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Biological durability of pine wood

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ABSTRACT

The genus Pinus represents more than a hundred different tree species, most of them forming stems that can be commercially utilised for both timber and wood pulp industry. Pines are native to most of the Northern Hemisphere, while introduced and often naturalized in the Southern Hemisphere. The sapwood of pines is considered 'not durable' but generally easy to impregnate. On the contrary, the coloured heartwood of pines is difficult to impregnate and considered 'less to moderately durable' against decay fungi, but due to varying content and composition of extractives, both moisture performance and inherent durability vary within and between species. This study reviewed the literature to quantify the extent of variability of pine wood and its potential causes. Literature data from durability tests performed under laboratory and field conditions made it possible to compile reference factors for 26 pine species. The inter-species variation of biological durability is more prominent in above-ground exposure (0.7–14.9 times higher compared to the non-durable pine sapwood) compared to soil contact scenarios (1.0–2.4). The latter might be explained by fungicidal and hydrophobic extractives of pines, which play a more dominant role in above-ground exposure compared to soil exposure with permanent wetting.

KEYWORDS

Basidiomycetes; heartwood; material resistance; natural durability; pine; sapwood

1. Introduction

Pines (*Pinus* sp.) are among the most commercially important tree species throughout the world, utilised for both timber and wood pulp for the paper industry. Pines are generally considered less sensitive to storm loads, drought stress, and pathogens compared to spruce species (*Picea* sp.) and there-fore among the species with good potential to handle future challenges related to climate change (Peltola et al. 1999, Zang et al. 2011, Gustafson and Sturtevant 2013, Muller et al. 2019).

Similar to other conifers, many pine species form long cylindrical stems that allow for high yields in the sawmill industry. The average oven-dry density of pinewood is in a range between 370 and 630 kg/m3 (Gottwald 1958, Wagenführ and Wagenführ 2021), and thus, pines represent moderately dense to dense conifers. Consequently, their elastomechanical properties allow use for structural purposes (e.g. Mirski et al. 2020, Wagenführ and Wagenführ 2021). Buildings have been made from pinewood for centuries as illustrated through famous historical examples such as the Norwegian stave churches from mainly pure heartwood (Aune et al. 1983, Øvrum and Flæte 2008), the Sungnyemun Gate in Seoul, Korea (Hwang et al. 2016), or log cabins and the Old Faithful Inn in Yellowstone National Park, Wyoming, USA (Bomberger 1991). The sapwood of pines is generally easy to impregnate, but there are variations in both resin content and permeability between species. Hence, pine species with a high ratio of sapwood to heartwood such as Pinus radiata are widely used for impregnation with wood preservatives or wood modification agents (Matsumura et al. 1998, Mantanis 2017).

The name pine in English derives from the Latin Pinus, allegedly traced to the Indo-European base *pīt, which means resin. Richness in resins contributed to several pine-wood properties such as moisture dynamics and biological durability. However, the latter can vary a lot within and between different Pinus species.

The review at hand focused on the inter-species variation of biological durability within the genus Pinus against wood deteriorating fungi. However, intra-species variation was also addressed as well as the durability against other wood-deteriorating organisms such as termites and beetle larvae. The aim of this study is to quantify differences in durability and to identify factors that increase durability.

2. Taxonomy

Pines are native to most of the Northern Hemisphere, while introduced and often naturalized in the Southern Hemi-sphere. The following brief taxonomic summary is based on Farjon (2018): Pines are gymnosperms (not a natural group, i.e. not a single ancestor) and belong to the conifers (a natural group, i.e. a single ancestor). Nearly half of the species in the Pine family (Pinaceae) belong to the true pines – the genus Pinus. With only a little over a hundred species, Pinus has proved to be remarkably successful in its adaptation to very different environments. Primary leaves in pines appear above the cotyledons and are later followed by secondary needles. The needles are grouped in bundles of fascicles of 2–5(−8) (except in Pinus monophyla). Pinus has been divided into two subgenera, Pinus ("hard" pines) with stomata line (i.e. openings in leaves for gas exchange) found on both sides of the needle and strobus ("soft" or "white" pines) with the stomata line on one side of the needle. Pinus has, especially in forestry literature, been referred to as Diploxylon and Haploxylon, respectively, but are illegitimate for subdivisions according to the International Code of Botanical Nomenclature.

Figure 1 provides a taxonomical overview, and Supplement Table 1 provides more details by listing 106 Pinus species, their synonyms, a brief overview of their ecology and distribution, use areas, and biological durability. The taxonomy for the genus Pinus, as for other genera, is under constant change because of new research data are being added to the puzzle. In this study, we based the taxonomy on Farjon (2018). Subspecies were not included in this study because there is little information to be found for most subspecies (i.e. the readability would have been reduced, while little additional information would have been provided). The sub-genus Pinus is referred to as fire-adapted species and the sub-genus Strobus as biotic stress-adapted (Singh et al. 2021). Among the species listed in Supplement Table 1, nearly half of the species (45) have no commercial value because of wood properties and/or because they are rare. Fifty-five of the species are found only above 500 m, and of these, 38 species are found only >1000 m. Regarding distribution, more than half of the species (64) are found on the American continent, and 15 of these are found only in Mexico, while 30 are found in Asia and 12 in Europe. According to Farjon (2018), 'pines are, in contrast to spruce, for example, trees with a "personality"' since the general form of the Pinus species differs both between species and between individuals. This makes the selection of characteristics for classification difficult, and many classifications, often conflicting with each other, have been suggested. But two developments have made an important progress in species classification: (1) wider application of cladistics methods evolving simultaneously with the improvement of computers and (2) DNA sequencing. The old division into the subgenera Pinus and Strobus remains, but the further subdivision of the two subgenera remains more controversial (Farjon 2018).

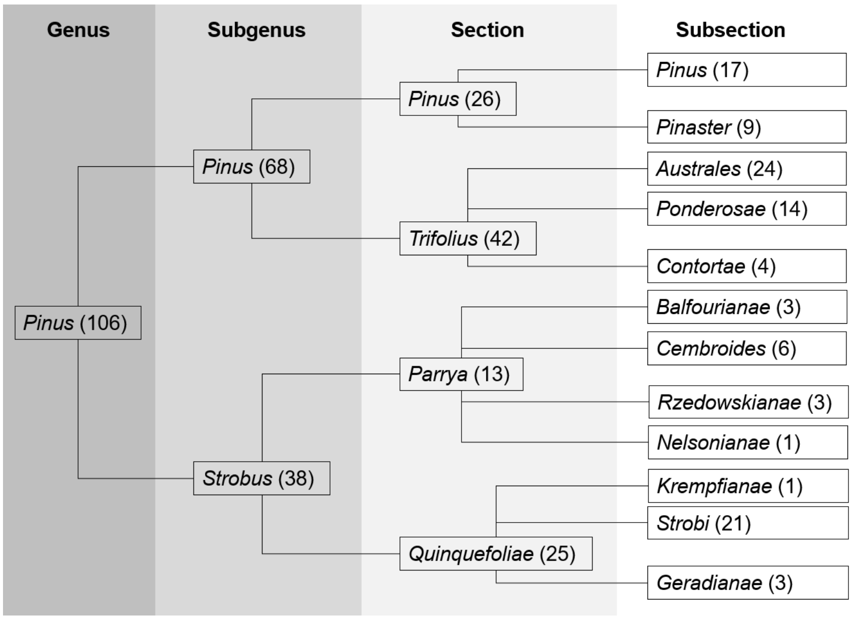

Figure 1. A taxonomic overview of the genus *Pinus* modified after Gernandt et al. (2005) and Farjon (2018).

3. Historic utilisation

In the United States, the term 'pine heart' refers to the heart-wood of pine trees, in particular, long-leaf pines (Pinus palus-tris). Before 1900 in the South-eastern USA, heartwood was a source for poles, posts, pilings, saw logs, flooring, plywood, pulpwood, and naval stores (tapped for turpentine) (Boyer 1990), but nowadays only recycled wood from old buildings is available (BRE 1977). There are historic examples from Norway where Scots pine boards were used for cladding until the sapwood decayed, typically after 100 years. Then the cladding was mounted down, and the decayed sapwood was removed before the remaining heartwood boards were reused (Øvrum and Flæte 2008). One of the challenges with pine as the cladding material is resin "bleeding" from knots. The resin will penetrate the surface treatment or create bubbles under the coating. Historically, Scots pine trees have in Norway been treated for years before harvesting to obtain "malmet" timber. It included the cutting of the top or reducing the number of top branches. New studies have revealed that this method did not give any net increase in heartwood, but reduced the width increment of the wounded trees. The heartwood ratio increased, but only as a result of the reduced growth. Hence, one does not gain more heartwood, but looses some sapwood (Øvrum and Flæte 2008). Another approach was removing strips of the bark. The tree reacts to the local damage with resin and phenolic compounds that protect against fungal deterioration and is referred to as pathological heartwood. However, this effect is only local, and utilisation of sawn wood is challenging. But it will contribute to some increase in durability if the entire roundwood log is used for construction purposes (Øvrum and Flæte 2008). Pinewood spills were among the most important light sources in medieval times (Krauskopf 2006), and the so-called fatwood, i.e. resinous wood, was preferentially used for making such dim lights.

Rosin, also known as colophony, is the term collectively used for the solidified, distilled form of resins from different conifers (Hamstra and Jacob 2015). Johann (2020) reported on the ethno-botanical significance of pine resins. Accordingly, resin is used around the world to produce turpentine oil, as well as being of traditional importance as medicinal and ritual incense. The fresh effluent (turpentine, terebinthinate) of pines forms the raw material for turpentine oil obtained by steam distillation. This colourless essential oil is highly flammable, soluble in alcohol, has a strong odour, and is volatile even at room temperature. Turpentine has long served as an important additive in paints, lacquers, cosmetics, solvents, and cleaning agents. Highly diluted turpentine oil is also used in folk medicine to treat inflammatory skin conditions or joint diseases (Johann 2020). The resinous, solid residue that occurs during the distillation of turpentine oil is called ‘colophony’, based on the ancient city of Colophone in Ionia, which was considered one of the most important trading centres for the so-called Pix graeca, ‘Greek pitch’ at the time (Hamstra and Jacob 2015). The use of colophony has been traced back to the Egyptian embalming methods of the Old Kingdom era (3050–2181 BC). Strips of linen were soaked in rosin prior to moulding them around the corpse (Lucas and Harris 2011). Later, the cleaned resin was used to produce chewing gum, glue, linoleum floors, and resin for violin bows (Johann 2020). The latter is used to coat the horsehair of stringed instruments so that they can vibrate better. Some musicians playing string instruments can suffer from allergic contact dermatitis to colophony (Gambichler et al. 2004).

Pitch is a colloquialism for non-wood resources derived from conifers. The use of tar pitch for wood preservation was first mentioned in the bible; in Genesis 6:14, Noah was instructed to ‘Make for yourself an ark of gopher wood; you shall make the ark with rooms, and cover it inside and out with pitch’. Pine tar had been manufactured in Europe since the late Roman iron age as evidenced by funnel-shaped pits excavated in middle Sweden (Hjulström et al. 2006). This type of tar was used in large amounts on the Norwegian stave churches and is believed to have contributed to the increased service life of the roof shingles and external cladding (Aune et al. 1983, Bakken 2016).

In 2005, the EU commission suggested a directive that banned the commercial trade of wood tar. This caused much concern in the Nordic countries because tar historically has been used for wood protection in traditional wood architecture. Tar is still being used for the maintenance of important wooden cultural heritage objects like stave churches and boats. It was argued that other conservation techniques would damage the wood. Therefore, the governmental cultural heritage institutions in Finland, Norway, Denmark, and Iceland applied for exceptions from the rules. The result was that since 2007 tar is not listed as a biocide in the EU biocide directive.

Pines played a role in mythology, but in contrast to other tree species such as oaks (Quercus spp.), they neither symbolise longevity nor durability. For the Celtic druid Merlin, the pine was a powerful world tree, on the top of which he attained the highest levels of knowledge. In both Phrygian and Greek mythology, examples can be found where nymphs or humans were transformed into pine trees to protect them from death or decay. Apollo slew Marsyas alive in a cave near Celaenae for his hubris of challenging a god. Apollo then nailed his skin to a pine tree. As a plant symbol in antiquity, the pine and the cones growing on it stood primarily for the aspect of fertility.

4. Wood anatomy and chemistry

The tree trunk of a Pinus species can be differentiated into the outer light-coloured sapwood and the dark-coloured heartwood. All Pinus species are forming coloured heartwood. According to IAWA Committee (1964), heartwood is defined as ‘the inner layer of the wood, which, in the growing tree, have ceased to contain living cells, and in which the reserve materials (e.g. starch) have been removed or converted into heartwood substance’. In pine species, the formation of heartwood includes (Flæte 2007): (1) the loss of stored starch in ray parenchyma cells (Frey-Wyssling and Bosshard 1959), (2) lowered moisture content (Vintila 1939), (3) pit aspiration and lignification and death of parenchyma cells (Bauch et al. 1974), and (4) deposition of extractives (Bergström 2003). Heartwood formation has been summarised in detail by Bamber and Fukazawa (1985), Hillis (1987) and Taylor et al. (2002). Heartwood is more durable than sapwood, while sapwood is easier to impregnate than heartwood. Harju et al. (2003) analysed brown-rot decay resistance in 18 Scots pine (Pinus sylvestris) trees from two 34-year-old progeny trials and found that the total phenolics concentration was higher in the decay-resistant heartwood than in the decay-susceptible heartwood.

According to Billek and Ziegler (1962), heartwood of different pine species contains a wide range – up to 1% –of pinosylvinphenols, where the monomethylether (3-hydroxy-5-methoxy-stilbene, R=CH3) is mostly found in higher concentrations than pinosylvin (trans-3,5-dihydroxy-stilbene, R=H) (Figure 2).

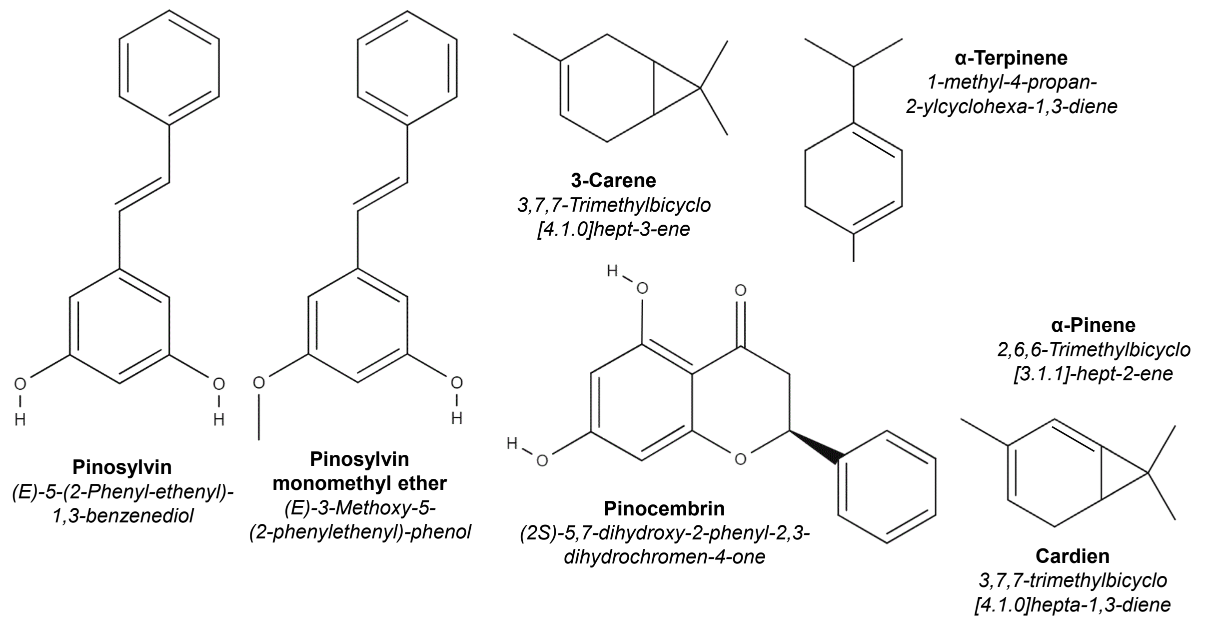

Figure 2. Examples of extractives frequently found in heartwood of different *Pinus* species.

More recently, Hovelstad et al. (2006) compared the content and distribution of resin acids and stilbenes in *P. sylvestris* and Norway spruce (*Picea abies*) from material collected in central Norway. The content of pinosylvin stilbenes in pine heartwood was 0.2% and 2–8% (w/w) in living knots. On the contrary, no stilbenes were detected in *P. abies*. The resin acid contents of pine wood were 1–4% (w/w) and for knots 5–10% (w/w).

The extractive content in numerous *Pinus* species is highest in knotwood followed by heartwood and sapwood. This has also been demonstrated by Wijayanto et al. (2015) for P. merkusii. Knotwood extracts of this tropical pine species contained mainly lignans, stilbenes, and resin acids, while its heartwood extracts were constituted mainly of stilbenes, especially pinosylvin monomethyl ether, pinosylvin and pino-sylvin dimethyl ether, and flavonoids like pinocembrin.

Similarly, Willför et al. (2003) found that stemwood of P. sylvestris contained around 1% (w/w) stilbenes and no detectable lignans, but knots contained larger amounts of phenolic stilbenes, 1–7% (w/w), and lignans, 0.4–3% (w/w). Furthermore, they showed that the ratio of pinosylvin mono-methyl ether to pinosylvin was higher in the knots than in the stemwood. Some intra- and inter-tree variation were seen for the content of resin acids, where abietane-type resin acids dominated over the pimarane-type acids, and abietic acid was the most abundant resin acid in both knots and stem-wood. The amount of resin acids in the radial direction decreased or was on the same level inside the stem, indicating lower extractive content in the juvenile wood. Similarly, Ekeberg et al. (2006) found that the outer part of the heartwood contained the highest amounts of pinosylvin and pino-sylvin monomethyl ether and that they decreased towards the centre of the trunk.

In a previous study, Bergström et al. (1999) showed changes in pinosylvin distribution and concentration across the sapwood/heartwood boundary of P. sylvestris. It was also shown that the concentration and spatial distribution of pinosylvin varied greatly between trees, but no seasonal trend in the distribution pattern or concentration of pinosyl-vin was found.

Wood chemistry and wood properties depend also on the wood origin. Fernandes et al. (2017) reported that Portuguese P. sylvestris has denser wood and higher extractive content than provenances from northern Europe. Among the Portu-guese stands they sampled, trees growing at high elevations showed higher amounts of lignin, while trees from lower alti-tude sites exhibited higher mechanical properties and denser wood.

Uçar and Fengel (1995) analysed wood of *Pinus nigra* vars. *pallasiana* and pyramidata with regard to lignin, holocellu-lose, and extractives. The latter were fatty and resin acids. The var. pyramidata was richer in resin acids and differed in the ratio of abietane- and pimarane-type acids from var. pal-lasiana. Slight differences were also found in the sterol- and neutral diterpene-containing fractions. In a second study, Uçar and Balaban (2002) compared the extracts of *P. nigra* var. *pallasiana*, naturally grown in eastern Thrace, with those from trees grown in Anatolia. Thracian wood yielded greater amounts of resin acids but somewhat fewer sterols compared to extractives of Anatolian black pine.

Significant differences in extractives' contents were also found between *Pinus* species such as the content of pinosyl-vin monomethyl ether in Pinus pinaster (0.00%) *Pinus pinea* (0.02%), *Pinus halepensis* (0.2%), and *P. nigra* var. *calabrica* (0.4%) (Alvarez-Novoa et al. 1950). Among these pine species, only *P. halepensis* contained a measurable amount of pinosylvin (0.03%). Hafizoglu (1983) examined the extrac-tive contents, the composition of fatty acids, resin acids, tur-pentine, and unsaponifiables of different pine species. The compositions of *P. sylvestris* and *P. nigra* did not differ considerably, but *P. brutia* showed a different composition in both acidic fraction and unsaponifiables.

5. Effect of extractives on biological durability

Similar to other coloured heartwood-forming tree species, the extractives of *Pinus* species have an inhibitory effect on insects, fungi, and bacteria, both in the living tree and in wood products. Jorgensen (1961) observed that sapwood of undamaged *P. resinosa* trees did not contain pinosylvin or its monomethyl ether. Both were found to be restricted to the heartwood, except for pinosylvin monomethyl ether, which was found to occur in the pith of branches. In experiments on the local formation of pinosylvins in the sapwood of live and wounded branches, he found that cells that were killed rapidly did not form pinosylvins. In contrast, cells dying slowly produced both pinosylvin and its monomethyl ether. Their formation was therefore considered a defence reaction against attack by pathogens, respective tissues sometimes named 'protection wood' or 'pathological heartwood'.

The fungistatic activity of different stilbenes, i.e. pinosylvin, pinosylvin monomethyl ether, and pinosylvin dimethyl ether, extracted from the cones of P. banksiana and *P. resinosa* were studied by Celimene et al. (1999). All three stilbenes inhibited the growth of white rot fungi, but slightly stimulated the growth of brown-rot fungi on agar media. Non-conforming, the three compounds impregnated at concentrations of 0.1% and 1.0% did impart any significant decay resistance neither to white-rot fungi inoculated on a hardwood (*Acer rubra*) nor to brown-rot fungi on a softwood (Southern yellow pine, *Pinus* species).

Gref et al. (1999) investigated the influence of wood extractives such as free fatty and resin acids, pinosylvin, steryl esters and triglycerides in sapwood, heartwood, and induced lightwood (i.e. tapped for resin) of *P. sylvestris* on decay resistance against brown and white rot. They found that mass losses caused by both fungi were lower in tissues with high levels of pinosylvin and/or resin acids, but concluded that pinosylvin alone was not responsible for decay resistance in the heartwood and the lightwood. In contrast, tissues with high amounts of triglycerides showed low decay resistance. Thus, the availability of nutrients such as triglycerides may interfere with the inhibitory effect of pinosylvin and resin acids.

The inhibitory effect of extractives from pine knot wood was further investigated by Vek et al. (2020). Purified pinosylvins and crude hydrophilic extracts of *P. sylvestris* and *P. nigra* inhibited the growth of different white and brown rot fungi in in vitro antifungal assays. The purified pinosylvins showed higher inhibitory effects compared to the crude hydrophilic extracts. Lee et al. (2005) also showed that pinosylvin exhibited inhibitory activity against different yeasts. Wijayanto et al. (2015) reported that acetone extracts from *P. merkusii* heartwood showed higher fungal growth inhibition activity than those from the knotwood.

Findings from several studies suggest that the different pine heartwood ingredients have positive effects on both resistance against wood-destroying fungi and hydrophobicity of wood, where the latter also contributes to the overall natural biological durability of pine wood. Venäläinen et al. (2004) studied the effect of individual stilbenes from decay-resistant and decay-susceptible *P. sylvestris* trees from a progeny trial. They concluded that a high concentration of phenolics was connected to the low hygroscopicity of wood and that the stilbenes contributed to differences in the wood decay rate. However, the stilbenes alone did not explain the variation in the decay rate.

Harju and Venäläinen (2006) subjected samples from 40 *P. sylvestris* trees to a 7-week decay test with the brown rot *Coniophora puteana*. Total phenolics concentrations were quantified by the Folin–Ciocalteu (FC) assay and ranged from 1.9 to 21.7 mg tannic acid equivalents (TAE)/g of heartwood. The correlation between mass loss by fungal attack versus total phenolics concentration was −0.82 ($p < 0.001$). They concluded that fungal decay tests could be replaced with quantification of the concentration of total phenolics for this species.

Zimmer and Melcher (2017) analysed variation in extractive content within P. sylvestris heartwood from three different stands in the Kongsberg, Norway. Evaluation of mass spectra (NIST library search) showed that α-pinene and carene as well as terpinene and cadinene derivatives were the main extractives in the petroleum ether extracts from both inner and outer heartwood (see also Figure 2). However, in the inner heartwood, these substances, which mainly have a hydrophobic effect, were found in lower quantities. A basidiomycete test indicated that also extractive-rich heartwood was degraded by the brown rot *Rhodonia* (*Poria*) *placenta*. The lower durability of the inner heartwood was explained by lower amounts of hydrophobic compounds.

Tall oil is a by-product from pulping of resinous pinewood wood by the sulphate process, principally a mixture of resin acids and fatty acids, with some sterols and smaller amounts of other compounds. The process parameters will influence the components of the tall oil and thereby also the antifungal properties. Alfredsen et al. (2004) screened the effect of four refined tall oils (with different chemical compositions) against wood-decaying basidiomycetes. All tall oil amended media were more efficient against the white rot fungus *Trametes versicolor* than against the brown rot fungus *R. placenta*, and the tall oils with highest resin acid content were most efficient. However, the concentrations used had no effect in a mini-block decay test. They concluded that tall oil-treated *P. sylvestris* sapwood with the given retention had roughly the same durability class as *P. sylvestris* heartwood. However, Alfredsen and Flæte (2015) concluded that tall oil performed well, even in soil contact, given a high enough retention.

enough retention.

6. Biological durability of pine wood

The wood of *Pinus* species shows significant variability in biological durability between decay organisms, between wood species, and within wood species as multiply recorded in standards and scientific reviews (e.g. Scheffer and Morrell 1998, Brischke et al. 2013, Stirling et al. 2016, EN 350 2016, Alfredsen et al. 2021). Sapwood of *Pinus* species is frequently used as reference species in standards and test protocols around the world. In Europe, *P. sylvestris* is used for field and laboratory durability tests (e.g. EN 252 2015, EN 113-2 2021). In Australia and New Zealand, *P. radiata* is commonly used for laboratory testing (AWPC 2015). In Australia, Southern pine sapwood (e.g. *P. elliottii*, *P. caribaea*, *P. elliottii* x *P. caribaea* hybrid) or *P. radiata*, is used for laboratory testing. In the USA, Southern pine (*P. elliottii, P. echinata, P. palustris, P. taeda, P. serotina, P. virginiana, P. glabra)* is used for stakes (AWPA E7-15 2015) and posts (AWPA E8-15 2016), *P. ponderosa* for above-ground L-joint tests (AWPA E9-15), *Pinus* spp. for horizontal lap-joint tests (AWPA E16-16 2016), Southern pine (*Pinus* spp.) for laboratory soil-block tests (AWPA E10-16 2016), *Pinus* sp. for natural decay resistance laboratory tests (AWPA E30-16 2016), and Southern pine (*Pinus* spp.) or *P. ponderosa* for laboratory soil bed tests (AWPA E14-16 2016).

6.1 Inter-species variation

In Europe, the biological durability of wood species against different deteriorating agents is classified according to EN 350 (2016) as very durable (DC 1), durable (DC 2), moderately durable (DC 3), less durable (DC 4) or not durable (DC 5). For fungi, two durability classifications are listed as follows: X (Y). The first one is usually derived from the results of laboratory or field tests simulating in-ground situations, i.e. soil contact. The second one is based on the results of laboratory tests aiming to determine the durability against monocultures of basidiomycetes, i.e. brown and white rot-causing fungi. In total, 13 *Pinus* species and subspecies are listed in EN 350 (2016) (Table 1). Durability classes based on laboratory basidiomycete tests are provided for only two species, i.e. *P. sylvestris* and *P. nigra*. The latter is surprising since many datasets from laboratory basidiomycete tests have been reported (Table 2). The highest durability in EN 350 (2016) is attested to American pitch pines such as *P. palustris* (DC 3), and the lowest durability is assigned to *P. pinea* (DC 5). The durability of other listed Pinus species is in between these extremes and shows different levels of variability with the widest range in durability for *P. sylvestris* (DC 2–5 against basidiomycetes).

Table 1. Biological durability of pine heartwood according to EN 350 (2016). Note that all listed pine species are not resistant to marine borers and are susceptible to termite attack (i.e. DC S).

Wood species	**Common name**	**Origin**	**Density [kg/m³]**[1]	**Fungi**[2]	***Hylotrupes***	***Anobium***
Pinus spp. *P. caribaea* *P. oocarpa*	Pitch pine	C. America	710–750–770	3	D	D
Pinus spp. *P. elliottii* *P. palustris*	Pitch pine	N. America	650–660–670	3	D	D

P. taeda *P. echinata*						
Pinus spp. *P. elliottii* *P. taeda*	Southern pine	Cultivated in C/N America	400–450–500	4	D	D
Pinus contorta var. contorta, *var. latifolia*	Lodgepole pine	N America, cultivated in Europe	430–460–470	3-4	D	D
a) Pinus nigra ssp. nigra, [= P. laricio] *b) P.nigra ssp. laricio*	a) Austrian pine, b) Corsican pine	SE Europe, cultivated in UK	510–580–650	4v (3)	D	D
Pinus pinaster *[= P. maritima)*	Maritime pine	S/SW Europe	530–540–550	3-4	D	D
Pinus pinea	Umbrella pine	Europe (Italy)	…- 584 -…	5	D	D
Pinus radiata	Radiata pine	Cultivated in Brazil, Chile, Australia, New Zealand, S Africa	420–470–500	4-5	D	S
Pinus strobus	Yellow pine Weymouth pine	N. America	400–410–420	4	D	S
Pinus sylvestris	Scots pine Redwood	Europe	500–520–540	3-4 (2-5)	D	D

[1] Information on density (in kilogram per cubic meter) is included when available in order to provide an indication of physical and mechanical properties. However, no clear correlation exists between density and biological durability or treatability. The density is based on mass/volume at wood moisture content (MC) of 12 % mass fraction. The range refers to commonly encountered values and not to the total possible variation.
[2] For fungi, two durability classifications are listed, noted as follows: X (Y). The first one is usually derived from the results of laboratory or field tests simulating in-ground situation. The second one is based on the results of laboratory tests aiming to determine the durability against basidiomycete wood-decay fungi.

Some species are listed twice (i.e. *P. taeda* and P*. elliottii*), but under different trade names and from different origins. When listed as Pitch pine with higher density, their durability is rated higher compared to listings as the less-dense Southern pine. The nomenclature of the North and Central American pine species is partly ambiguous and so are the attributed wood properties.

Pitch pine is the trade name for different particularly heavy and resinous Pinus species, which are native to the Southeast of the United States. In a narrower sense, pitch pine denomi-nates Longleaf pine (*P. palustris*) and Black pine (*P. rigida*). Pitch pine wood often reaches raw densities above 700 kg/m3 and was therefore appreciated for timber construction. Due to intensive harvesting, slow-grown qualities with low sapwood portions are rarely available today and partly replaced by similar qualities of Central American *P. caribaea* and *P. oocarpa.* Fast-grown pine wood of lower quality from reforestation in the Southeast of the United States is mainly derived from P. taeda and either named Yellow pine or Carolina pine.

The group Southern pine consists of four main species: *P. palustris*, *P. taeda*, *P. echinata*, and P. elliottii. Similarly, the term Yellow pine is ambiguous and refers to a number of conifer species that tend to grow in similar plant communities and yield wood of similar qualities. In the Western USA, Yellow pine refers to *Pinus jeffreyi* or *Pinus ponderosa*. In the South-eastern USA, it refers to the aforementioned Southern pines (Southern yellow pines). In the United Kingdom, Yellow pine refers to *Pinus strobus* and *P. sylvestris*,and in NewZealand, it refers to *Halocarpus biformis*, a species of the Dipterocarpaceae family, which is also known as pink pine.

Different studies pointed on the positive relationship between wood density and biological durability either among different wood species (Perrot et al. 2020), or within one wood species such as *Quercus robur* (Humar et al. 2008), *Entandophragma cylindricum* (Dadzie et al. 2015), and *Larix sibirica* (Polubojarinov et al. 2000, Venäläinen et al. 2001). However, such correlations appear to be spurious, since they come along with a positive correlation between the durability of wood and its extractive content. The latter is also positively correlated with wood density and more likely decisive (Larjavaara and Muller-Landau 2010, Humar 2013). Welzbacher (2001) and Welzbacher et al. (2004) showed that technically increased wood density does not affect the decay resistance of *Picea abies* in experiments with constant mass-based extractive contents. Similarly, the biological durability of pitch pines is defined by its extractive content rather than higher wood density as shown by Schmidtling and Amburgey (1982) who studied the environmental and genetic basis for decay susceptibility and its relationship to specific gravity and growth in loblolly pine (*P. taeda*).

Besides durability against decay fungi, EN 350 (2016) is also addressing the durability against wood boring beetle larvae. Accordingly, all listed pine species are durable (DC D) against *Hylotrupes* and *Anobium* except *P. strobus* and *P. radiata* which are susceptible (DC S) against *Anobium* for reasons that are not further specified.

Attack by *Hylotrupes bajulus* is restricted to the sapwood of conifers (Becker 1963, Nerg et al. 2004, Lukowsky 2017). It is also commonly agreed that *Anobium* spp. attacks preferentially sapwood of both conifers and deciduous trees; heartwood is rarely affected. Mahlke et al. (1950) stated that "*soft timbers are decayed particularly rapid, but heartwood of pine, larch, oak, ash, black locust is avoided*". Hence, it is rather unlikely that *Anobium* attacks pine heartwood, but it is not excluded. The *Anobium* larvae require proteins, which they can only find in sapwood. Hence, scarce heartwood attacks are likely coming along with an attack of the adjacent sapwood.

Numerous further European (-grown) *Pinus* species are not addressed in EN 350 (2016), e.g. Mountain pine (*P. mugo*), Swiss stone pine (*P. cembra*), Macedonian pine (*P. peuce*), Siberian pine (*P. sibirica*), Siberian dwarf pine (*P. pumila*), Turkish pine (*P. brutia*), Canary Island pine (*P. canariensis*), Aleppo pine (*P. halepensis*), Bosnian pine (*P. heldreichii*). Most of them are only of regional importance, but sought for particular applications not at least due their anecdotal alleged durability.

Further evidence of a significant variability in biological durability within the *Pinus* genus emanates from a comprehensive review on wood durability reported by Scheffer and Morrell (1998). Their list of in total 1,500 wood species contains also 30 different pine species covering the full range of decay resistance according to a 4-class scale between 'very resistant' (class 1) and 'nonresistant' (class 4). The value for both scientific and practical use of such a comprehensive list is undisputed. However, similar to other classification schemes, class-based durability data which refer to ranges rather than discrete values allow only for limited quantification and quantitative comparison between wood species. Some standards use normalized data (i.e. mass loss in decay tests, lifetimes of field test specimens) as a basis for durability classes. The advantage of this approach is that durability assignments become more independent from the virulence of test fungi and the severity of attack in test fields respectively. Hence, the comparability between test data is enhanced. In previous studies, we further elaborated on this approach and reviewed results from durability tests with respect to the different reference wood species that are used worldwide (Brischke et al. 2013, 2021a,b).

For this study, international literature and scientific reports were reviewed with respect to data from durability tests that included the heartwood and/or sapwood of at least one Pinus species and a sapwood reference, which was per definition 'non-durable'. The evaluation criterion for laboratory decay tests was the average mass loss due to fungal decay (Equation (1)); in field tests, the average service life (Equation (2)) or the decay rate were used (Equation (3)).

$$ML_{mean} = \frac{\sum_i^n ML_i}{n} \quad (1)$$

$$SL_{mean} = \frac{\sum_i^n ML_i}{n} \quad (2)$$

$$v_{mean} = \frac{\sum_i^n v_i}{n} = \frac{\sum_i^n \frac{R}{t}}{n} \quad (3)$$

Reference factors were calculated, where MLi is the mass loss of a single specimen (%), SLi is the service life of a single specimen (the year when a specimen was recorded to have failed) (y), vi is the decay rate of a single specimen (y−1), R is the decay rating (score), t is the exposure time (y) and n is the number of replicate specimens.

The decay rate, as represented by the rate of change in decay rating over time, was considered as a less desirable quantity with which to determine resistance factors. While decay does not necessarily proceed at a linear rate, it was necessary to consider it as such for the purposes of this study since many field trials were not run long enough to capture the failure of all specimens. Different decay rating schemes were applied, e.g. the five step scales according to EN 252 (2015) and EN 330 (2014).

To make the different durability measures comparable, they were related to the respective reference species, and resistance factors f were calculated according to Equations (4)–(6).

$$f_{ML} = \frac{ML_{tested\ species}}{ML_{reference\ species}} \quad (4)$$

$$f_{SL} = \frac{SL_{tested\ species}}{SL_{reference\ species}} \quad (5)$$

$$f_v = \frac{v_{tested\ species}}{v_{reference\ species}} \quad (6)$$

Where f_{ML}, f_{SL} and f_v are resistance factors based on mass loss, service life or decay rate (after x years) respectively, *ML* is the mass loss (%), SL is the service life (y), and v is the decay rate (y^{-1}). The formula used depended on the durability measure applied for each test: Equation (4) for mass loss data from laboratory experiments, Equation (5) if service life measures were reported from field tests, or Equation (6) if decay ratings were recorded.

Reference factors based on laboratory decay tests were determined for in total 20 *Pinus* species and are summarized in Table 2. As expected, the range of reference factors varied between sapwood and heartwood as well as between tests against basidiomycetes and those against soft rot in unsterile soil. Among the pure sapwood, the factor was between 0.6 (*P. leucodermis* against *C. puteana*) and 1.3 (*P. leucodermis* against *C. puteana* and *P. pinea* against *Fibroporia vaillantii).* In contrast, the reference factor of heartwood was between 0.5 (*P. sylvestris* in unsterile soil) and 83.5 (*P. sylvestris* against *C. puteana*). The difference in variability between sapwood and heartwood is apparently the results of differences in durability between both tissues as such. The hydrophobicity of pine wood contributes considerably to its biological durability (Venäläinen et al. (2004). Hence, the variability of the latter is less in soil contact (i.e. heartwood reference factors between 0.5 and 1.8) where forced permanent wetting eliminates the protective effect of hydrophobic substances such as resins and resin acids.

Similar conclusions can be drawn from the reference factors based on field tests in and above ground, which were determined for in total 10 *Pinus* species as summarized in Table 3. The factors of the different pine heartwoods ranged between 0.7 (*P. elliottii* in deck test in Tåstrup) and 14.9 (*P. sylvestris* in deck test in Brisbane). In contrast, the factors varied considerably less in field tests with soil contact, i.e. between 1.0 (several cases) and 2.4 (*P. sylvestris* in Hannover). Data for pine sapwood were available only from field tests in ground contact, where the reference factors varied only between 0.9 and 1.1. One may conclude, that the durability of pine heartwoods against wood-destroying fungi is generally lower in soil contact and shows less variability compared to above ground exposure. Similar observations were made with other wood species as well as treated timbers which are rather hydrophobic but poor in fungicidal extractives (Augusta 2007, Meyer-Veltrup et al. 2017).

Despite the global economic importance of pine timber, the amount of available data on biological durability of pines is surprisingly low. However, several aspects might explain this discrepancy: (1) Large volume shares of pine wood are not used untreated, e.g. for outdoor use as poles, posts, and railway sleepers. In such applications, the natural durability of the heartwood is overshadowed by effectiveness of the preservative treatment of the respective sapwood portions. The latter is addressed in a large number of scientific papers dealing with preservative treated wood. (2) Many economically important pine species are traded as mixed assortments (e.g. Southern pines), and thus single species have not been the subject of tests. (3) Substantial numbers of scientific publications including research reports do not contain the data which are needed for comparison with other studies, either through using codified durability measures such as durability classes which are usually representing a range rather than concrete values or due to a lack of data about common reference species. (4) Many pine species have a restricted distribution and/or are found in remote mountain areas. Hence, there is no commercial utilization potential.

In particular, the reference factors based on data from laboratory studies (Table 2) show high variation and need to be interpreted carefully. Rather often, single reference factors stand out and can be related to specific test fungi or soil types, respectively. Such extremes can point in both directions, but are not necessarily outliers. Those species which had been tested frequently such as *P. sylvestris* do illustrate this phenomenon exemplarily. The overall maximum reference factor had been reported for *P. sylvestris*, i.e. 83.5 in a test against the brown rot fungus *C. puteana*, which is way different from the majority of reference factors determined for other laboratory test results. However, at least in two other cases factors > 40 were found. Results of laboratory incubation tests are affected by the virulence of the test fungi and the resistance of the reference test material, i.e. the respective pine sapwood. Further parameters such as specimen size and shape, incubation time, and sterilization methods may additionally affect test results (Brischke et al. 2020, 2022). Such disturbance variables are usually less pronounced in field tests, but still reference factors can vary from one test to the other solely through differences in the site-specific decay hazard (Brischke et al. 2013). Thus, it seems advisable to consider a variety of test results representing different decay organisms and exposure scenarios if reliable service life estimates shall be derived.

Exclusively considering the field test data, differences in durability between *Pinus* species became apparent, but suffered from variability within the species. On average, *P. sylvestris* showed the highest reference factor above ground of 2.5 followed by *P. elliottii* (1.1) and *P. caribaea* (1.0). In ground contact, the average reference factor of *P. sylvestris* was 1.5 followed by the heartwood of seven other *Pinus* species with factors between 1.2 and 1.0.

Table 2. Global laboratory data review. The fungal species names listed in this table is the one provided in the respective papers even if that in some cases no longer is the valid name. Current valid names are listed in brackets. *C.p.* = *Coniophora puteana, C.v.* = *Cryptoporus volvatus, F.v.* = *Fibroporia vaillantii, F.a.* = *Fomes annosus (Heterobasidion annosum), G.t.* = *Gloeophyllum trabeum, L.l.* = *Lentinus lepideus (Neolentinus lepideus), L.s.* = *Lenzites sepiaria (Gloeophyllum sepiarium), L.t.* = *Lenzites trabea (Gloeophyllum trabeum), P.m.* = *Poria monticola (Rhodonia placenta), P.p.* = *Poria placenta (Rhodonia placenta), P.v.*= *Poria vapoaria, S.l.* = *Serpula lacrymans, T.v.* = *Trametes versicolor.* References were made from sapwood of the following species: *F.s.* = *Fagus sylvatica, P.c.* = *Pinus contorta, P.e.* = *Picea engelmannii, P.p.* = *Pinus ponderosa, P.s.* = *Pinus sylvestris, P.t.* = *Pinus taeda.*

Wood species	Stem area	Type of test	Biol. agent	Ref. sp.	Origin	ML [%]	Ref. factor [-]	Lit. ref.
P. banksiana	hw	soil-block	*P.m.*	*P.e.*	US	53.0	1.2	[14]
			L.s.			43.0	1.8	
			L.g.			37.0	2.0	
P. cooperi	sw/hw	soil-bed	soil	*F.s.*	MX	2.0	2.0	[5]
		mini-block (16 w)	*C.p.*,			0.8	14.1	
			T.v.			18.3	2,.7	
P. contorta	hw	agar block	*C.v.*	*P.c.*	US	6.0	3.7	[11]
			F.a.			11.0	2.0	
			P.p.			4.0	1.0	
			T.v.			5.0	2.4	
		soil-block	*P.m.*	*P.e.*	US	56.0	1.1	[14]
			L.s.			65.0	1.1	
			L.g.			63.5	1.1	
P. durangensis	sw/hw	soil-bed	soil	*F.s.*	MX	2.2	1.7	[5]
		mini-block (16 w)	*C.p.*			0.4	32.1	
			T.v.			2.1	23.8	
P. halepensis	hw	agar-plate	*C. p.*	*P.s.*	MA	47.4	1.0	[3]
			G.t.			21.9	1.4	
			P.p.			35.2	1.1	
P. lambertiana	hw	soil-block	*P.m.*	*P.e.*	US	46.0	1.3	[14]
			L.s.			36.0	2.0	
			L.g.			43.0	1.7	
P. leucodermis	sw	agar-plate	*C.p.*	*P.s.*	GR	30.7	1.3	[1]
	hw					34.7	1.1	
	sw	agar-plate	*C.p.*	*P.s.*	RS	39.6	0.6	[6]
			S.l.			16.7	1.2	
	hw		*C.p.*			0.7	32.0	
			S.l.			0.6	33.3	
P. monticola	hw	soil-block	*P.m.*	*P.e.*	US	60.0	1.0	[14]
			L.s.			60.0	1.2	
			L.g.			59.0	1.2	
P. palustris	hw	soil-block	*P.m.*	*P.e.*	US	37.0	1.7	[14]
			L.s.			19.0	3.8	
			L.g.			16.5	4.4	
P. patula	hw	mini-block (12 w)	*P.p.*	*P.s.*	KE	19.5	2.0	[2]
P. pinea	sw	agar-plate, pre-leaching	*G.t.*	*P.s.*	IT	27.1	1.0	[4]
			F.v.			14.2	1.0	
			T.v.			12.2	0.5	
		agar-plate, no pre-leaching	*G.t.*			35.9	1.2	
			F.v.			16.0	1.3	
			T.v.			17.7	1.0	
	hw	agar-plate, pre-leaching	*G.t.*			4.5	6.0	
			F.v.			2.0	7.1	
			T.v.			1.4	4.5	
		agar-plate, no pre-leaching	*G.t.*			1.0	43.1	
			F.v.			2.2	9.1	

			T.v.			0.4	44.5	
P. ponderosa	hw	soil block test (21 different strains)	*L.l.*	*P.p.*	US	34.0/47.9/ 57.8	1.0/1.2/ 1.6	[13]
		soil-block	*P.m.*	*P.e.*	US	52.5	1.2	[14]
			L.s.			26.0	2.8	
			L.g.			19.0	3.8	
P. resinosa	hw	soil-block	*P.m.*	*P.e.*	US	56.0	1.1	[14]
			L.s.			38.0	1.9	
			L.g.			31.0	2.3	
P. strobiformis	sw/hw	soil-bed	soil	*F.s.*	MX	4.3	0.9	[5]
		mini-block (16 w)	*C.p.*			1.4	8.2	
			T.v.			2.7	17.9	
P. strobus	hw	soil-block	*P.m.*	*P.e.*	US	43.0	1.4	[14]
			L.s.			25.0	2.9	
			L.g.			28.5	2.5	
P. sylvestris	hw	agar-plate	*C.p.,*	*P.s.*	RS	5.9	3.4	[6]
			S.l.			4.7	4.8	
		agar-plate	*C.p.*	*P.s.*	NO	3.4	12.2	[8]
			P.p.			16.8	2.1	
			T.v.			13.9	2.4	
			C.p.			0.5	83.5	
			P.p.			21.9	1.6	
			T.v.			15.1	2.2	
		mini-block	*C.p.*	*P.s.*	SE	41.1	0.6	[8]
			T.v.			0.2	47.4	
		soil-bed	soil I			13.6	1.0	
			soil II			4.9	0.5	
			soil III			24.5	1.8	
		agar-plate	*C.p.*	*P.s.*	DE	47.5	1.3	[9]
			P.p.			31.0	0.9	
			T.v.			5.1	7.0	
		soil-bed	soil I			21.7	1.1	
			soil II			21.9	1.6	
		agar-plate (4 different labs)	*C.p.*	*P.s.*	na	10.2/21.6/ 31.1	0.7/1.0/ 1.1	[10]
			G.t.			0.8/7.3/17.8	2.0/16.2/ 47.1	
			P.p.			19.6/22.1/ 24.5	1.7/1.9/ 2.1	
		agar-plate (2 different labs)	*S.l.*			17.6/20.2/ 23.6	0.9/1.2/ 1.4	
		agar-plate	*T.v.*			7.8	2.4	
		agar block	*C.p.*	*P.s.*	na	26.0	2.6	[11, 12]
			L.l.			31.0	1.4	
			P.v.			34.0	1.5	
P. taeda	hw	agar block	*F.a.*	*P.t.*	US	4.0	3.6	[11]
		soil-block	*P.m.*	*P.e.*	US	48.0	1.3	[14]
			L.s.			28.0	2.6	
			L.g.			28.0	2.6	
P. teocote	sw/hw	soil-bed	soil	*F.s.*	MX	2.9	1.4	[5]
		mini-block (16 w)	*C.p.*			2.4	5.0	
			T.v.			1.1	45.8	
P. pinaster var *atlantica*	hw	agar-plate	*C.p.*	*P.s.*	MA	28.4	1.4	[7]
			G.t.			24.4	1.4	
			P.p.			7.9	3.2	
P. halepensis	hw	agar-plate	*C.p.*	*P.s.*	MA	37.4	1.1	[7]
			G.t.			21.9	1.5	

			P.p.			22.6	1.1	

* [1] Adamopoulos et al. (2012), [2] Mohareb et al. (2012), [3] Elaieb et al. (2017), [4] De Angelis et al. (2018), [5] Cruz Carrera et al. (2018), [6] Petrovic and Miric (1981), [7] Fidah et al. (2016), [8] Meyer-Veltrup et al. (2017), [9] Brischke and Meyer-Veltrup (2016), [10] Van Acker et al. (2003), [11] Hart and Shrimpton (1979), [12] Rennerfelt (1956), [13] Schulz (1958), [14] Clark (1957)

Table 3. Global field data review. References were made from sapwood of the following species: *P.e.* = *Pinus elliottii, P.p.* = *Pinus ponderosa, P.r.* = *Pinus radiata, P.s.* = *Pinus sylvestris, P.t.* = *P. taeda.*

Wood species	**Stem area**	**Type of test**	**Location**	**Refe-rence**	**Ori-gin**	**Decay rate [a^{-1}]**	**Refe-rence factor [-]**	**Ref.***
P. banksiana	hw	graveyard	Asakawa, JP	*P.t.*	na	0.45	1.2	[12]
	sw					0.50	1.1	
P. caribaea	hw	L-joint painted	Beerburrum, AU	*P.r.*	AU	0.85	1.0	[6]
		L-joint unpainted				0.74	0.9	
P. densiflora	hw	graveyard	Asakawa, JP	*P.t.*	JP	0.45	1.2	[12]
	sw					0.63	0.9	
P. elliottii	hw	deck-test	Brisbane, AU	*P.e.*	AU	0.68	1.0	[7]
			Corvallis, US			0.14	1,4	
			Hamburg, DE			0.51	1.0	
			Sarawak, MY			1.32	0,8	
			Kuching, MY			1.04	1,5	
			Tåstrup, DK			0.44	0.7	
		L-joint painted	Beerburrum, AU	*P.r.*	AU	0.71	1.2	[6]
		L-joint unpainted				0.57	1.2	
P. koraiensis	hw	graveyard	Asakawa, JP	*P.t.*	na	0.50	1.1	[12]
	sw					0.45	1.2	
P. penta-phylla	hw	graveyard	Asakawa, JP	*P.t.*	JP	0.50	1.1	[12]
	sw					0.56	1.0	
P. strobus	hw	graveyard	Asakawa, JP	*P.t.*	na	0.56	1.0	[12]
P. sylvestris	hw	graveyard	Borås, SE	*P.s.*	SE I	1.37	1.2	[1]
			Hanover, DE			1.11	2.4	
			Borås, SE		SE II	1.22	1.3	
			Hanover, DE			2.19	1.2	
		sandwich	Borås, SE		SE I	0.24	2.2	
			Hanover, DE			0.24	2.8	
			Borås, SE		SE II	0.26	2.0	
			Hanover, DE			0.24	2.7	
		horizontal double layer	Borås, SE		SE I	0,24	2,2	
			Hanover, DE			0,24	2,8	
			Borås, SE		SE II	0,26	2,0	
			Hanover, DE			0,24	2,7	
		Lap-joint	Borås, SE		SE I	0.46	1.8	
			Hanover, DE		SE II	0.14	2.1	
	hw	graveyard	Hamburg, DE	*P.s.*	DE I	0.62	1.8	[3]
					DE II	0.51	2.2	
					SE	0.66	1.7	
			Hamburg shade, DE		DE I	0.51	2.1	
					DE II	0.71	1.5	
					SE	0.63	1.7	
			Stuttgart, DE		DE I	0.51	1.7	
					DE II	0.44	1.9	

					SE	0.38	2.2	
			Freiburg, DE		DE I	0.70	1.5	
					DE II	0.58	1.8	
					SE	0.75	1.4	
			Reulbach, DE		DE I	0.33	1.3	
					DE II	0.34	1.2	
					SE	0.30	1.4	
		horizontal double layer	Hamburg, DE		DE I	0.36	1.6	
					DE II	0.37	1.5	
					SE	0.24	2.3	
			Hamburg shade, DE		DE I	0.56	1.2	
					DE II	0.48	1.4	
					SE	0.44	1.5	
			Stuttgart, DE		DE I	0.17	2.9	
					DE II	0.33	1.5	
					SE	0.28	1.8	
			Freiburg, DE		DE I	0.29	2.0	
					DE II	0.27	2.2	
					SE	0.25	2.4	
			Reulbach, DE		DE I	0.41	1.5	
					DE II	0.48	1.3	
					SE	0.25	2.4	
	sw/hw	graveyard	Hamburg, DE	*P.s.*	DE	1.20	1.0	[5]
		horizontal double layer	Hamburg, DE			0.47	1.3	
			Hamburg shade, DE			0.51	1.2	
	hw	graveyard	Ghent, BE		FR	0.78	1.0	[10]
			Garston, UK		UK	0.72	1.3	[2]
			Birnie Wood, UK			1.53	1.1	
			Punkaharju, FI		FI I	0.63	1.4	[11]
					FI II	0.60	1.5	
		horizontal double layer	Oslo, NO		NO I	0.14	3.3	[1, 2]
			Ås, NO			0.20	2.0	
			Bergen, NO			0.27	1.2	
			Oslo, NO		NO II	0.16	3.0	
			Ås, NO			0.20	2.0	
			Bergen, NO			0.26	1.3	
		modified horizontal double layer	Espoo, FI		FI	0.24	2.8	[9]
		Lap-joint coated	Göttingen, DE		na	0.19	1.9	[8]
		Lap-joint uncoated				0.18	1.5	
		decking test	Ljubljana, SI		SE	0.45	1.4	[4]
		deck-test	Brisbane, AU	*P.e.*	AU	0.04	14.9	[7]
				P.s.	na	0.13	3.6	
			Hamburg, DE		na	0.16	3.0	
			Kuching, MY	*P.e.*	AU	0.29	3.5	
			Tåstrup, DK		AU	0.12	2.7	
		multiple layer, upper	Borås, SE	*P.s.*	SE I	0.10	4.0	[6]
					SE II	0.30	1.3	
		multiple layer, bottom			SE I	0.40	1.0	
					SE II	0.10	4.0	
P.taeda	hw	graveyard	Asakawa, JP	*P.t.*	na	0.56	1.0	[12]
P. thunbergia	hw	graveyard	Asakawa, JP	*P.t.*	JP	0.50	1.1	[12]
	sw					0.50	1.1	

* [1] Meyer-Veltrup et al. (2017), [2] Brischke et al. (2021a), [3] Augusta (2007), [4] Humar et al. (2019), [5] Brischke and Meyer-Veltrup (2016), [6] Brischke et al. (2013), [7] Francis et al. (2019), [8] Brischke et al. (2017), [9] Metsä Kortelainen and Viitanen (2017), [10] Van den Bulcke et al. (2011), [11] Venäläinen et al. (2019), [12] Matsuoka and Amemiya (1970)

6.2 Intra-species variation

Very little is reported about the intra-species variability of biological durability of pine heartwoods. Standard protocols for testing biological durability usually include minimum requirements for sampling. According to EN 350 (2016) "*a log shall be taken from at least 3 trees of the species under test, originating from 3 different sites representative of the diversity of the geographical regions or sites where the tree species grows*." Hence it is assured that results from single durability tests imply some of the intra-species variability. However, systemic analysis and interpretation of test data with respect to varying durability within one species is extremely scarce and – to the best knowledge of the authors - not available for the heartwood of any *Pinus* species.

In contrast, a systematic approach has been followed by Alfredsen et al. (2021) who studied the intra-species variability of *P. sylvestris* sapwood. Decay tests with brown and white rot fungi as well as soft rot tests in terrestrial micro-cosms containing unsterile compost soil were performed with wood specimens sampled at 28 different locations in 11 European countries. In addition, different moisture performance tests were conducted with matched specimens representing vapour uptake (VU), vapor release (VR), liquid water uptake (LWU), capillary water uptake (CWU), and the equilibrium moisture content in water saturated atmosphere (EMC(sat)). A summary of their findings is shown in Figure 3. The variation of the examined durability and moisture performance indicators was surprisingly low where the moisture performance indicators varied to a greater extent than the mass loss data from durability tests. Nevertheless, annual ring width and oven-dry density turned out to be decisive parameters and explained the variation of the sapwood of *P. sylvestris* to a great extent.

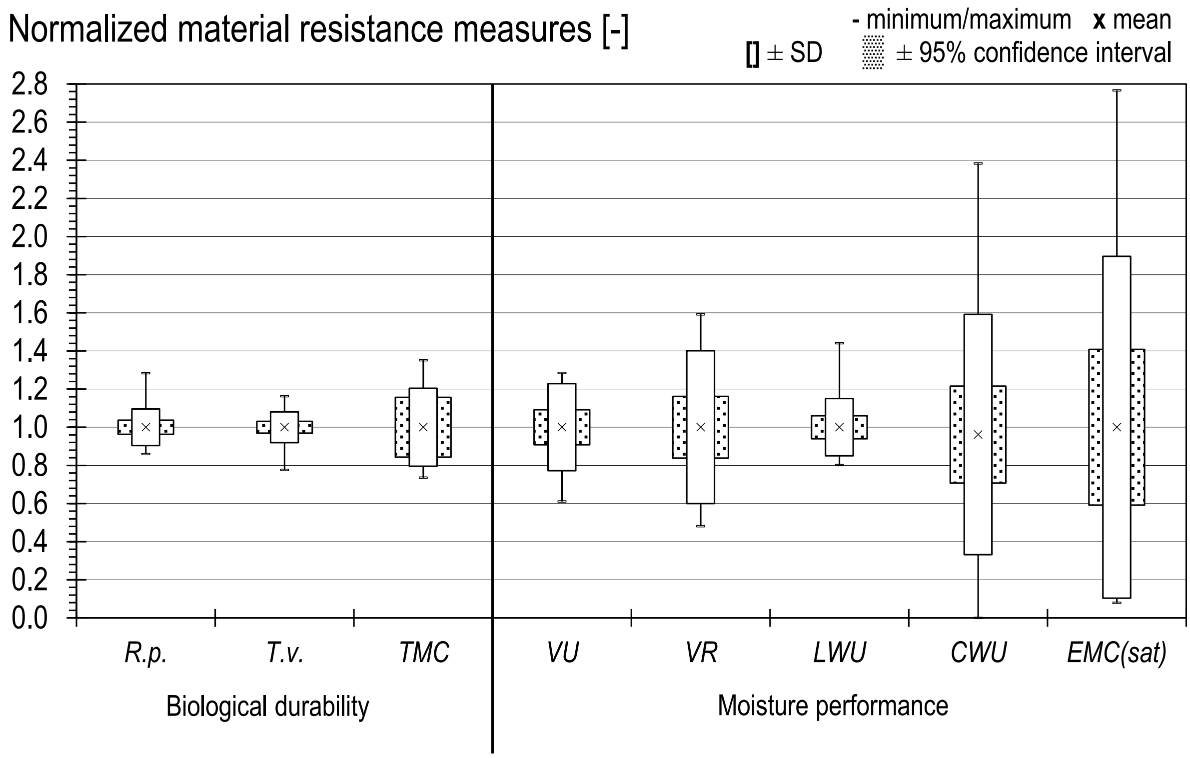

Figure 3. Different normalized material resistance measures taken from Alfredsen et al. (2021). *R.p.* = *Rhodonia placenta*, *T.v.* = *Trametes versicolor*, TMC = terrestrial micro-cosm, VU = vapour uptake, VR = vapour release, LWU = liquid water uptake, CWU = capillary water uptake, EMC(sat) = equilibrium moisture content in water saturated air.

Parts of the materials in Figure 3 were collected and published by Zimmer (2014) and Behr (2011). They studied treatability variation of P. sylvestris sapwood (Zimmer 2014) and heartwood (Behr 2011) from Northern Europe.

Zimmer (2014) concluded that: (1) significant differences in treatability were found between stands, (2) high latewood content and wide annual rings (from stands with sufficiently high annual mean temperatures) were favourable for high treatability, (3) increasing stand density and decreasing socio-logical position within a stand reduced treatability, (4) trees growing near the timberline of the species and under environmental conditions impairing the wood growth developed refractory wood, (5) easy to impregnate material contained a higher number of ray parenchyma cells (increased area of fenestriform pits in the cross-field between ray parenchyma and longitudinal tracheids), while refractory samples had developed smaller bordered pit features with comparatively small pit apertures.

Further, an analysis of the genetic structure of the sampled Scots pine revealed segmentation into an eastern and a western group. They hypothesised that this might be a result of recolonizing Fennoscandia from at least two different directions after the last glaciation. The segmentation into different refugia can be a reason for variant adaptions to growth conditions, as the eastern group developed larger latewood proportions under similar conditions compared to the western group.

Behr (2011) concluded that (1) site and tree characteristics did not significantly correlate with RoF (ratio of filling – a measure for treatability), (2) the investigated anatomical wood properties (diameter class, diameter in breast height, tree height, age, site index of tree (H40), annual ring width of sample, exposition site in the tree, distance of the sample from the pith (radial position) and density) had no significant influence on the RoF, and (3) climatic and geographic differences influenced treatability more than site and tree characteristics. The most influential factors on RoF were the hardiness zone and precipitation during winter and the mean annual precipitation, i.e. the treatability decreased towards north and east. (4) Extractive content of Scots pine heartwood correlated negatively with the treatment performance.

7. Conclusions

Despite its richness in species, the genus Pinus shows rather little variability of its wood-inherent durability against decay organisms. The heartwood of most pines is susceptible to attack by termites, but durable against wood-boring beetle larvae. It is less to moderately durable against decay fungi (i.e. DC 3–4 according to EN 350 2016), but can vary within one species. The durability of many pines is the result of fungicidal and hydrophobic extractives. However, the latter plays only a role in applications without permanent contact with water or wet soil. Forced wetting eliminates the advantageous moisture performance of pine heartwood. Consequently, the inter-species variation of biological durability is more prominent in above-ground exposure (0.7–14.9 times higher compared to non-durable pine sapwood) compared to soil contact scenarios (1.0–2.4). This study also showed that systematic comparative durability tests have been reported only scarcely, in particular, those using field test methods. Therefore, exceptionally higher durability of particular species might be overlooked. But higher durability by the trend of other particular species requires confirmation through more comprehensive tests, taking also into account the intra-species variation, which can be the result of different origins and corresponding growth conditions.

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No potential conflict of interest was reported by the authors

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Supplement Table 1.

The information about author, synonym, common name, ecology and distribution is extracted from Farjon (2018) unless indicated with an asterisk * in front of the species name. For species marked with * the information about author, synonym, common name, ecology and distribution is based on The IUCN Red List of Threatened Species (2022).

Mainly information about use is from The IUCN Red List of Threatened Species (2022) but some additional information from BRE (1977) is provided (and if so the reference to BRE is included). Like every other wood species also pine can be utilised for fuel purposes and therefore fuel is not listed under use areas.

Durability classifications listed are according to EN 350 (2016), Scheffer & Morrell (1998) and BRE (1977) because they are comprehensive studies with uniform classifications.
Durability classification in EN 350 (2016): refers to results of laboratory or field tests simulating in-ground situation, 1 = Very durable, 2 = Durable, 3 = Moderately durable, 4 = Slightly durable, 5 = Not durable.
Durability classification in Scheffer & Morrell (1998): 1 = Very resistant, 2 = Resistant, 3 = Moderately resistant, 4 = Nonresistant, TA = Temperate America, AM = Tropical America, AS = Australia-Asia, EU = Europe, AF = Africa, F = developed in field, L = laboratory exposure, ? = lack of information on test methodology.
Durability classification in BRE (1977): non-durable, moderately durable or durable.

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Scientific name	Common name	Ecology	Distribution	Use areas	Durability
Genus *Pinus* L. (106)					
Subgenus *Pinus* (68)					
Section *Pinus* (26)					
Subsection *Pinus* (17)					
Pinus densata Mast	Gaoshan pine, gao shan song	Altitude: 2600-4000 m. Occurs in high mountains, forms open pure stands at the highest elevations.	Endemic to China: Tibet [or Xizang], Yunnan, Sichuan, Qinghai.	Presently little economic use, primarily because it occurs in high mountains in often inaccessible places.	

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
Pinus densiflora Siebold et Zucc. Syn.: *P. funebris* Kom.; *P. densiflora* var. *sylvestriformis* (Taken.) Q.L.Wang	Japanese red pine, akamatsu, chi song	Altitude: near sea level-2300 m. Form extensive forests. In boggy lakeside moors and on rocky slopes.	Japan: main islands excl. Hokkaido; Asian mainland: North and South Korea, Russian Far East; China: Heilongjiang, Jilin, Liaoning, Shandong.	Very similar (and closely related) to *P. sylvestris*, consequently similar wood properties; important timber in NE Asia. Today mainly pulp & paper, but also underground mining, railway sleepers and construction.	Scheffer & Morrell: 2-3, AS, F
Pinus henryi Mast. Syn.: *P. tabuliformis* Carrière ssp. *henryi* (Mast.) Businský *P. tabuliformis* Carrière var. *henryi* (Mast.) C.T. Kuan	Henry's pine, ba shan song	Altitudes: 1100-2000 m. Subtropical mountains. Primarily on dry, sunny slopes. A pioneer in secondary vegetation.	Endemic to China: Chongqing, Hubei, Hunan, Shaanxi, and Sichuan.	Similar in its wood properties to *P. tabuliformis*, but less common and widespread, thus less important timber.	
Pinus hwangshanensis W.Y.Hsia Syn.: *P. taiwanensis* Hayata var. *damingshanensis* W.C.Cheng & L.K.Fu	Huangshan pine, huang shan song	Altitudes: 500-2500 m. In mixed montane deciduous forests, in open areas on slopes and ridges. In undisturbed forest the pines would occupy areas with shallow, sandy acidic soils and rocky outcrops.	Endemic to China: Anhui, Fujian, Guangxi, Guizhou, S Henan, Hubei, Hunan, Jiangsu, Jiangxi, SE Yunnan, and Zhejiang	Good quality timber with suitable strength for construction	
Pinus kesiya Royle ex Gordon Syn.: *P. khasyana* Griff.; *P. kasya* Royle ex Parl.; *P. khasya* Royle ex Hook. f.	Khasia pine, Khasi pine, Luzon pine, Benguet pine (var. in Philippines)	Altitude: 800-1500 m in Thailand and Burma, scattered and in dry regions, 1000-2700 in the Philippines in areas where fires are frequent.	Occupies a large area in SE Asia, from the Indian Khasi states throughout Assam and the mountains of N Burma and SW Yunnan in China, into Laos, Vietnam, Thailand and the Philippines.	Important timber tree in much of SE Asia, planted as a forestry tree in many countries in Africa, S America and Oceania (incl. Australia). Fast growing and commonly used for pulpwood. Other use areas: poles, construction timber, floorboards, plywood, and furniture.	
Pinus luchuensis Mayr	Luch pine, Okinawa pine	Altitude: from sea level-700 m. A pine of maritime coasts, very tolerant of saline air and ocean spray.	In the southernmost parts of the Japanese archipelago, mainly the island of Okinawa and some nearby smaller islands in the Ryukyu Group.	Not important as a timber resource and as such only of local use.	

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
Pinus massoniana Lamb. Syn.: *P. sinensis* D. Don; *P. canaliculate* Miq.; *P. argyi* Lemée at Lév.; *P. cavalieri* Lemée et Lév.; *P. crassicorticea* T.C. Zhong et K.X. Huang; *P. massoniana* var. *shaxianensis* D.X. Zhou	Masson pine, Chinese red pine, ma wei song	Altitudes: sea level-2000 m. Grows well in lowlands and highlands, from moist lowland river valleys to dry mountain plateaus.	Distributed across large areas of China, mostly in the S, center, and E. Also occurs on the islands of Taiwan and Hainan.	Among most important conifers in China. Fast growing and widely used. Natural stands, especially old growth, provide most of the sawn timber, while fast growing plantations are mostly converted into pulpwood. Resin forms basis for variety of chemical products. Extracted oil extensively used in traditional Chinese medicine.	
Pinus mugo Turra Syn.: *P. montana* Mill.; *P. mughus* Scop.; *P. pumilio* Haenke	Dwarf mountain pine	Altitudes: Alps and Pyrenees as high as 2300 m, Carpathians and elsewhere 100-1800 m. Hardy, primarily subalpine. In the European lowlands on poor, sandy soils. Often on very exposed mountain sides.	From Spain across central Europe to Ukraine, Italy and Romania.	The shrubby subspecies (mugo) has been used in N Europe to stabilize drifting sand dunes and as initial shelter belts for plantations with *P. sylvestris* in similar sandy areas.	
Pinus nigra J.F Arnold	Black pine, Schwarz-Kiefer, subsp. *laricio* Corsican pine	Altitudes: 250-1800 m. Mountain pine in most of its range, but around the Black Sea it is found in hills.	Climate ranges from Mediterranean to subcontinental in C Europe.	Important timber species and amenity tree; extensively planted in Europe and to a lesser extent in the USA. Used for general construction, pulp, stabilisation of dunes along the North Sea coast. BRE (1998): Use similar *to P. sylvestris.* Thick permeable sapwood; well suited for impregnation.	BRE (1998): Susceptible to attack by *Anobium spunctatum.* Natural durability: Non-durable EN 350 (2016): Origin: SE Europe, cultivated in UK Fungi: 4v (3) *Hylotrupes*: D *Anobium*: D Scheffer & Morrell: subsp. *laricio* 4, EU, F
Pinus resinosa Aiton Syn.: *P. rubra* F. Michx., non Mill.	Red pine, Norway pine, pin rouge, Canadian pine	Altitude: 200-800 m, 1300 in USA: WV. Occupies a region that has been covered by the	Widespread in the NE part of N America, from Newfoundland and S Quebec westward to	Important timber species; widely planted in NE USA and E Canada. Used mostly for	BRE: Resistance to insects: Damage by

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
		land icesheet of the Wisconsin Glaciation. The area has a natural climax vegetation of boreal and north temperate angiosperm-conifer forests, soil condition and altitude determine the tree species. Pines generally restricted to drier, nutrient-poor sites. Grows well on sandy or gravelly and acidic soils, but intolerant of shade.	Ontario and MN, WI, MI and IL. Also common in the New England states. Isolated populations in the Appalachian Mountains and in IL.	pulpwood and rough construction timbers, piling, cabin logs, posts, railway sleepers, paving blocks, crates, and nowadays less frequently mine timbers. Also used for Christmas trees and shelter belts to prevent wind erosion on farmland. BRE (1998): Source for rosin and turpentine in the USA	ambrosia (pinhole borer) beetles and by longhorn beetles Natural durability: Non-durable Scheffer & Morrell: 4, TA, L
Pinus sylvestris L.	Scots pine, Gemeine Kiefer, furu, Sosna lesnaya, Sosna obiknovennaya	Altitude: sea level-2600 m. Adapted to a wide range of environments. Occurs far N of the Arctic Circle, but also on the steppe of Mongolia, on the Atlantic seaboard and at 2600 m in the Caucasus. In mesophytic environments it behaves like a xerophyte, but in arid regions it occurs only along stream courses. Found in both humid and arid climates. In stabilized sand dunes, rocky outcrops and even on edges of acidic peat bogs.	*P. sylvestris* has the greatest distribution of all *Pinus* species. Found from the Iberian Peninsula eastward throughout W Europe, the Balkan Peninsula, Turkey to the coastal regions of the Black Sea. In N Europe in Scotland, Scandinavia except Denmark (in the wild) and E Europe with interruptions in Russia. Occupies enormous range in Siberia, from the Ural Mountains nearly to the Pacific coast, S to Kazakhstan and Mongolia. Reaches 71°N in Norway, making it the most northernly pine. In much of lowland Europe *P. sylvestris* has been widely planted and has become naturalized in several areas.	Important timber species. In much of W Europe it is a widely planted forestry tree for timber; it was introduced in the USA for similar purposes and for growing as Christmas trees. BRE (1998): The timber is used for all kinds of construction work. Use area depends on the grading.	BRE (1998): Resistance to insects: Damage by ambrosia (pinhole borer) beetles and by longhorn beetles is sometimes present Natural durability: Non-durable EN 350 (2016): Origin Europe Fungi: 3-4 (2-5) *Hylotrupes*: D *Anobium*: D Scheffer & Morrell: 4, EU, F
Pinus tabuliformis Carrière Syn.: *P. densiflora* Siebold et Zucc. var *tabuliformis* (Carrière) Mast.; *P. sinensis* Mayr, non D. Don	Chinese red pine, you song	Altitude: 100-2600 m. From hills to the mountains. Occupies dry sites and is a pioneer forming secondary woodland where it becomes mixed with other trees in later succession stages.	Occupies a large area in N and NE China.	Important forestry tree yielding timber for construction; its wood is hard and strong with a straight grain. The wood is used for mining props, railway sleepers, bridges, carts or wagons, and tools. The resin is extracted from the bark.	

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
				Essential oils and the pollen are used in traditional Chinese medicine.	
Pinus taiwanensis Hayata	Taiwan Black pine, Formosa pine, tai wan song	Altitude: 800-3000 m. Grows in the mountains or along the mountain coast. Occurs in different climate zones from warm temperate to subalpine. At lower and middle elevations, it is mostly restricted to open spaces, exposed ridges and places with sandy, acidic and nutrient poor soils.	Occurs only on the island of Taiwan if treated in the strict sense taxonomically.	Good quality timber. Uses: buildings, bridges, railway sleepers, mine props, fences and gates, crates and boxes, panelling, flooring, furniture, industrial and domestic woodware, tools, plywood, fibreboard and wood pulp.	
Pinus thunbergii Parl. Syn.: *P. massoniana* Siebold et Zucc., non Lamb.; *P. thunbergiana* Franco	Japanese black pine, kuro-matsu	Altitude: up to 1000 m. Costal hills and mountains. Pioneer species. Much planted in afforestation schemes.	Japan: coastal regions of Honshu, Shikoku and Kyushu: South Korea: along the coast.	Similar properties as *Pinus nigra.* Use: construction, poles, railway sleepers, fences, pallets and crates, flooring, fibreboard, pulp, and stabilisation of sand dunes in coastal areas.	Scheffer & Morrell: 2-3, AS, F
*****Pinus tropicalis*** Morelet	Tropical pine	Altitude: sea level-300 m. On the coastal plains and low foothills, nutrient-poor sandy or gravelly alluvial soils which are dry due to rapid drainage.	Endemic to western Cuba.	Important regional source of timber mainly used by local sawmills. Its wood is dense and durable, but resinous.	
Pinus uncinata Ramond ex DC. Syn.: *P. mugo* Turra subsp. *uncinata* (Ramond ex DC.) Domin; *P. mugo* var. *uncinata* (Ramond ex DC.) Fiori; *P. montana* Mill. var *uncinata* (Ramond ex DC.) Heer; *P. uncinata* var. *rostrata* Antoine; *P. mugo* var. *rostrata* (Antoine) Hoopes	Mountain pine, Spirke	Altitude: 600-1600 m. Wet moors in W European mountains.	Europe: Pyrenees of France and Spain, scattered populations on the Massif Central, the Jura and the Vosges in France and Switzerland, and Böhmerwald and the Erzgebirge of the Czech Republic and Germany.	Not commercially important. Uses: light construction. Some of the wood is excellent for special uses like turnery, woodware and musical instruments due to its density and hardness properties.	

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
Pinus yunnanensis Franch. Syn.: P. sinensis D. Don var yunnanensis (Franch.) Shaw; P. tubuliformis Carrière var. yunnanensis (Franch.) Dallim. Et A.B. Jacks.; P. kesiya Royle ex Gordon subsp. yunnanensis (Franch.) Businský	Yunnan pine, yun nan song	Altitude: 400-3100 m. In valleys and deep river gorges and on high mountain slopes. Most abundant on dry and sunny slopes.	Abundant in SW Sichuan and Yunnan and occurs in Guangxi, Guizhou and SE of Xizang of China.	Of considerable economic importance in China. Uses: round wood for poles and stakes, sawn timber for construction, both exterior and interior, for fences and gates, pallets, crates and boxes, cooperage and vats, furniture, veneers, all kinds of plywood and boards, tool handles, pulp, chemical industry. Resin is tapped for naval stores, in particular turpentine, and the bark is used to extract tannins. Needle litter provide fodder for animals and are distilled for oils and medicinal products. Much planted for wind breaks and erosion control.	
Subsection *Pinaster* Mayr ex Koehne (9)					
Pinus brutia Ten. Syn.: *P. halepensis* var. *brutia* (Ten.) A. Henry	Calabrian pine	Altitudes: 100-1500 m. Usually in warm and sunny, dry environments. Probably pioneer species after destructive fires.	E Mediterranean region and around the Black Sea; Iraq, Syria, Lebanon, Turkey, Azerbaydzhan, Georgia, Russia and Ukraine, Cyprus, Crete, and some islands in the Aegean, but also on the Greek mainland.	Uses: fencing posts, telephone posts, building timbers, railway sleepers, carpentry, boxes and crates, hardboard and pulp. Resin used from ancient times to flavour white wines known as retsina and is still tapped especially in Turkey, now mainly for the production of turpentine.	
Pinus canariensis C. Sm.	Canary pine, Canary Island pine	Altitudes: 1200-2200 m. Extensive forest areas. Occurring in belts on the highest mountains. Grows well on exposed mountain slopes of volcanic origin.	Endemic to several of the Canary Islands.	Heavily exploited in the past for construction. Present use is as a belt of forest to retain rainfall in urbanizing coastal areas, especially on Tenerife and Gran Canaria.	

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
		Subtropical species. Restricted by winter frost.			
Pinus halepensis Mill. Syn.: *P. maritima* Mill.; *P. genuensis* S.E. Cook; *P. carica* D. Don; *P. abasica* Carrière; *P.* x *saportae* Rouy; *P. ceciliae* Llorens et L. Llorens	Aleppo pine	Altitudes: sea level-1700 m. Grows especially well on dry, rocky limestone soils in semi-arid mountains with winter precipitation. Drought-resistant tree. Seldom in closed forest stands.	Occurs in the entire coastal region around the Mediterranean Sea. One of the few pine species which occur naturally in Africa, especially Morocco and coastal areas of Algeria.	Due to size and shape of most trees and poor quality, is of little value as timber. Use for charcoal burning. Rich in resin.	
Pinus heldreichii H. Christ Syn.: *P. leucodermis* Antoine; *P. pindica* Formánek; *P. laricio* Poir. var *heldreichii* (H. Christ) Mast.; *P. laricio* var. *leucodermis* (Antoine) Christ; *P. nigra* J.F. Arnold var. *leucodermis* (Antoine) Rehder; *P. heldreichii* var. *leucodermis* (Antoine) Markgr. ex Fitschen	Heldreich's pine	Altitudes: 100-2500 m. Mountain pine from Balkan. Forming dense pure stands on gentle slopes with well-drained soil.	Scattered in the mountains across the Balkan peninsula and occurs in Albania, Bosnia Hercegovina, Montenegro, Serbia, North Macedonia, Croatia, Slovenia, Bulgaria, and Greece.	Not an important timber tree, although it is planted in some Balkan countries with timber production as an objective. Local use: heavy construction or as round timber, e.g. for poles, and to build traditional fences.	
Pinus latteri Mason Syn.: *P. merkusii* var. *latteri* (mason) Silba; *P. merkusii* subsp. *latteri* (Mason) D.Z. Li; *P. ikedae* Yamam.; *P. tonkinensis* A. Chev.; *P. merkusiana* Cooling et Gaussen, nom. inval. (Art. 37.1)	Tenasserim pine, nan ya song	Altitude: from near sea level-1200 m. Forming more or less open stands on old river terraces with sandy or gravel soil or in seasonally dry hills.	Widespread species of SE Asia; China: Guangdong, Guangxi and Hainan; Cambodia, Laos, Myanmar, Thailand and Vietnam.	Used in SE Asia for light construction purposes. The wood is moderately hard and very resinous. Uses: only suitable for indoor applications, sawn timber, pulp industry, charcoal burning. Important tree for resin tapping in some countries.	
****Pinus merkusii*** Jungh. & de Vriese	Merkus's pine, mindoro pine, Sumatran pine, damar batu,	Altitude: 300-1300 m. Mountainous regions. Forms more or less open pine woods	Sumatra (Indonesia) and Philippines	Extensively planted throughout Indonesia in colonial times. Most important producer of pine resin. Wood of higher	Scheffer & Morrell: 2-4, AS, L

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
	damar bunga, uyam, Sonsongbai, Western white pine	or pine savannas influenced by periodic grass fires.		grade is used in house construction.	
Pinus pinaster Aiton Syn.: *P. maritima* Lam., non Mill.	Maritime pine	Altitude: near sea shore-2000 m. Mainly low-lying coastal plains, grows well on mineral soil (sand dunes).	Predominantly in the coastal regions of the W Mediterranean, from Italy, Malta, S France, Portugal and Spain to N Morocco and boarder area between Algeria and Tunisia.	Important timber tree as well as Europe's major source of turpentine since the 16th century. Planted to stabilize dunes in coastal areas. Wood is of coarse grain and very resinous. Uses: mining pit props, construction, poles, fence posts, boatbuilding, and furniture. Smaller sized logs with many knots or blemishes are usually chipped or pulped for particleboard and paper, mulch (high bark-to-wood ratio).	BRE (1998): Resistance to insects: Damage by ambrosia (pinhole borer) beetles, longhorn beetles and wood wasps (*Sirex* spp.) is sometimes present. Natural durability: Moderately durable EN 350 (2016): Origin: S/SW Europe Fungi: 3-4 *Hylotrupes*: D *Anobium*: D

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
					Scheffer & Morrell: 3, EU, F
Pinus pinea L. Syn.: *P. sativa* Garsault; *P. maderiensis* Ten.; *P. esculenta* Opiz	Stone pine, Umbrella pine	Altitude: 1-600 m. Primarily coastal areas, but also lower mountain slopes. Tolerant to salty and/or desiccating winds.	The Mediterranean coasts of Europe from Spain to Italy. Also in the E Mediterranean and around the Black Sea.	The quality of the wood for sawn timber is poor, being coarse and resinous and seldom straight for any substantial length. Locally used for furniture. The true economic value of this pine has since ancient times mostly resided in the edible seeds. Millions of kilogrammes of seeds or 'pine kernels' are harvested in the Mediterranean countries each year.	EN 350 (2016): Origin: Europe (Italy) Fungi: 5 *Hylotrupes*: D *Anobium*: D
Pinus roxburghii Sarg. Syn.: *P. longifolia* Roxb. ex Lamb., non Salisb.	Chir pine, Long-leaved Indian pine, Sula	Altitude: 400-2300 m. Indigenous in the mild, NS oriented valleys of the mountains and cover large areas. Able to adapt to a great variety of soils but is intolerant of frost.	Foothills and valleys of the great Himalaya Range, from Afghanistan and Pakistan into Bhutan, India and Tibet.	Important pine for resin production in the Himalayan region. Artificial camphor is the main end product in the region; it is also used for medicinal treatments. Wood use: railway sleepers, construction, carpentry and joinery, pulp. The bark has a high tannin content (11-14%) and is used for tanning leather and for staining wood to give it an orange colour.	Scheffer & Morrell: 4, AS, F
Section *Trifolius* Duhamel (42)					
Subsection *Australes* Loudon (24)					
Pinus attenuata Lemmon Syn.: *P. californica* Hartw.; *P. tuberculate* Gordon	Knobcone pine, Narrowcone pine	Altitudes: 300-1700 m. Common in the Coast Mountains of SW USA. Fire adapted.	USA: SW Oregon, Sierra Nevada and coast ranges of California.	Has little or no value as a timber species.	

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
Pinus caribaea Morlet Syn.: *P. recurvata* Rowlee	Caribbean pine, pitch pine	Altitude: up to 300 m, seldom above. Lowland areas. Can grow on extremely poor limestone or sands. Gras and bush fires are extremely frequent in the dry season.	Occurs in disjunct areas on several islands in the Caribbean and on the mainland in Central America.	Important timber species. The heavily resinous wood is used for building, crates, pallets, boat decks, poles and posts, plywood, and particleboard, and pulp. BRE (1998): Used for vat making, boat decking, masts, spars and temporary bulkheads. Often seen as panelling and interior joinery in old buildings.	BRE (1998): Resistance to insects: Damage by ambrosia (pinhole borer) beetles occasionally present Natural durability: Moderately durable EN 350 (2016): Origin: C. America Fungi: 3 *Hylotrupes*: D *Anobium*: D Scheffer & Morrell: 3-4, AM, L
*Pinus cubensis Griseb. Syn.: *P. maestrensis* Bisse	Cuban pine	Altitudes: 100-1200 m. In foothills and highlands as well as in 'pine barrens' along the coast. Mostly pure but open stands or is invasive in disturbed sites on serpentine or serpentine-derived, often ferruginous soils or on alluvial sediment near the coast.	Endemic to eastern Cuba.	The only pine occurring in the eastern part of Cuba and as such of economic importance as a timber source to this part of Cuba	

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
Pinus echinata Mill Syn.: *Pinus viginiana* Mill. var *echinate* (Mill.) Du Roi; *P. taeda* L. var. *echinata* (Mill.) Castigl.; *P. squarrosa* Walter; P. taeda var. *variabilis* Aiton; *P. variabilis* Aiton) Lamb; P. mitis Michx.; *P. rolyeana* Jamieson ex Lindl.	Shortleaf pine	Altitudes: 150-600 m. Lowland tree. Primarily grows on sandy, gravelly, well-drained soils and avoiding lime.	Common in many parts of the eastern USA: NY, MA, NJ, PA, OH, KY, MO, OK, TX and GA.	Important commercial conifer species in the SE USA. It is used for railway sleepers, construction lumber, indoor finishing like panelling, plywood, furniture, and kraft pulp and dissolving pulp. Most of the plantation timber goes to pulping.	EN 350 (2016): N. America Fungi: 3 *Hylotrupes*: D *Anobium*: D
Pinus elliottii Engelm. Syn.: *P. taeda* L. var. *heterophylla* Elliot]	Slash pine, pitch pine	Thrives in wetlands such as sandy islands. Warm temperate to subtropical.	SE USA: SC, GA, AL and FL.	A main source for naval stores, a term used first by the English for course resin products used in the navy to make wooden ships waterproof and tar the rigging. Plantation trees are still tapped for resin up to 20 years of age, after which the timber is harvested for the pulp industry, yielding sulfate turpentine as a by-product. Other uses: roundwood for poles and posts	EN 350 (2016): N. America Fungi: 3 *Hylotrupes*: D *Anobium*: D Cultivated in C/N. America Fungi: 4 *Hylotrupes*: D *Anobium*: D
Pinus glabra Walt.	Spruce pine, Poor pine	Altitudes: sea level-150 m. Lowland tree. Warm temperate to subtropical. Well adapted to moist environment.	USA: From SC through GA and NW FL as far as the mouth of Mississippi River in LA.	The quality of its timber is poor, the wood is brittle and not durable while the scattered occurrence of this species also discourages exploitation on a large scale.	
Pinus greggii Engelm. ex Parl	Gregg's pine, pino prieto	Altitudes: 1300-2700 m. In cool highlands. In the north mainly on alkaline soils, in the south predominantly on acid soils. Indications of adaptation to fires.	Occurs in the Sierra Madre Occidental in Mexico.	Although locally exploited with other pines, it is not specifically in demand as a timber tree in Mexico.	

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
Pinus herrerae Martínez	Herrera pine, ocote, pino chino	Altitudes: 1500-2600 m. Mountain pine growing scattered among other pines in mixed pine forests or pine-oak forests.	In W Mexico, in the Sierra Madre Occidental, more abundant in the Sierra Madre del Sur.	Along with other tall growing pines (heavily) exploited for timber throughout almost all of its range.	
Pinus lawsonii Roezl ex Gordon	Lawson pine, Lawson's pine	Altitude: 1300-2600 m. Temperate to warm temperate montane forest or woodland, most commonly in pine-oak forest, but also found in pine forest with various other species of *Pinus*.	Scattered distribution in S Mexico, from the Eje Volcánico Transversal south to the mountains of Oaxaca.	Along with other pines cut commercially for lumber, although most trees are of medium size and the boles sometimes tortuous. Resin tapped as well.	
Pinus leiophylla Schiede ex Schltdl. et Cham.	Smooth-leaved pine, Chihuahua pine	Altitude: 1800-3000 m. Wide-spread constituent of the montane to high montane pine and pine-oak forests.	Volcanic mountain ranges of Mexico.	Heavily exploited for timber in the latter half of the 20th century. Due to its high resin content it does not provide high quality wood but at the same time is a producer of good resin. Wood uses: heavy construction, crates and boxes.	
Pinus lumholtzii B.L. Rob. Et Fernald	Lumholtz pine, ocote dormido, pino Amarillo, pino lacio, pino triste, pino barba caida	Altitude: 1600-2700 m. Subtropical climate. Only in small scattered populations.	Grows on the W side of the Sierra Madre Occidental in Mexico.	Due to its scattered occurrence it is not a commercially important tree.	
Pinus muricata D. Don Syn.; *P. remorata* H. Mason: *P. muricata* var. *borealis* Axelrod ex Farjon; *P. muricata* var. *stantonii* Axelrod ex Farjon	Bishop pine	Altitude: sea level-300 m. Well adapted to strong, prevailing sea wind. Grows within the chaparral zone. Adapted to forest fires.	USA: Rocky coast of CA. Two populations in Mexico.	Due to a limited range and small populations it is not a commercially valuable timber species. Wood of medium quality, with a coarse grain and much resin. Uses: heavy construction, beams, crates and some light construction, and carpentry or joinery.	
Pinus occidentalis Swartz	Cuban pine	Altitudes: 100-1200 m. Common on serpentine and often a pioneer after disturbance. Forms "pine	In E Cuba.	Important timber species on its native island Hispaniola. Uses: round wood for poles, fence posts, construction timber,	

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
		barrens" on poor soils in coastal areas.		crates, boxes, pulp, and particleboard. Limited resin tapping for local use only.	
Pinus oocarpa Schiede ex Schltdl.	Egg-cone pine, ocote chino, pino chino, pino Colorado, Ocote pine	Altitude: 500-2400 m. Usually on open, grassy slopes. Indications of adaptation to grass fires in a variety of climatic conditions.	In the mountains of Mexico and southwards as far as Guatemala, Honduras and Nicaragua.	Important timber tree, especially for local and regional markets. Uses: sawn timber, carpentry, joinery and floors in houses, railway sleepers, beams, and poles. The species is also widely tapped for resin.	EN 350 (2016): Origin: C. America Fungi: 3 *Hylotrupes*: D *Anobium*: D Scheffer & Morrell: 3. AM, ?
Pinus palustris Mill. Syn.: *P. longifolia* Salisb.; *P. australis* F. Michx.	Longleaf pine, Florida pine	Altitude: warm temperate to subtropical coastal plain-700 m. Requires warm humid climate and a moist soil. Well adapted to fire.	SE of the USA: NC, SC, GA, AL, LA, MS and FL. Small populations in VA and TX.	Important species providing good quality timber as well as naval stores derived from its resin. Uses: sawlogs, stage flooring, plywood, pulpwood, poles, fence posts, and piling as it makes straight stems largely free of branches when grown in closed stands.	EN 350 (2016): Origin: N. America Fungi: 3 *Hylotrupes*: D *Anobium*: D Scheffer & Morrell: 1-3, TA, L
Pinus patula Schiede ex Schltdl. et Cham.	Jelcote pine, Spreading-leaved pine, ocote, pino, piono triste, Patula pine	Altitude: 1800-3000 m. Warm to temperate highlands.	Common in a relatively limited area of S-central Mexico.	One of the most important pines for timber in Mexico, as it grows fast and produces a long, straight bole, for the most part free of branches. Uses: flooring, panelling, plywood, particleboard, veneers, crates, boxes, and pulp.	Scheffer & Morrell: 4, AM, ?
Pinus pringlei Shaw	Pringle pine, Pringle's pine, pino rojo	Altitude: 1500-2700 m. Subtropical mountains.	S Mexico.	Dense wood; used for lumber; the resin is also tapped commercially.	
Pinus pungens Lamb.	Table Mountain pine, Prickly pine	Altitude: 500-1300 m. A true pioneer species. Very tolerant to bright sunlight and resistant to dry and warm conditions.	USA: Common in the Appalachian Mountains and Piedmont, also found in NJ, PA, DE, MD, VA, TN, NC, SC, N GA.	Low value as a timber tree due to small size and 'poor' form, with crooked stems and long branches. Uses: Pulp.	

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
Pinus radiata D. Don Syn.: *P. tuberculate* D. Don; *P. insignis* Douglas ex Loudon; *P. sinclairii* Hook et Arn.	Monterey pine	Altitude: sea level-400 m. Usually found on exposed, infertile and rocky terrain, growing in the fog zone along the coast. Appears to be resistant to salt spray and sea wind.	Native to a small area in California and Mexico. However, it is extensively cultivated for timber throughout the world.	The most widely planted tree species in the world due to its spectacularly rapid growth under plantation conditions. The wood is rather brittle, coarse grained, and most suitable for pulp wood. Other uses: construction, carpentry and joinery, veneers, furniture, laminated wood, and crates and boxes.	BRE (1998): Resistance to insects: Damage by ambrosia (pinhole borer) beetles and by longhorn beetles is occasionally present. The timber is recorded in New Zealand as susceptible to attack by the common furniture beetle, A*nobium punctatum* Natural durability: Non-durable EN 350 (2016): Origin: Cultivated in Brazil, Chile, Australia, New Zealand, S Africa

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
					Fungi: 4-5 *Hylotrupes*: D *Anobium*: S Scheffer & Morrell: 4, AS, F
Pinus rigida Mill. Syn.: *P. taeda* L. var. *rigida*	Pitch pine, Hard pine, pin rigide	Altitude: sea level-1400 m. Usually on poor soils, well drained or nearly waterlogged. Adapted to fire. Readily occupying open waste land.	Canada: ON, QC; USA: New England states south to GA, OH and KY. Retreats from the coast to the Appalachian Mountains.	It is of limited commercial value because it is coarse and resinous, of small or moderate size and often not straight for any considerable length except in planted stands. Uses: rough construction. The high resin content makes it decay resistant, a property which was made use of in past ship building and more recently railway sleepers.	
Pinus serotina Michx. Syn.: *P. rigida* Mill. var. *serotina* (Michx.) Loudon ex Hoopes	Pond pine	Altitude: sea level-100 m. Predominantly sandy flats or swampy areas on the coastal plains of the Atlantic Ocean seaboard.	SE USA from NJ, VA along the Atlantic coast as far as N FL w to AL.	Becoming increasingly important as pulp wood, because coarse grained and resinous, the tree only attains modest size and is often crooked or divided into long branches at two thirds of its height.	
Pinus taeda L. Syn.: *P. lutea* Walter	Loblolly pine	Altitude: sea level-450 m. Warm temperate regions. Lowland species. In the SE USA it is well adapted to a wet environment. Along the Gulf of In Mexico it grows well on low, sandy knolls and islands, dense stands, predominantly in pioneer vegetation. In GA, KY and SC USA it extends to the uplands on dry ground, partly helped by plantations.	SE USA: Atlantic Coast Plain, from NJ south to FL and westward along the Gulf coast as far as TX, also northward into Mississippi Valley. Planted in recent decades in AR, LA and MS. Fast growing and appears to regenerate and spread spontaneously.	Commercially, the most important pine of the S USA. Its sawn wood properties are not of sufficient quality to be used in high grade construction and manufacture, and its fast growth and great volume is consequently put mainly to the wood pulp industry for paper and other long-fibre products.	EN 350 (2016): Origin: N America Fungi: 3 *Hylotrupes*: D *Anobium*: D Origin: Cultivated in C/N America *Fungi:* 4 *Hylotrupes*: D *Anobium*: D Scheffer & Morrell: 3-4, TA, L

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
Pinus tecunumanii Eguiluz et J.P. Perry Syn.: *P. oocarpa* var. *ochoterenae* Martínez; *P. patula* subsp. *tecunumanii* (Eguiluz et J.P. Perry) Styles	No English or Spanish name	Altitude. 500-2500 m. Subtropical to tropical mountains. Fires play a natural role in maintaining the pines against the angiosperms.	Mexico, Guatemala, Belize, Honduras, El Salvador, and Nicaragua.	Important timber tree in C America. Largely exploited for sawn timber in its native range; potentials for wood pulp production are considered to be high if it was to be grown extensively in plantations.	
Pinus teocote Schiede ex Schltdl. et Cham. Syn.: *P. teocote* var. *macrocarpa* Shaw	Aztec pine, Teocote pine, pino chino, pino Colorado, pino real pino rosillo	Altitude: 1500-3000 m. Highlands of Mexico.	Most commonly and abundantly in the S half of Mexico but extends northward in both the Sierra Madre Occidental and Sierra Madre Oriental. One of the most widely distributed pines of Mexico.	Of importance as a timber species. Apparently due to its moderate size resin production may locally count as the more important mode of exploitation. Uses: sawn timber, railway sleepers, coarse construction work, containers, crates, particleboard, and pulp.	
Subsection *Ponderosae* Loundon (14)					
Pinus arizonica Engelm. Syn.: *P. ponderosa* var. *arizonica* (Engelm.) Shaw	Arizona pine	Altitudes: 1300-3000 m. In mountain forests of mixed pines and oaks. Temperature generally cool.	SW USA: more widespread in the Sierra Madre Occidental of Mexico.	In Mexico a major timber species. Use areas are similar to *P. ponderosa*.	
Pinus coulteri D. Don	Coulter pine, Bigcone pine	Altitudes: up to 2200 m. In dry locations in the foothills and mountains. Often loamy, rocky soils and even bare granite boulders. Optimal growth in the Coast Ranges where fire is less frequent than at lower elevations.	USA: CA; Mexico: Sierra Juárez and Sierra San Pedro Mártir.	Uses: window frames, doors, stairs, flooring, sidings, panelling, veneers, furniture, cabinetwork, boxes, and woodware.	
Pinus devoniana Lindl. Syn.: *P. macrophylla* Lindl.; *P. montezumae* Lamb. Var macrophylla (Lindl.) Parl; *P. michoacana* Martínez	Michocan pine, pino blanco, pino lacio	Altitudes: 900-2500 m. Often on volcanic soils. In warm temperate to subtropical, moist climate with a long drying season. Most common in open pine-oak forests. Well adapted to grass and bush fires.	Mountains of C and S Mexico; highlands of Guatemala.	Not often selected as a timber species. Local uses: fence posts, boxes, furniture, toll handles, and other woodware.	

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
Pinus douglasiana Martínez	Douglas pine, ocote, pino hayarín	Altitudes: 1400-2500 m. Common in mixed pine forests and pine-oak forests in the mountains.	Mountains of SW Mexico.	Important timber species in most of its range.	
Pinus durangensis Martínez Syn.: *P. martinezii* E. Larsen	Durango pine, ocote, pino blanco, pino real	Altitudes: 1500-3000 m. Associates with other species of its genus in the "Yellow pine belt" of Sierra Madre Occidental.	Occurs scattered throughout the Sierra Madre Occidental in Mexico.	Important timber species. The timber is used for construction such as roof beams, general carpentry, furniture, floors, and plywood.	
Pinus engelmannii Carrière Syn.: *P. macrophylla* Engelm.; *P. ponderosa* Douglas ex C. Lawson var. *macrophylla* (Engelm.) Shaw; *P. latifolia* Sarg.; *P. mayriana* Sudw.; *P. apacheca* Lemmon	Apache pine, pino real	Altitudes: 1500-2800 m. Grows on a variety of soils, both of volcanic and sedimentary origin. In open pine woodland or pine-oak forest.	USA: AZ and NM; Mexico: south to the Sierra Madre Occidental.	Commonly logged, but not specifically selected as a timber species. Wood properties and uses similar to those of *P. ponderosa* and *P. jeffreyi*.	
Pinus hartwegii Lindl. Syn.: *P. montezumae* Lamb. subsp. *hartwegii* (Lindl.) Engel.; P. *montezumae* var. *hartwegii* (Lindl.) Shaw; *P. rudis* Endl.; *P. montezumae* var *rudis* (Endl.) Shaw; *P. donell-smithii* Mast.	Hartweg's pine, ocote, pino	Altitudes: 2500-4000 m. High altitude pine of Mexico and Central America. Dominate on higher slopes of the large volcanos.	Occurs from isolated mountains in northern Mexico throughout central Mexico to the highlands of Guatemala and a few isolated mountain summits in Honduras.	Fairly dense, but resinous wood. Exploited as a timber species where stands are extensive and accessible. Uses: round wood for posts and sawn for construction or railway sleepers, and pulp.	
Pinus jeffreyi Balf. Syn.: *P. ponderosa* var. *jeffreyi* (Balf.) Vasey; *P. ponderosa* subsp. *jeffreyi* (Balf.) Engelm.	Jeffrey pine, Jeffrey's pine	Altitudes: 1000-3000 m. Grows in mountains.	USA: From southern OR across the entire length of the Sierra Nevada CA, with more scattered populations in the mountains	Important timber species. Very similar to *P. ponderosa* in its wood properties. The timber industry does not differentiate the wood from the two species;	

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
			further south as far as northern Baja California in Mexico.	details are therefore given under *P. ponderosa*.	
Pinus maximinoi H.E. Moore Syn.: *P. tennifolia* Benth., non Salisb.; *P. pseudostrobus* var. *tennifolia* (Benth.) Shaw	Thin-leaf pine; ocote, pinocanís	Altitude: 500-2800 m. In a wide range of forest types from wet subtropical forest to much drier pine or pine-oak woodland.	From C Mexico throughout the highlands of S Mexico into Guatemala, Honduras and parts of El Salvador and Nicaragua.	Important timber species in most of its range. The wood is relatively soft and light. Uses: construction (beams and planks), carpentry and joinery, crates, containers and boxes, woodware, tool handles, and matches, as well as various types of board, plywood and pulp.	
Pinus montezumae Lamb. Syn.: *P. occidentalis* Kunth, non Sw.; *P. russelliana* Lindl.	Montezuma pine, Rough-branched Mexican pine, ocote blanco, pino de Montezuma pino real	Altitude: 1200-3500 m. In a wide range of habitats throughout the mountains of C and S Mexico, from semi-arid pinyon-juniper woodland up to cold temperate mixed conifer forest.	Mexico and reaches into the W highlands of Guatemala.	Exploited as a timber species throughout its range.	
Pinus ponderosa Douglas ex C. Lawson Syn.: *P. benthamiana* Hartw.; *P. parryana* Gordon; *P. washoensis* Mason & Stockw.	Ponderosa pine, Western Yellow pine, California white pine, British Columbia soft pine	Altitude: lowlands-3300 m. Found in very different habitats. Common and abundant in the "yellow-pine belt" of high mountains.	Widely distributed in the American W, from S British Columbia and Alberta in Canada eastwards to the Black Hills of SD, further south to the Rocky Mountains as far as the Mexican border. In the W abundantly in WA, OR, ID, CA.	Uses: Material for boxes and packing, timber for building, general carpentry, sleepers, poles and posts. The timber is heavy and strong and in demand for constructional purposes, plywood, parquet flooring, and furniture. Together with the wood of other pines it is pulped for the paper industry.	BRE (1998): Resistance to insects: Damage by ambrosia (pinhole borer) beetles, longhorn and Buprestid beetles is occasionally present Natural durability: Non-durable Scheffer & Morrell: 2-4, TA, L
Pinus pseudostrobus Lindl. Syn.: *P. orizabae* Gordon, *P. pseudostrobus* var. *estevezii* Martínez; P. estevezii (Martínez) J.P.	Weymouth pine, Smooth-bark Mexican pine, pino blanco, pino chalamaíte, pino lacio, pino liso	Altitude: 1900-3000 m. Ranging from temperate latitudes into the tropics at high elevations. Thrives in moist climate.	Common pine in the mountain pine forests of Mexico, further in Guatemala, El Salvador and Honduras.	One of the most common and important 'hard pines' in the southern half of Mexico, the highlands of Guatemala, and parts of Honduras. Uses: light construction, carpentry and	

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
Perry; P. nubicola J.P.Perry; P. yecorensis Debreczy et RáczFalsw				joinery, wall panelling, veneers, boxes and containers, matches, and wood pulp. In Mexico, this species is also used as a source of resin.	
Pinus sabineana Douglas ex D. Don	Digger pine, Grey pine, Bull pine	Altitude: 50-1800 m. Summer-dry foothills and mountains.	USA: Native to CA, in the mountains around the Central Valley.	Little value as a timber species. The wood, because of its irregular size and shape and high resin content, is only used for railroad sleepers, pallets and wood chips.	
Pinus torreyana Parry ex Carrière	Torrey pine	Altitude: sea level-180 m. In a few locations along the rocky coast of the Pacific Ocean in CA, USA. Depends on daily fog from the ocean. On dry, eroding slopes or in rocky ravines facing the ocean.	A very rare pine. USA: Naturally occurring in only two localities on the coast of S CA, near Del Mar (San Diego County) and on Santa Rosa Island (Santa Barbara County).	Rare and not used as a timber species.	
Subsection *Contortae* Little et Critchfield (4)					
Pinus banksiana Lamb. Syn.: *P. hudsonica* Poir.: *P. rupestris* F. Michx.	Jack pine, Black pine, Princess pine	Altitudes below 800 m. Lowland pine. On sandy well-drained soil. Not in steep terrain. Extremely cold winters in much of its region. Succession species after fire and in drying bogs and the transition zone between taiga and tundra.	N America: Occupies a large area from the Mackenzie River and Great Bear Lake in the Northwest Territories, through subarctic Canada as far east as Newfoundland and Nova Scotia, southwest to British Columbia and Alberta, and also the NE part of the US, especially around the Great Lakes.	Despite its relatively small size, Jack Pine is an important source of pulpwood, lumber and round timber, mainly because it is the most widely distributed pine species in Canada and its pioneer ecology guarantees even-aged stands with high yields per ha even under natural conditions. Uses: carpentry and joinery, containers, pallets, crates, and particle-board.	BRE (1998): Resistance to insects: NA Natural durability: Non-durable Scheffer & Morrell: 3-4, TA, L
Pinus clausa (Champ. ex Engelm.) Sarg. Syn.: *P. inops* Aiton var. *clausa* Chapm. ex Engelm.: *P. clausa* var. *immuginata* D. B. Ward	Sand pine, Florida spruce pine	Altitudes: sea level-60 m. Mesotrophic, sandy soils away from swamps and eutrophic rivers. Succeeds after fires on sandy soils.	USA: Abundant in C and N FL and along the coast of the Mexican gulf, westwards to AL.	Is of some value as a timber species only in plantations, where it can give a reasonably high yield for the pulp wood industry.	

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
Pinus contorta Dougl. Ex. Loudon	Lodgepole pine, Tamarack pine	Altitudes: sea level-3350 m. Adapted to forest fires in the mountains.	From Yukon Territory and the coastal areas of S Alaska and British Columbia, E into Northwestern Territories and Alberta. USA: Rocky Mountains to the Cascades and the Sierra Nevada CA. Widest distribution of all North American pines. Second in extent of pines, only to the Eurasian *P. sylvestris*.	Major timber tree in western N America. Uses: similar to *P. sylvestris*, but mass production is for the pulp industry or increasingly the manufacture of structural particleboard. BRE (1998): Extensively used on the E slopes of the Rockies. Primarily used for railroad sleepers, mining timbers, transmission and poles and fencing.	BRE (1998): Resistance to insects: Damage by ambrosia (pinhole borer) beetles, longhorn and Buprestid beetles is sometimes present Natural durability: Non-durable EN 350 (2016): Origin: N America, cultivated in Europe Fungi: 3-4 *Hylotrupes*: D *Anobium*: D Scheffer & Morrell: 3-4, TA, L
Pinus virginiana Mill. *P. inops* Aiton; *P. turbinate* Bosc ex Loudon	Virginia pine, Scrub pine	Altitude: sea level-300 m. In lower parts of the Appalachian Mountains to about 800 m. Does very well in very poor soil but avoids calcareous substrates. On sandy, nearly sterile land and invades abandoned fields.	USA: Common on the Atlantic Coastal Plain. Occurs from NY as far as GA. More scattered to the W, found as far as IN and KY in the N. N AL and MS in the south.	Foresters dismissed this species as 'weedy' in the past, but it has the capacity to grow upright to a moderate size, especially when planted on abandoned farmland and former coal strip mines. Uses: rough lumber and pulpwood; also important as a Christmas tree.	
Subgenus *Strobus* Lemmon (38)					

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
Section *Parrya* Mayr (13)					
Subsection *Balfourianae* Engelm. (3)					
Pinus aristata Engelm. Syn.: *P. balfouriana* subsp. *aristata* (Engelm.) Engelm.	Colorado bristlecone pine, Hickory pine	Altitudes: 2500-3500 m. Subalpine to alpine zones. On extremely exposed ridges and slopes. Individual trees estimated to exceed 3000 years of age.	USA: Rocky Mountains of CO and NM. San Francisco Mountains of northern AZ.	Primary use is research study, particularly dendrochronology and climatic conditions during the late Holocene.	
Pinus balfouriana Balf.	Foxtail pine	Altitudes: 1600-2400 m in the north, 2900-3700 in the south. Subalpine to alpine species. Mainly in dry and rocky places. Individual trees can reach a very great age.	USA: Two separate (meta) populations: the Siskiyou Mountains of N CA and the Sierra Nevada CA.	Not a timber tree due to extremely slow growth and general inaccessibility of the stands of relatively small trees.	
Pinus longaeva D.K. Bailey Syn.: *P. aristata* var. *longaeva* (D.K. Bailey) Little; *P. balfouriana* subsp. *longaeva* (D.K. Bailey) E. Murray]	Intermountain bristlecone pine, Great Basin Bristlecone Pine	Altitude: 1700-3400 m. Subalpine to alpine species. Xerophyte, adapted to extreme conditions and fluctuations of temperature and moisture. Often in bare, rocky ground.	USA: Occurs on isolated mountain summits and ridges in the Great Basin of SW: W UT trough NV to E CA.	Main use: Christmas trees, though most harvesting or wood gathering is now prohibited. Invaluable to dendrochronologists, by virtue of providing the longest continual and climatically sensitive tree-ring chronologies available.	
Subsection *Cembroides* Engelm. (6)					
Pinus cembroides Zucc.	Pinyon pine, Mexican nut pine, piñón	Altitudes: not provided. Adapted to aridity. Occurs on the fringes of (semi-)deserts and on arid plateau.	From ID and UT USA to Puebla in southern Mexico.	Although not a timber species in most areas due to its low stature and low and heavy branching, it is nevertheless an economically important species of pine in Mexico. Its principal value locally is the edible seeds	

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
				(piñones). Further uses: carpentry, timber.	
Pinus culminicola Andresen et Beaman	Cerro Potosi pinyon, piñón	Altitude: 3000-3700 m. Below or on the summits of some of the highest mountains in the region. Alpine or subalpine dwarf conifer. Adaptations to snow drifts, blasting by ice- or sand-laden winds and very short growing season. Mostly on calcareous rocky soil.	Rare pine who occupies a very restricted area of the Mexican Highlands.	This rare species is not used commercially.	
****Pinus edulis*** Engelm.	Pinyon pine, Colorado pinyon, two-needle pinyon pine	Altitude: 910-3200 m. Widely distributed in the interior basins, plateaus, mesas and mountains of the 'Four Corner' States of the USA. Soils are commonly thin to sceletal or may be absent altogether, with the trees growing from fissures in the sandstone, limestone, or shale.	Recorded from SW USA: AZ, S CA, CO, NM, W OK, NV TX, UT, and S WY.	Has a higher than average heat value and burns with a distinctive aroma.	
****Pinus monophylla*** Torr. & Frém. Syn.: *P. californiarum* D.K.Bailey	Single leaf pinyon pine, one-leaved nut pine, piñon	Altitude: 950-300 m. Common on the dry mountain slopes of the Great Basin.	USA: AZ, CA, ID, NV, UT, W CO, SW NM and Mexico (Baja California Norte).	Due to its irregular shape and slow growth, this tree is not used for lumber.	
****Pinus quadrifolia*** Parl. ex Sudw.	Parry Pinyon, Nut Pine	Altitude: 900-2700 m. Grows between the semi-desert and the chaparral scrub zones and the mixed coniferous forest on the highest parts of the mountains. Often grows in cracks among boulders.	USA: CA and Mexico: Baja California Norte.	There is no use of this species for timber.	
****Pinus remota*** (Little) D.K.Bailey & Hawksw. Syn.: *P. catarinae* Rob.-Pass.; *Pinus cembroides* Zucc. var. *remota* Little; *P. culminicola* Andresen & Beaman var. *remota* (Little) Eckenwalder	Texas pinyon pine, nut pine	Altitude: 450-1850 m. Has retreated to isolated mountains. Restricted to canyons or rocky mountain slopes, often on calcareous soil or limestone rock.	Mexico: NE and SE Chihuahua, Coahuila, and extreme W Nuevo León and the USA: TX.	Any use of this species is probably incidental or at most on a very small scale.	

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
Subsection *Nelsoniae* Van der Burgh (1)					
Pinus nelsonii Shaw	Nelson Pinyon pine, Nelson's pine, piñon prieto	Altitude: 1600-2400 m. On rocky limestone with shallow soils.	Restricted to a few localities in the desert mountain ranges of Mexico.	There is no commercial exploitation of this species due to its low stature and its rarity in remote and inaccessible locations.	
Subsection *Rzedowskianae* Carvajal (3)					
Pinus maximartinezii Rzed.	No English name. piñon real	Altitude: 1800-2400 m. On mountains together with deciduous oaks. E flanks and ridges.	Strictly endemic to one locality in Mexico, near the village of Pueblo Viejo in Zacatecas.	Due to its low stature and branching of the trunk, its timber is not used. Like other 'piñon' (pinyon pines) in Mexico, this species is of local importance for its nutritious, edible seeds.	
Pinus pinceana Gordon Syn: *P. latisquama* Engelm.	Pince's pine, Weeping Pinyon pine, piñón	Altitude: 1400-2300 m. On calcareous slopes and in ravines in arid or semi-arid mountains. Often widely scattered.	Most common in N Mexico.	As this species only forms a small tree or large shrub, its timber has limited use.	
Pinus rzedowskii Madrigal et M. Caball.	Rzedowski's pine	Altitude: 2100-2400 m. Rare species restricted to a few localities where eroded limestone outcrops protrude from ancient volcanic formations in a mountain region. Fires are a treat.	Occurs at three localities in the Sierra Madre del Sur, Michoacán, Mexico. All within 40 km of each other.	No uses are recorded of this species. It is a botanical rarity.	
Section *Quinquefolius* Duhamel (25)					
Subsection *Kempfianae* Little et Critchfield (1)					
Pinus krempfii Lecomte Syn.: *Ducampopinus kempfrii* (Lacomte) A. Chev.; *P. kempfrii* var. *poilanei* Lecompte	Kempf's pine	In temperate highlands. Occupies steep slopes and ridges. Predominantly in well-drained, low-pH lateritic clay soils. Survival strategy is	Endemic to Vietnam and three major populations restricted to the Da Lat Plateau between Da Lat and Nha Trang and north of Nha Trang.	The timber is thought to have similar qualities to that of *P. kesiya* but rare and not heavily exploited. Current legal	

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
		based on regeneration after episodic disturbance of the angiosperm forest by fire.		protection forbids commercial exploitation.	
Subsection *Strobi* Loudon (21)					
Pinus albicaulis Engelm.	Whitebark pine	Altitude: 1350-3650 m. An exclusively subalpine species. Famously co-evolved with a mountain bird, Clark's nutcracker (*Nucifraga columbiana*)	Canada: BC; USA: ID, MT, WY, NV, WA, OR, CA	Less than 1,000 acres in the USA are harvested each year, typically within a timber sale for *P. contorta*.	
****Pinus amamiana*** Koidz. Syn.: *P. armandii* Franch. var. *amamiana* (Koidz.) Hatus.	Amami pine, amami goyo, yakutane-goyo	Altitude: 50-900 m. In exposed, open stands in often sparsely vegetated localities on rocky slopes.	Japan, Kyushu (Yaku-shima, Tanega-shima). It is known from two locations.	No recent uses have been recorded. In the past its timber was exploited for construction, carpentry and wooden canoes.	
Pinus armandii Franch. Syn.: *P. levis* Lemée et Lév.; *P. excelsa* Wall. ex. D. Don var. *chinensis* Patschke	Armand's pine; hua shan song	Altitude: 1000-3500 m. In mountains. Seldom in pure stands. Often in rocky areas.	China: Gansu, Guizhou, Hainan, Henan, Hubei, Shaanxi, Shanxi, Sichuan, Xizang, Yunnan; and Myanmar.	As a timber tree it is of limited value and exploited only for local use. A notable ornamental tree in China.	
Pinus ayacahuite Ehrenb. ex Schltdl.	Mexican White pine, acalote, ayachuite, ocote gretado, pinabete, pino gretado	Altitude: 1900-3200 m. Highlands of S Mexico and C America. In mixed montane conifer forests on mesic sites.	From C Mexico south to the highlands of Guatemala, Honduras and El Salvador.	Very important and highly sought-after timber species. The wood is used for construction, carpentry, furniture and utilities such as containers, pallets and crates as well as wood pulp.	
****Pinus bhutanica*** A.J.C.Grierson, D.G.Long & C.N.Page *	Bhutan pine, Bhutan white pine	Altitude: 1000-2750 m. Occurs in warm temperate zone.	Bhutan; China: Tibet, Yunnan, India: Arunachal Pradesh.	The uses as a timber tree are unknown.	
Pinus cembra L. Syn.: *Pinus montana* Lam., non Mill.	Arolla pine, Swiss stone pine, Arve, Zirbel Google: Zirbel-Kiefer, Zirbelkiefer, Zirbe, Swiss pine, Austrian stone pine, Stone pine, Le pin cem	Altitude: 1200-2600 m. High mountain to subalpine. This species is dependent on the European nutcracker (*Nucifraga caryocatactes*) for seed disposal.	High mountains in Europe: Swiss Alps, Tirol of Austria, the High Tatra between Poland and the Slovak Republic. Scattered in the eastern Carpathians.	Not a significant timber tree due to its slow growth and commonly curved or contorted shape. The wood has been used for the building of traditional houses and is valued for special uses such as joinery, panelling, cabinet making, tools, and woodturning.	

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
Pinus dalatensis Ferré Syn.: *P. wallichiana* A. B. Jacks. var *dalatensis* (Ferré) Silba	Dalat pine	Altitudes: 1400-2300 m. Mountain pine growing in tropical climate. Mostly occupying rocky outcrops or ridges and adjacent slopes.	S and C Vietnam and the Ngoc Linh Mountains.	This species is not directly exploited, probably due to its rarity.	
Pinus fenzeliana Hand.-Mazz. Syn.: *P. parviflora* Siebold et Zucc. var. *fenzeliana* (Hand.-Mazz) C.L. Wu; *P. kwangtungensis* Chun et Tsiang; *P. wangii* var. *kwangtungensis* (Chun et Tsiang) Silba; P. kwangtungensis var. *varifolia* Nan Li et Y.C. Zhong; *P. wangii* subsp. *varifolia* (Nan Li et Y.C. Zhong) Businský	No English name, hai nan wu zhen song, hua nan wu zhen song	Altitudes: 500-1600 m. Scattered in warm temperate to subtropical mountains.	N Vietnam; China: Anhui, Guangdong, Guangxi, Hainan, Henan, Hubei, Sichuan and Yunnan.	Will yield excellent timber for construction, carpentry and perhaps furniture making. Uses are presumably local only, as there are no great quantities of it anywhere.	
Pinus flexilis E. James	Limber pine, Rocky Mountains White pine	Altitudes: 1000-3700 m. Subalpine zone in the eastern ranges of the Rocky Mountains. At or near the tree line or in exposed places the tree is prostrate and shrub-like.	In the Rocky Mountains from AB in Canada through the USA to south of the Mexican border. Also in the Sierra Nevada and the White Mountains of CA.	The wood is not of high quality. For timber the species is of minor importance due to its occurrence at high altitudes, where it is generally inaccessible and most of the trees do not grow into straight boles. Locally, it was heavily used for railroad ties and mine shaft construction in 'pioneer times'.	
Pinus koraiensis Siebold et Zucc.	Korean pine, hong song	Altitude: 200-600 m in the Russian Far East, in Japan up	Widely distributed in the NE China, in Russian Far East, N and S Korea and in Japan.	Highly important timber species. Timber is of good quality, light and soft, straight	

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
Syn.: P. strobus Thunb., non L.; P. mandschuria Rupr.; P. prokoraiensis Y.T. Zhao et al.; Apinus koraiensis (Siebold et Zucc.) Moldenke; Strobus koraiensis (Siebold et Zucc.) Moldenke		to 2500 m. In dry places among broadleaf trees.		grained and easy to work with in milling and carpentry. Uses: poles, railway sleepers, bridges, and boat building, construction, building timbers, flooring, furniture, sports equipment and musical instruments, plywood and veneers, particleboard, flakeboard manufacture, and pulp. Resin is extracted from wood pulp and used to produce turpentine and other products.	
Pinus lambertiana Douglas	Sugar pine	Altitudes: 600-2400 m in Sierra Nevada of CA, 2200-2800 m in Mexico. Restricted to the relative moist western slopes of mountain ranges.	N America: On the W coast of the USA from the Cascade Range in N OR, southward as far as the Coast Ranges north of Los Angeles CA, in the Sierra Nevada on western slopes, southward as far as San Pedro Martír Mountains of Baja California in Mexico.	Among the most valuable of the pines due to its enormous size and its light, soft, even-grained, knot-free wood of which very large, straight pieces can be sawn. Consequently, old growth stands of this species command very high prices; many are now protected in National Parks and other reserves. This species is used for high quality construction timber and the finished milled wood of this 'king of pines' makes it ideal for high standard windows and doors as well as foundry casting and even musical instruments such as organ pipes and piano keys. Plantation forestry has not been very successful.	Scheffer & Morrell: 3-4, AS, L
Pinus monticola Douglas ex D. Don Syn.: *P. strobus* L. var. *monticola* (Douglas ex D. Don) Nuttall	Western white pine	Altitude: sea level-3200 m. In rain catching W slopes.	W North America: from southernmost British Columbia throughout the Cascade Range in WA and OR, south to central part of the Sierra Nevada in CA. In E reaches from AB throughout ID and W MT.	Important timber species. Uses: interior construction and panelling, doors and windows of houses, plywood, furniture, matches and toothpicks. BRE (1998): Material for boxes and packing. The timber is also used for building, general	BRE (1998): Resistance to insects: Damage by ambrosia (pinhole borer) beetles a d by longhorn and Buprestid beetles is sometimes

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
				carpentry and when treated for sleepers, poles and posts	present. The timber is recorded in West Indies as susceptible to attack by drywood termites Natural durability: Non-durable Scheffer & Morrell: 4, TA, L
Pinus morrisonicola Hayata Syn.: *P. formosana* Hayata; *P. uyematsui* Hayata; *P. parviflora* Siebold et Zucc. var. *morrisonicola*	Taiwan white pine, tai wan wu zhen song	Altitudes: 300-2300 m. Especially on mountain ridges.	Taiwan: near the coast of mainland China	A minor timber species for local use, with wood properties similar to those of *P. parviflora* and other E Asian white pines.	
Pinus parviflora Siebold et Zucc. Syn.: *P. himekomatsu* Miyabe et Kudô	Japanese white pine	Altitude: sea level-2500 m, optimum between 1000-1500 m. Mountain forests. Both in pure and mixed stands. Usually on steep slopes, dry sites or rocky ridges.	Native in Japan.	Little value as a timber tree, but great value as an ornamental.	
Pinus peuce Griseb. Syn.: *P. excelsa* Wall. ex D. Don var. *peuce* (Griseb.) Beissn.	Balkan pine, Macedonian pine	Altitude: 800-2000 m. Mountain pine. Scattered populations.	SW Balkan Peninsula, Albania, Serbia, N Greece and W Bulgaria.	Valuable timber tree in the Balkans. Local uses: carpentry and furniture.	
Pinus pumila (Pall.) Regel Syn.: *P. cembra* L. var. *pumila* Pall; *P. cembra* subsp. *pumila* (Pall.) Endl.; *P. cembra* var. *pygmaea* Loudon; *P. nana* Lemée et Lev.	Dwarf Siberian pine, Kiedrovnik	Altitude: Kamchatka Peninsula sea level-1200 m, in Japan 1400-3200 m. Well adapted to extreme climate. Especially on exposed mountain slopes close to the summer snow line it forms extensive, dense thickets. Seeds distributed by birds in the family Corvidae.	Widespread in Russia, N Mongolia, and the far NE of China.	Of little economic value since its wood is of small, contorted size and shape.	

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
Pinus sibirica Du Tour Syn.: *P. cembra* L. var *sibirica* (Du Tour) G. Don; *P. cembra* subsp. *sibirica* (Du Tour) Krylov; *P. coronans* Litv.	Siberian pine, Sibirskii kedr	Altitude: 100-2400 m. Both lowland areas along river and in the mountains.	Eurasia: far E of European Russia in the Ural Mountains, in Siberia from the Ural Mountains eastwards beyond Lake Baikal. Just crosses the arctic circle in the N, in S reaches Kazakhstan, N Mongolia and Xingjiang, Nei Mongol and Heilongjiang in China	Is considered inferior in quality to that of *P. sylvestris* and *Picea obovata*. However, it still serves numerous uses, such as roundwood for poles, sawn timber for light construction, carpentry, furniture, veneers, utensils, boxes, wood carving, and musical instruments. The wood is soft, lightweight and rose-coloured with a good texture for finer applications. Trees are also tapped for resin.	
Pinus strobiformis Engelm. Syn.: *P. ayacahuite* var. *brachyptera* Shaw; *P. ayacahuite* var. *novogaliciana* Carvajal	Sothern limber pine, Southwestern white pine, acahuite, pinabete, pino blanco	Altitude: 1900-3500 m.	Predominantly in the northern parts of Mexico, but also in AZ, NM, and TX in the USA. In Mexico relatively abundant in the Sierra Madre Occidental and more scattered in the Sierra Madre Oriental.	Sought after as it is considered to supply wood of good quality for construction and carpentry work. The wood is also considered good for making violins. The resin is used medicinally.	
Pinus strobus L.	Eastern white pine, Weymouth pine	Altitude: above sea level-1500 m. Scattered above 599 m. grows well on a variety of non-calcareous soils.	N America: From Newfoundland in the NE westward as far as Lake Superior, s into WI and Il, then back E to the Atlantic coast of New England, in the Appalachian Mountains south into Sc and GA. *P. strobus* var. *chiapensis* occurs in S Mexico and in the highlands of Guatemala.	One of the most valuable softwood timber in N America. Its fine grained, smooth textured wood low in resin makes excellent construction timbers, while doors and windows, furniture, and matches are other uses.	BRE (1998): Resistance to insects: Damage by ambrosia (pinhole borer) beetles a d by longhorn beetles is occasionally present. It is also susceptible to the common furniture beetle, *Anobium punctatum*, and has been recorded in W Indies as susceptible to attack by drywood termites

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
					Natural durability: Non-durable EN 350 (2016): Origin: N America Fungi: 4 *Hylotrupes*: D *Anobium*: S Scheffer & Morrell: 2-3, TA, L
Pinus wallichiana A.B. Jacks. Syn.: *P. excelsa* Wall. ex D. Don, non Lam.; *P. griffithii* M'Celland, non Parl.	Bhutan pine, Himalayan white pine	Altitude: In the Himalayas to a maximum of 2700 m, in Bhutan it reaches 3400 m. In the valleys and foothills.	Widespread pine in the S and C valleys of the great Himalaya Range, from Afghanistan in W to Myanmar and NW Yunnan in China in the E.	Important timber tree in many parts of the Himalaya.	Scheffer & Morrell: 4, AS, F
****Pinus wangii*** Hu & W.C.Cheng	Maozhi wuzhen song	Altitude: 500-1800 m. Probably restricted to the 'limestone country' where it occurs on steep slopes and limestone ridges, associated with Quercus variabilis and other, mostly small-leaved, evergreen trees and shrubs	Known from four localities in China: Yunnan.	Uses: Locally for house building. Otherwise for construction, carpentry and joinery, wall paneling, veneers, furniture, fences and gates, crates and boxes, and railway sleepers.	
Subsection *Gerardianae* Loudon (3)					
Pinus bungeana Zucc. ex Endl.	Lace-bark pine, bai pi song	Altitude: 500-1800 m. Occurs scattered among other trees in the mountain region of China. Often on limestone rocks on south facing mountain slopes. Widely used for ornamental purposes.	China: Gansu, Henan, Hubei, Shaanxi, Shandong, Shanxi, Sichuan. Potentially introduced.	A decorative tree. Of lesser importance is the use of its timber, but in NE China it is locally a source for roundwood for poles and construction timber, fences and gates, as well as utilities such as boxes, crates and pallets, while more refined applications are in furniture and veneers.	
Pinus gerardiana Wall. ex D. Don	Gerhards's pine, chilgoza	Altitude: 2000-3350 m. In the Himalayas restricted to valley floors between very high	In the Himalayas, NW Punjab and upper valley of the Indus, on the borders of Kashmir, NE	The main economic use of this pine is of its edible, oil-rich seeds. The wood is used locally	

Scientific name	Common name	Ecology	Distribution	Use areas	Durability
		mountain ranges. Prefers dry, sunny slopes.	Afghanistan and N Baluchistan (Pakistan).	for light construction and carpentry.	
***Pinus squamata* X.W.Li	Qiao jia wu zhen song	Altitude: 2100-2200 m.	Endemic to China: Yunnan. Known from a single locality only 4 km^2 in extent.	No uses have been recorded; the species is locally propagated for conservation purposes.	