2	l	
Sesendok	420	480	530	5		nd	S	1	1	nd	
Silver Beach	540		550	5		nd	nd	4	1	m	
Sipo	590	640	660	2_3		nd	M	4	2	m	
Tchitola	590	610	640	3		nd	M	3_4	1	l	
Teak	650	680	750	1		nd	M	4	3	f	M
Plantation teak				1_3		nd	M_S	nd	nd	nd	
Tiama	550	560	570	3		nd	S	4	3	l	
Lime	520	540	560	5		nd	S	1	1	x	
Tola	480	500	510	2_3		nd	S	3	1	m	
Tornillo	370	520	660	3		nd	S	2_3	nd	f	
Virola	400	440	480	5		nd	S	1_2	1	x	
Walaba	890	900	910	1		nd	D	4	3	f	
Wenge	780	830	900	2		nd	D	4	nd	f	

Legend for previous tables:
Durability against fungi: 1 = very durable; 2 = durable; 3= moderately durable; 4 = not very durable; 5 = not durable
Durability against wood-eating insects, Hylotrupes (house longhorn beetle) or Anobium (furniture beetle): S= susceptible or D= durable
Durability against termites: S= susceptible, M = moderately durable or D = durable
Durability against marine termites: S= sensitive, M = moderately durable or D = durable
Impregnability: 1= impregnable; 2 = moderately impregnable; 3 = slightly impregnable; 4 = non-impregnable
Sapwood width: tf < 2 cm; f < 5 cm; m < 10 cm; l > 10 cm; x indiscriminate
Durability with respect to marine terebrants: D = durable; M = moderately durable; S = sensitive.
«nd» = performance not determined

APPENDIX 3

https://www.tandfonline.com/doi/full/10.1080/17480272.2020.1779810#d1e149
https://www.fcba.fr/wp-content/uploads/2020/11/bien-comprendre-la-pr%C3%A9servation.pdf
https://www.atibt.org/files/upload/technical-publications/ATIBT-GUIDE-TOME-2-FSC.pdf

Document produced by Michel VERNAY, Emmanuel GROUTEL and Patrick MARTIN. Reviewed on 11/06/2025

FSC PEFC

Fair&Precious recommends the purchase of FSC® and PEFC-PAFC certified tropical timber.