Interreg Sudoe

EUROPEAN UNION

IMIP_
Innovative Eco-Construction System Based on Interlocking Modular Insulation Wood & Cork-Based Panels

European Regional Development Fund

D1.1.1 PRELIMINARY STUDY ON RENEWABLE AND AUTOCHTHONOUS BIOMATERIALS AVAILABILITY

IMIP-SOE3/P3/E0963

Project funded by the Interreg Sudoe programme through the European Regional Development Funds (ERDF)

PROJECT CONTEXT

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Main authors	Gominho, J.[1]; Miranda, I.[1]
Contributing authors	Brunet-Navarro, P.[2]; Lanvin, J.D.[3]; Luengo, E.[4]; Sánchez-González, M.[5];
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[1] Instituto Superior de Agronomia (ISA), Universidade de Lisboa (Ulisboa)

[2] Universitat Politècnica de València (UPV), ITACA Institute

[3] Institut Technologique Forêt Cellulose Bois-construction Ameublement (FCBA)

[4] Asociación de Investigación Técnica de las Industrias de la Madera (AITIM)

[5] Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)

PARTNERS

Universitat Politècnica de València

Instituto Universitario de las Tecnologías de la Información y Comunicaciones

Information and Communications Technologies versus Climate Change

Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, O.A., M.P - Centro de Investigación FORestal - Departamento de Dinámica y Gestión Forestal (INIA-CIFOR)

Institut Technologique Forêt Cellulose Bois-construction Ameublement (FCBA)

Asociación Clúster de la Construcción Sostenible de Andalucía (ClusterCSA)

Asociación de Investigación Técnica de las Industrias de la Madera (AITIM)

Agencia Andaluza de la Energía (AAE)

Instituto Valenciano de la Edificación Fundación de la Comunitat Valenciana (IVE)

Instituto Superior de Agronomia (ISA)

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Pôle de Compétitivité XYLOFUTUR XYLOFUTUR PROD MAT FORETS CULTIVEES (Xylofutur)

ASSOCIATED PARTNERS

ESPADAN CORKS SLU (EC)

Comité de Développement Forêt Bois Aquitaine (CODEFA)

Observatòri de la Sostenibilitat d'Andorra (OSA)

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CONTENT

SUMMARY

Forests in the SUDOE region

The SUDOE Space comprises the entire territory of Spain and of Portugal and the Southwestern regions of France. The three countries contain 39 million hectares of forest land (39.8 % of the the European Union's area). Forests in **Spain** occupy about 18.6 million of hectares. The conifer species which have the greatest presence are the Aleppo pine (*Pinus halepensis* Mill.), Maritime pine (*P. pinaster* Mill.), Scots pine (*P. sylvestris* L.) and Black pine (*P. nigra* Arnold). The broadleaf species which cover the greatest forest area are the Holm oak (*Quercus ilex* L.), Pyrenean oak (*Q. pyrenaica* Willd.), Pubescent oak (*Q. humilis* Mill.), Eucalyptus (*Eucalyptus* spp.) and Cork oak (*Q. suber* L.). The **French** forest occupies about 17.3 million hectares located mainly in the Mediterranean basin, in the Landes forest, in the East of the country and in the mountainous regions. The main species covering the French territory are oaks, beech (*Fagus sylvatica*), Maritime pine (*P. pinaster* Mill.), Scots pine (*P. sylvestris* L.), Silver fir (*Abies alba*) or Norway spruce (*Picea abies*). Forests in **Portugal** occupy 35% of the territory, about 3.3 million of hectares. The most important tree species are Eucalypt (*Eucalyptus globulus*), Cork oak (*Q. suber* L.) and Maritime pine (*P. pinaster*), with around 72% of the total forest area.

Maritime pine (Table 1) is widely distributed across Spain, where it occupies large areas in Galicia and the Central Iberian and Baetic mountain systems, and it is widely distributed in the northern plateau. In Portugal, Maritime pine is the third most important native forest species, mainly located at the Central, Northern, Lisbon and Tagus Valley regions. In France, Maritime pine habits in the Southwest, mainly in the Landes de Gascogne forest.

The **Aleppo pine** (Table 2) is a native tree species widely distributed in the SUDOE region where it is dominant mainly in Mediterranean climate forests. In Spain, the Aleppo pine is widespread mostly in western part of the Mediterranean basin and In France, the Aleppo pine is mainly located in Provence-Alpes-Côte d'Azur region.

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The natural forests of **Black pine** (Table 3) in the Iberian Peninsula are restricted to Spain. In France, Black pine is found in a few isolated populations in the Pyrenees and Cévennes regions.

Table 1. Area, growing stock and industrial roundwood production of Maritime pine in the three main countries of the SUDOE region.

	Area (million ha)	Growing stock (million m^3)	Industrial roundwood production (million m^3)
Spain	1.1	153.6	3.3
France	1.0	143.0	6.9
Portugal	0.7	63.9	3.8

Table 2. Area, growing stock and industrial roundwood production of Aleppo pine in the three main countries of the SUDOE region.

	Area (million ha)	Growing stock (million m^3)	Industrial roundwood production (million m^3)
Spain	2.1	82.9	0.23
France	3.5	0.3	-
Portugal	-	-	-

Table 3. Area, growing stock and industrial roundwood production of *Pinus nigra* in the three main countries of the SUDOE region.

	Area (million ha)	Growing stock (million m^3)	Industrial roundwood production (million m^3)
Spain	0.71	77.1	0.54
France	-	71.0	-

The evergreen **Cork oak** (Table 4) grows in the Western Mediterranean Basin, occurring spontaneously in Portugal and Spain and in restricted areas of France. In Portugal, cork oak forests cover extensive area in the Alentejo region in the south of the country. In Spain, Cork oak woodlands, covers extensive areas in the autonomous regions of Andalusia, Extremadura and Catalonia.

Table 4. Area of Cork oak and cork production in the three main countries of the SUDOE region.

	Area (million ha)	Cork production (k tons/year)
Portugal	0.74	100.0
Spain	0.55	60.1
France	0.07	5.2

Wood and cork industries in the SUDOE region

The sawn wood industries in the SUDOE region produce a wide variety of products ranging from wood construction to packaging or furniture. Traditionally, sawmills working with Maritime pine also produce sawn wood from other pine species. France holds the largest production of Maritime pine sawn wood with a mean annual sawn timber volume of 1.1 million m^3 (89% of Maritime pine wood comes from Nouvelle Aquitaine) followed by Portugal (1.1 million m^3) and Spain (0.8 million m^3). In Nouvelle Aquitaine (France) 28,300 industries employed 56,300 workers. In Spain the furniture and timber sector register 36,781 companies and 212,900 workers. In Portugal, more than 248 sawmills employ 4,592 persons.

Geographical localisation of cork industry is mainly concentrated in the Iberian Peninsula. In Portugal, the main production activities are preparation, manufacture – production of stoppers, agglomeration and granulation. Spain has specialized in unmanufactured cork, but Catalonia has an important cork-processing industry that is world leader producing champagne stoppers. Portugal is the world leader of the cork sector in terms of exports. It had a market share of 62.4% in 2017, followed by Spain (18.5%) and France (5.1%). Total world exports in 2017 were 1,578.2 million € (Portugal accounted for 985.2 million € and Spain for another 292.9 million €).

INTRODUCTION

Information on the supply of cork and softwood is crucial for wood processing industry and for those responsible for the formulation of environmental policies. The availability of wood and cork is evaluated using data from the National Forest Inventories (NFIs) of the Sudoe regions, since they have uniform protocols applied throughout the country and guaranteed quality measures that provide consistent and comparable data. When possible, the Net Annual Increase and management plans should be used to estimate the future supply of wood and biomass.

OBJECTIVE

The aim of D1.1 is to identify and provide information of availability of wood of autochthonous pines species (*Pinus pinaster, Pinus halepensis, Pinus nigra*) and cork in the SUDOE space. It includes information on the potential supply of resources, information on actual potential use and a comparative analysis between countries.

This task consisted of gathering, summarizing, and sharing timber harvest and standing timber inventory data for its use in WP2.

METHODOLOGY

Data from the NFIs of the countries of the Sudoe region (Portugal, Spain and France), FAO, Institute of Nature and Forestry Conservation (ICNF), CentroPINUS and industrial associations of the wood sector (AIMMP, *Association* of *Industries* of *Wood* and Furniture *Portugal,* AEIM, The *Spanish Association* of *Wood Trade* and *Industry*) and the sector cork from Portugal (APCOR, *Associação Portuguesa de Cortiça*), Spain and France were collected to produce information on the availability of wood (*P. pinaster*, *P. halepensis*, and *P. nigra*) and cork (*Q. suber*).

RESULTS

Based on the FAO definition of forests (Land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10 percent, or trees able to reach these thresholds *in situ*), the Mediterranean region contains an estimated 88

million hectares of forest land (in 2015), representing 2.20 % of the world's total forest area (FAO and Plan Bleu, 2018).

The forests area achieves in Spain 18.6 million of hectares (covering 37.2 % of the territory), in France 17.3 million of hectares (covering 31.5% of the territory), and Portugal 3.3 million of hectares (covering 36.2% of the territory) (Table 5).

Table 5. Forest area in France, Spain and Portugal for 2020 according to FAOSTAT.

Country	Land area (1,000 ha)	Forest area (1,000 ha)	Forested area (%)	Net annual change 2010-2020 (%)
France	54,756	17,253	31.5	1.52
Spain	49,960	18,572	37.2	0.05
Portugal	9,161	3,312	36.2	0.65
FR+SP+PT	113,877	39,137	34.4	0.81
EU27	399,962	159,231	39.8	0.65
Europe	2,213,750	1,017,460	46.0	0.16
World	13,028,122	4,068,934	31.2	-0.36

In 2015, the estimated total forest growing stock (*stem volume of living trees)* in the Mediterranean countries was 10.3 billion m^3 with an average of 117 m^3/ha in all Mediterranean forests. This value is more or less evenly distributed between broadleaved and coniferous in almost all countries (41 % conifers and 58 % broadleaved species). Total growing stock was the highest in France, reaching an average of 2.9 million m^3 followed by Spain, with an average of 1.2 million m^3, and Portugal with an average of 0.186 million m^3 (FAO and Plan Bleu 2018).

Forest Composition

Spain

According to the Spanish NFI, Spain has a total area of non-cultivated countryside termed '*montes*' of 28.0 million ha of which 18.4 million ha correspond to forest as defined by FAO.

Around 71% of the forest types are dominated by trees, mainly species from the genera *Pinus* and *Quercus*. The forest types having an area greater than 1 million hectares are

the holm oak forest (*Quercus ilex* L. s.l.) (5.0 million ha), and other agrosylvopastoral systems, Aleppo pine forest (*Pinus halepensis* Mill.) (2.1 million ha) scots pine forest (*Pinus sylvestris* L.) (1.0 million ha), and the mixed autochthonous broadleaves and coniferous forests of the Mediterranean biogeographical region (AvAE 2019; Alberdi et al. 2017, Nunes at al. 2019)

Maritime pine in Spain, is the pine with the largest natural area of distribution and the most frequently used species in reforestation. This species occupies large areas in Galicia and the Central Iberian and Baetic mountain systems, and it is widely distributed in the northern *submeseta*. Currently, it occupies approximately 1.1 million ha (5.8 % of the total national forest area) according to the Spanish NFI. The growing stock volume is estimated in 153.6 million m^3 and the annual production of industrial roundwood is approx. 3.3 million m^3 (40% of the total harvested; 84% come from Galicia).

The **Aleppo pine** occupies 2.1 million of ha (11.4 % of the total national forest area), where 1.04 million of ha in monospecific stands, and 0.498 million of ha in mixed stands (which 0.230 million ha are with *P. nigra* ssp. salzmanii, 0.183 million ha with *P. pinaster* and 0.084 million ha with *Quercus ilex*). The growing stock volume is estimated at 83 million m^3.

The natural presence of **Black pine** in the Iberian Peninsula is restricted to Spain. This species occupies one of the largest high mountain areas in a wide latitudinal and longitudinal gradient. In Spain, the predominant subspecies is ssp. *salzmannii*, with two varieties that are also identified: the *hispanica* variety located in the Iberian Central System and Betic Cordilleras and the *pyrenaica* variety, which extends throughout Castellón, Aragón and Catalonia (Afzal-Rafii and Dodd 2007). The natural forests of Laricio pine (*Pinus nigra* Subsp. salzmannii) cover an area of 0.71 million of hectares (3.8 % of the total national forest surface). The growing stock volume is estimated at 77.1 million m^3.

Cork oak (*Quercus suber* L.) is an important forest species in Spain which occupies 0.574 million hectares. Cork oak woodlands covers extensive areas in the autonomous regions of Andalusia (in the south), Extremadura (to the west) and Catalonia (to the north-eastern). Cork is the main product harvested from cork oak forests with an

annual production of about 60.5 kton representing 30.5% of the worldwide cork production (APCOR 2019).

France

The French forest is mainly occupied by broadleaf species (64% of the growing stock volume and more than two thirds of the total forest area). Broad-leaved trees are located mainly in flat, low-lying areas, while conifers are in mountainous and Mediterranean areas. The flat and low-lying area of Gascogne region in south-western France (Nouvelle Aquitaine region) is an exception, itis dominated by the coniferous

Maritime pine (*Pinus pinaster*) occupies an area of 1.0 million ha (4.9% of the total area of the national forest). The Landes aera produces 16% of the wood in France, despite covering only 7% of French forests (IFN 2006). The estimated growing-stock volume of the Maritime pine is approximately 143 million m^3 (9.9 % of the total national standing tree volume). The 87% of Maritime pine harvested wood comes from Nouvelle Aquitaine (Agreste NA 2018) and contributes on 24% of the total marketed of roundwood with 3.6 million m^3 in timber and 2.6 million m^3 in pulpwood (Agreste EAB 2017). The harvested volume is around 10 million m^3 to fulfil local industries (pallets, plywood and panels, papers). As a result of the 1999 and 2009 storms, the area and standing volume of stands over 30 years old is much lower than normal.

Aleppo pine is a very common species in the western part of the French Mediterranean basin, where it occupies more than 3.5 million ha (Le Houerou, 2005). The Aleppo pine is abundant from the sea level to 800 m in altitude, mainly located in Provence-Alpes-Côte d'Azur region and in a lesser measurement in Languedoc-Roussillon. It occupies an area of 0.25 million ha. Most of this expansion was achieved through natural regeneration, invasion of abandoned fields and pastures or densification of existing areas after forest fires (Vennetier et al. 2018). This resource is quite important with a very low annual harvest of 130 000 m^3 mainly for energy field. Regional statistics identify only 3 000 m^3 of sawn timber.

In France, **Cork oak** forests, occupy 0.07 million ha. About 5.2 ktons/year of cork are extracted from *Q. suber* trees in France, representing 2.6% of the worldwide cork production (APCOR 2019).

Portugal

Forests are the main use of land in Portugal. In the Mainland, forests are dominated by indigenous species, namely several oaks including Cork oak (34% of Portuguese forest area) and Holm oak (*Quercus ilex* 11% of Portuguese forest area), and pine species (*Pinus pinaster* and *Pinus pinea,* 23% and 6%, respectively). Eucalypt (mainly *Eucalyptus globulus* 26% of the forest) also occupies a large share of the forest area. The remaining area is occupied by less common species including Sweet chestnut, Carob tree, Acacia, poplar, Riparian species and other species.

Maritime pine is the third most important native forest species, occupying approximately 22.1% (0.713 million ha) of the Portuguese forest area (Centro PINUS 2019). The largest stands are mainly located at the Central, Northern, Lisbon and Tagus Valley regions (57%, 37% and 22% of forest stands, respectively). The Maritime pine forest area has been decreasing continuously. Just during the 5 years after the 6th NFI the forest has reduced by almost 63 000 ha as a consequence of forest fires (ICNF 2015, Centro PINUS 2019). In addition to fire, this decrease may be related to pine wilt disease (PWD) control measures, including not only phytosanitary cuts but also the logging of apparently healthy stands to prevent the spread of the disease.

In Portugal, **Cork oak** forests or "*montados",* represent 34% of the Portuguese forest area (0.737million ha) with a strong geographical concentration in the south of the country. The largest concentration of cork oak forest is found in the Alentejo (84% of the forest area), with Central Portugal in second position at 6%. Portugal produces about 100 000 tons of cork per year, representing 49.6% of the worldwide global cork production.

Species characteristics

Maritime pine (Pinus pinaster Ait.)

Maritime pine spreads naturally in Atlantic-influenced regions of Portugal, Spain and France (subspecies *atlantica* at the Atlantic coast) and in the Mediterranean regions of France (including Corsica), Spain (subspecies *pinaster* or *mesogeensi* at the Mediterranean basin), Italy, Morocco, Algeria and Tunis (Figure 1). Together France,

Spain, Northern and Central Portugal regions represent almost 2.9 million ha of Maritime pine forested area.

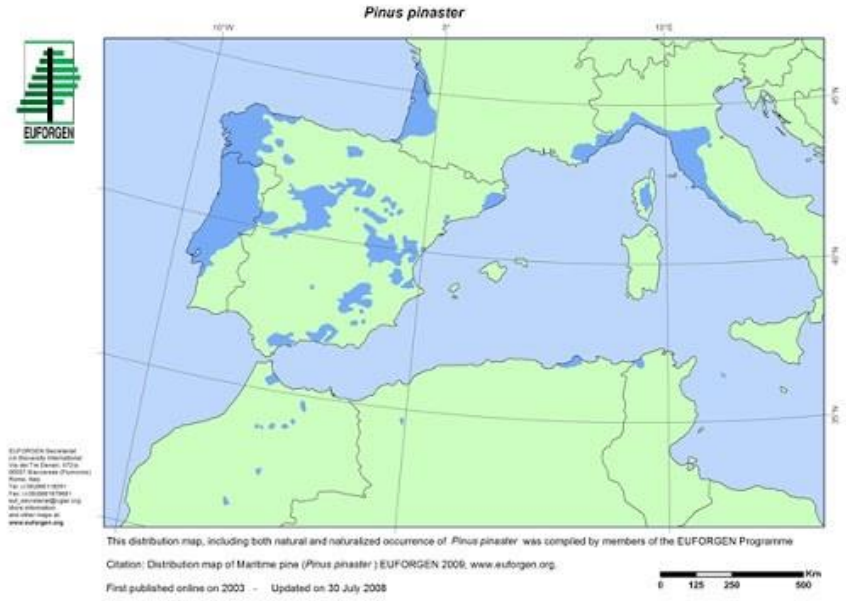

Figure 1. Range of distribution of *Pinus pinaster* (adapted from Euforgen)

Maritime pine is considered a fast-growing species in the Atlantic region, where rotation ages of 40-50 years are common. In the Mediterranean regions, growth rates are lower (often less than 3 m^3/ha.year, or even less than 1 m^3/ha.year) and the rotation length varies from 80 to 120 years (Ruíz Sánchez 1963; Balbuna and Allué 1998; Serrada e Montero 2008).

In Portugal, the average growing stock volume of Maritime pine forest is 63.9 million m^3 and the estimated annual production of industrial Maritime pine roundwood is approx. 3.8 million m^3 (ICNF, 2017). In France, the average growing stock volume of Maritime pine forest is 143 million m^3 (9.9 % of the total national standing softwood tree volume) and the estimated annual production of industrial Maritime pine roundwood is approx. 3.1 million m^3 (89% of Maritime pine come from Nouvelle Aquitaine). In Spain, the average growing stock volume of Maritime pine forest is 153.6 million m^3 (15 % of the total national standing tree volume) and the estimated annual

production of industrial Maritime pine roundwood is approx. 3.3 million m^3 (40% of the total harvested) (84% of Maritime pine come from Galicia).

Maritime pine primary processing consists in sawn timber production. In France, Portugal and Spain, the annual production of *P. pinaster* industrial round wood is approx. 10.2 million m^3, of which approx. 30% is for industrial purposes in this sector. France holds the largest production of sawn wood with a mean annual sawn timber volume of 1.1 million m^3 (89% of MP come from Nouvelle Aquitaine) followed by Portugal (1.1 million m^3) and Spain (0.8 million m^3).

In Portugal, more than 248 sawmills produce about 90% of the Maritime pine lumber. Moreover, there are more than 7 000 small sawmills and installations that produce for household consumption, but not on a permanent basis.

This species has a recognized economic importance. In Spain about furniture and timber sector register 36.781 companies and 212.900 workers (FEIM, 2020). Sawmills in Portugal employ 4 592 persons. (ICNF 2015). In Nouvelle Aquitaine (France), from upstream (silviculture and exploitation) to downstream (finished products and trade), the forest-based sector plays a key role in the regional economy and employment. At the end of 2012, 28 300 industries employed 56 300 people (Agreste NA Analyse et résultats mai 2015).

The estimated volume of all species used in construction, including Maritime pine, is up to 100 000 m^3 in France, 3.6 million m^3 in Portugal (ICNF and DAPFVRS, 2018) and 6 million m^3 in Spain (80% from 7.5 million m^3 of sawn timber are from construction purpose, direct or indirectly, for all national species).

Sawn wood products are used mainly in industrial and structural applications, such as building components (timber frames, flooring, decking, joinery, etc.), and in domestic applications for panelling, built-in fixtures, furniture and finishing.

Aleppo pine (Pinus halepensis Mill.)

Aleppo pine is the species of the *Pinus* genus most widely distributed in the Mediterranean environment, becoming a fundamental characteristic of the forests of the Western Mediterranean (Figure 2). It adapts well to drought and its seed dissemination strategy is well adapted to forest fires although it is not able to

regenerate. Therefore, it is a pioneer species in degraded areas. This coniferous wood species covers about 2.5 million ha in the Mediterranean basin, mostly at low elevations (below 500 m) and along the coastline. In Spain, *Pinus halepensis* is widely used for land protection and afforestation of degraded mountain areas.

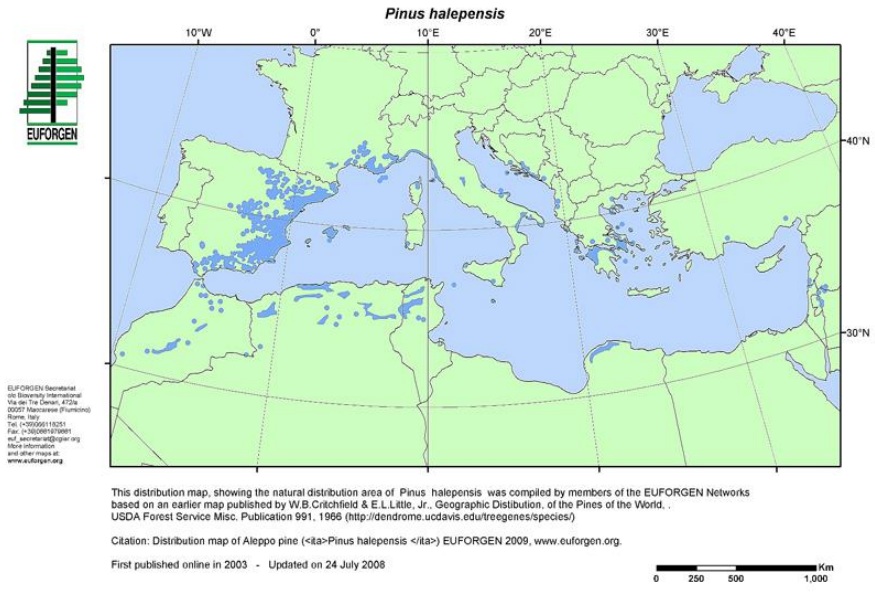

Figure 2. Range of distribution of *Pinus halepensis* (adapted from Euforgen)

In Spain, the mean productivity of Aleppo pine is estimated at 1-2 m^3/ha.year and its maximum yield can reach 12-15 m^3. The estimated annual roundwood production of Aleppo pine is approx. 0.23 million m^3 (3% of the total harvested). The mean annual saw timber volume is approx. 0.11 million m^3. In France, the mean productivity of Aleppo pine reaches 4 m^3/ha.year (Jaouadi et al. 2019).

Sawn wood products are used mainly for pallets and packaging manufacturing industries, to produce train crossings, to obtain resin or produce firewood (ACS, 2020).

Black pine (Pinus nigra Arnold.)

Black pine is native to the calcareous Mediterranean mountains of eastern Spain and southern France. Black pine is the fourth most important Spanish conifer. Its timber is frequently used in construction. The natural forests of black pine cover in Spain an area of 0.709 million ha (Figure 3). The estimated standing tree volume of *Pinus nigra* is approximately 77.1 million m^3 (7.5 % of the total national standing tree volume) and

the estimated annual production of industrial roundwood is 534 890 m^3 (5% of the total harvested) (Anuario de Estadística Forestal 2018). In France Black pine is found in a few isolated populations in the Pyrenees and Cévennes regions.

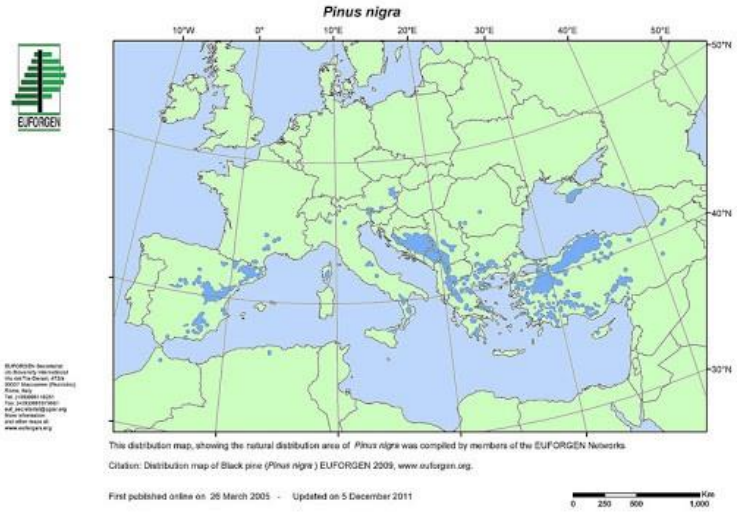

Figure 3. Range of distribution of *Pinus nigra* (adapted from Euforgen)

Cork oak (Quercus suber L.)

The cork oak is a typical species of the Western Mediterranean region, occurring spontaneously in Portugal and Spain, in the North Africa and also, in restricted areas of France and on the west coast of Italy (Figure 4). The total occupied area is currently around 1.43 million ha in Europe. More than the half of this area is located in the Iberian Peninsula.

Most cork oaks integrate multifunctional agro-forestry systems, which combine cork production with cattle grazing, hunting and other non-wood productions (Pereira, 2007).

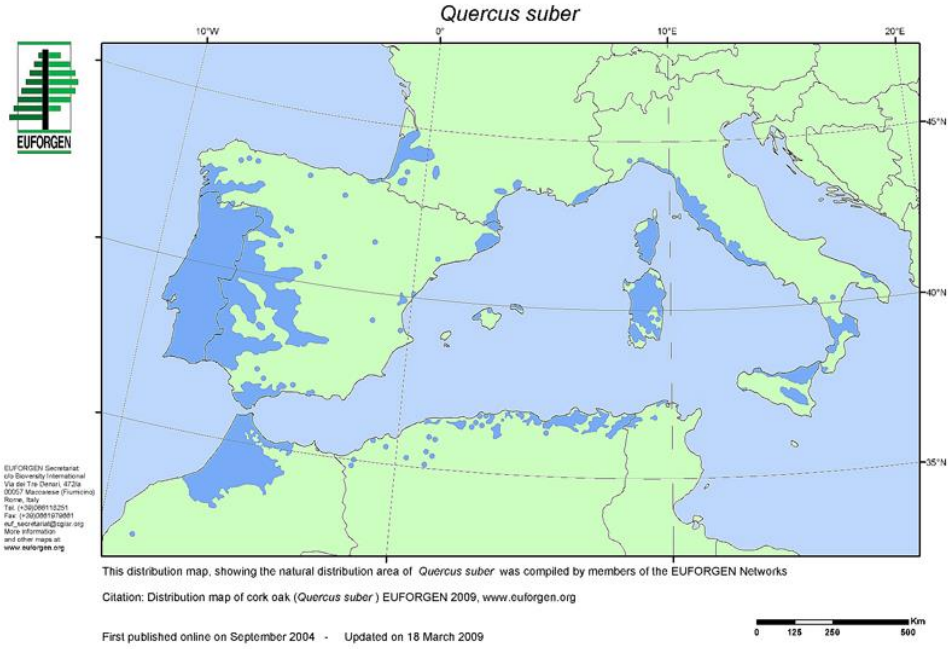

Figure 4. Distribution of cork oak in Europe and North Africa (adapted from Euforgen).

Cork oak is a long-lived (200 years or more) evergreen tree, its outer bark is composed of a compact, elastic, and thermally insulating tissue of dead cells with impermeable walls (Pereira 2007). Each year, cork oak trees produce a new cork ring that is not shed naturally.

Cork is the raw material for an integrated industrial chain of high economic importance. In Portugal, cork products represent about 1 % of Gross Domestic Product, and are directed towards global markets with annual exports of more than 1 billion euros (exports achieved in 2018), according to recent data from the Portuguese Cork Association (APCOR 2019). There are approximately 642 companies operating in the cork industry in Portugal, and they employ about 8 305 workers (Ministry of Labour and Social Solidarity, 2016). The cork industry in Spain provides more than 2 000 full-time jobs in more than 98 cork processing and producing companies.

Although representing only 3% of the world's coarse-grained area and 1% of the world's world production of cork, France has a rich sub-cork tradition. It was the Benedictine monk Dom Pérignon who first used cork to cork the champagne, a drink he had just invented. The French regions that currently produce cork are reduced to

Corsica, Var and the Pyrénées-Orientales, although were many others in the past. Because of its colonial past, France administered for a long time the vast suberaies of North Africa, and more particularly Algeria, which made it one of the pioneer countries of subériculture, as attested by one of the first works written on the subject by Lamey (1893). On the other hand, the proximity of the Pyrénées-Orientales department to the province of Girona (Spain), the cradle of the modern cork industry in Spain, meant that the northern Catalan suberaies were put into production very early on, and a relatively large industry was established (with the Sabaté company as a notable representative). In the South-West of France, and more precisely in the departments of Landes and Lot-et-Garonne, the exploitation of cork has been able to develop thanks to the strong demand for cork stoppers on the part of the wine estates of Bordeaux, and to the presence of the harbour of Bordeaux allowing easy export via the Garonne.

Wood characteristics

The tree growth occurs by the action of two living tissues called meristems, with cell division capacity, responsible for the growth in height (apical meristem) and in diameter (cambium). These two tissues, despite having different functions and characteristics, form a unique physiological system in the tree. The apical meristem, located at the apex of the trunk and branches, it is responsible for growth in height.

The cambium, located between the bark and the wood, covering the entire trunk of the trees, is responsible for the growth in diameter. This cambium consists of a thin layer of meristematic cells that, under the action of hormones, are stimulated to divide forming new cells, both towards the outside and towards the centre of the trunk. The cells formed to the outside will compose the phloem or bark and those formed towards the interior will compose the xylem or wood.

The wood formed during spring (when weather conditions are favourable), with a lighter colour, is called initial wood or springwood (Figure 5). The wood formed during summer and autumn, which is darker in colour, is called final wood or autumn wood. In winter there is no growth, the trees go into vegetative dormancy. The set of a layer of initial wood and a final wood is called a growth ring and corresponds to one year of tree life.

Figure 5. Softwood pine. Wood annual rings

Throughout the tree life, the cells of the oldest rings accumulated inside the trunk become places of deposition of substances from the tree's vegetative activity, forming a tissue with its own characteristics and properties called heartwood. The outermost and newest rings form the sapwood.

The different chemical, physical, mechanical and technological characteristics of the heart and the sapwood are responsible for much of the heterogeneity of the wood in a single tree.

Anatomically, wood consists of cells arranged longitudinally: fibers and tracheid (responsible for the mechanical resistance of the tree and, in the case of tracheid for the transport of sap), parenchyma (with functions of storage of reserves) and vessels (ensure the transport of sap in the tree). In conifers, the double function of transport and support is ensured by tracheid.

In most resinous plants, namely Maritime pine, there is another structure called the resin channel responsible for the transport of resin produced by special cells that surround it. This structure usually has a longitudinal arrangement, but it can appear in a horizontal orientation.

Contrary to what happens with most other alternative materials, the natural variability of wood is enormous. This aspect, combined with its anisotropy, means that in a given piece of wood the characteristics can be very affected only by the way (or orientation) in which that piece is removed from the tree (Figure 6).

The cut of a trunk as shown in the Figure 7 allows observing 3 planes with different aspects and characteristics, due to the disposition in which the cellular elements are presented in each of these planes. This anisotropy has implications for the performance of the wood

when put into use, being the main responsible for the defects that arise when drying the wood.

Figure 6. Pine wood, Tangential plane (A) and radial plane (B)

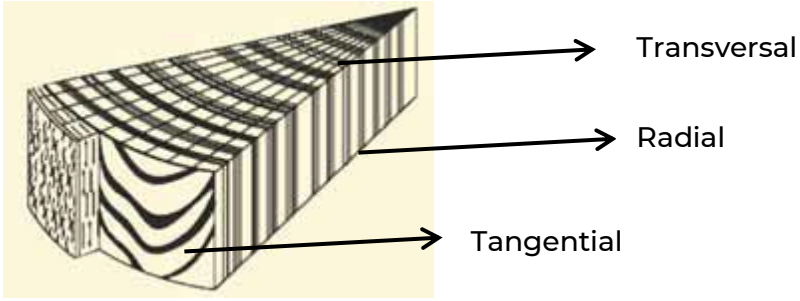

Figure 7. Illustration of the three planes of section

Maritime pine wood

The wood of Maritime pine has distinct yellowish white sapwood and reddish heartwood. The proportion of the heartwood is related with the tree age and its growth level. The annual (age) rings are quite visible, due to the contrast between spring and summer zones. The number of growth rings per cm ranges from 1 to 4 (average of 2.2), although as a consequence of the eccentricity and the climatic variation from year to year, its distribution is irregular within the same log. If the stands were not pruned, knots will appear in large numbers and without an even distribution. They are relatively large, dark greyish-brown coloured, and in general, are loose or

dead (Figure 8). Another characteristic of this wood is the presence of well-located resin pockets/bags. The grain is straight, with a medium, even texture.

Figure 8. *Pinus pinaster* wood with knots.

Workability: Overall, Maritime pine works fairly well with most tools, though the resin can gum up tools and clog sandpaper. Maritime pine glues and finishes well.

Drying: Although the open-air drying process is an advantageous option in some ways (easy to handle, energy costs, maintenance costs, investment requirements etc.), nowadays there is a trend towards the incorporation of artificial drying in a chamber. This fact is motivated by the following factors:

- Need to guarantee that the final product obtained is compatible with applications that require low moisture contents (floorings, surfaces, ...).
- Need to improve the drying duration, reducing stocks of products under manufacture, to obtain relevant financial advantages and a larger organisation flexibility.
- Sawn timber transport optimisation, due to the wood weight reduction.
- Elimination of the possible degradation of sawn timber (by fungi or other causes as blue stain).

Among artificial drying technologies, there are the following types:

- Conventional drying (atmospheric pressure) with Controlled hot-air supply
- Vacuum drying

Maritime pine is a species relatively easy to dry. Its drying cycles with standard drying systems are quite short even in the case of large thicknesses.

- The duration of its drying cycles grows steadily with the thickness increase of products.
- Increasing the drying process temperature helps to reduce the drying cycles, but in practical terms, the use of temperatures higher than 100 °C requires the availability of highly efficient and specific techniques (High temperature kiln 100-120° C).
- To remove the resin from the wood to avoid later problems in the wood application, an 80 °C temperature is enough

Maritime pine is a fast-drying species with a slight tendency to check.

Untreated wood durability: In Maritime pine, the heartwood is naturally resistant and sapwood is very easily impregnated by preservation products. The sapwood is susceptible concerning wood-destroying fungi, termite, and wood-boring beetles like *Anobium* and *Hylotrupes*. The heartwood is slightly no moderately durable to fungi, moderately durable to termites, and durable to wood-boring beetles (Cruz et al. 1998).

Physical-mechanical characteristics: In general, each European country has developed its own grading rules for timber, adapted to the specific particularities of their species and market. All of them use similar criteria and the principles set in European guidelines. In Europe, there is a set of standards that regulate timber-grading procedures and the determination of mechanical properties. All national grading standards must meet these European guidelines. For this purpose, EN 338 sets the common strength class system while EN 1912 includes the assignment of species and visual grades from national standards to strength classes (Table 6).

Table 6. Selected strength class assignments for *Pinus pinaster*

Mechanical and physical properties	**Spain**	**Portugal**	**France**
Strength assessment standardisation	UNE 56544	NP 4305	NF B 52-001 part 1
Available strength classes (EN 338) **According to EN 1919**	ME1-C24 ME2-C18	E-C18	STII-C24; STIII-C18; STIV-C14

The available literature values for physical and mechanical properties from small clear wood specimens of *Pinus pinaster* wood are shown in Table 7.

Common uses: paper (pulpwood), flooring, boxes/crates, and construction lumber.

Table 7. Maritime pine technical information. Physical and mechanical properties on small clear wood specimen tests (Muñoz and González (2007), García-Iruela et al. (2016); Prades et al. (2001)). Fernando Sanz "Technical Co-operation for the Development of the Industrial Applications of Pinus Pinaster" (Atlanwood-59) cofinanced by the Programme Interreg IIIB "Atlantic Area" (2000-2006) with ERDF funds.

Basic density at 12%H (kg/m³) (*UNE 56531*)	430 ± 350
Shrinkage (%) (*NFB 51006; UNE 56533*) • **Radial** • **Tangential** • **Volumetric**	 3.7 ± 0.5 6.9 ± 0.9 10.7 ± 0.8
Static bending (*UNE 56537)* • **Modulus of elasticity; MOE (N/mm²)** • **Modulus of rupture. MOR (N/mm²)** **Tensile strength perpendicular to the grain (*UNE 56538*)** • **Radial (N/mm²)** • **Tangential (N/mm²)**	 8 800 – 11 500 80.0 – 151.9 1.8 ± 0.32 1.6 ± 0.30
Untreated wood durability (*EN 350 2016*)	Termites: not durable (S) Mushrooms: moderately to slightly durable (3-4) Cerambicids, lipids and anobids: durable
Impregnability (EN 350 2016)	Heartwood: not impregnable Sapwood: easily impregnable

Aleppo pine wood

The sapwood is white and differs well from the heartwood, which is resinous and reddish in colour. The growth rings are heavily marked. The spring and summer areas are clearly differentiated. The spring area is lighter in colour with light and low lignified tracheid's. On the contrary, the summer area is very dark in colour, with tight, highly lignified tracheid's. As a consequence of the different colouring of the spring and summer areas, in the longitudinal sections the rings appear forming bands or parallel lines. The resin canals are quite thick, coloured by a reddish-brown resin. They can be isolated or in groups of 2 to 5 channels, distributed throughout the ring or, more

frequently, aligned in the transition zone of the springwood with that of the autumn. The fiber is somewhat irregular, frequently deviated due to existing knots. The grain is medium-coarse.

Mechanical and physical properties of Aleppo pine (*Pinus halepensis* Mill.). Selected strength class assignments for *Pinus halepensis* in Spain and France (Table 8).

Table 8. Selected strength class assignments for *Pinus halepensis*.

Mechanical and physical properties	**Spain**	**France**
Strength assessment standardisation	-	NF B 52-001 part 1
Available strength classes (EN 338)	-	STII-C24; STIII-C18; STIV-C14

The intrinsic characteristics of pine of Aleppo are often comparable to those of Maritime pine. Values from small clear wood specimens physical and mechanical properties of *Pinus halepensis* wood are shown in Table 9.

Table 9. Aleppo pine technical information WoodTech project (**www.woodtech-project.eu**). Clear wood small specimens.

Basic density (H% -12%)(kg/m³) (UNE 56531)	550 (450.0-589.0)
Hardness (UNE 56534)	2.8 (2.4-3.1)
Shrinkage (%) • **Radial** • **Tangential**	 4.1 (3.7-4.7) 7.3 (7-8.1)
Static bending (*UNE 56537)* • **Modulus of elasticity; MOE (N/mm²)** • **Modulus of rupture. MOR (N/mm²)** **Axial compression strength (kg/cm²) (*UNE 56535*)**	 10873 117.3 485
Untreated wood durability (*Montibus 2015*)	Mushrooms: moderately durable (4-5)
Impregnability (*Montibus 2015*)	Heartwood: not impregnable Sapwood: easily impregnable

France has developed a upgraded website on Aleppo pine including all international papers (see https://www.pindalep.ofme.org/)

Black pine wood

The heartwood is light yellowish-brown clearly demarcated from the yellowish-white sapwood (Figure 9). It is similar in appearance to Scots pine, but the sapwood is wider. The wood weighs 510 kg/m³ when dried, and often contains a greater number of large knots than Scots pine. Resin droplets within the transition zone from spring to summer are also noticeable.

Figure 9. *Pinus nigra* wood

Drying: Dries very rapidly and well, with little degrade except slight checking around knots and some splitting of these. The wide sapwood is liable to fungal staining unless dried quickly after conversion.

Treatability: Heartwood: difficult to extremely difficult to treat Sapwood: easy to treat

Use(s): Heavy structural use, Joinery - Exterior, Joinery – Interior

Mechanical and physical properties of *Pinus nigra* wood. Selected strength class assignments for *Pinus nigra* in Spain and France (Table 10)

Literature values for physical and mechanical properties from clear small specimens of Pinus nigra wood are shown in Table 11.

Table 10. Selected strength class assignments for *Pinus nigra*

Mechanical and physical properties	**Spain**	**France**
Strength assessment standardisation	UNE 56.544	NF B 52-001
Available strength classes (EN 338) according to EN 1919	ME1-C30; ME2-C18 for timber of 70 mm thickness and less. MEG-C22 timber of more than 70 mm width	STII-C24; STIII-C18; STIV-C14

Table 11. Physical and mechanical properties of *Pinus nigra* wood (Tsoumis 1991; Guler et al. 2007)

Wood density	576
Shrinkage (%) (DIN 52184) • **Radial** • **Tangential** • **Ratio T/R shrinkage**	 4.1 7.7 1.9
Swelling (%) (TS 4084; TS 4085) • **Radial** • **Tangential** • **volumetric** **Static bending (DIN 52186)** • **modulus of elasticity; MOE (N/mm²)** • **modulus of rupture. MOR (N/mm²)** **Axial compression strength (N/mm²) DIN 52185**	 3.70 7.78 11.50 11,765 103 39
Untreated wood durability (EN 350 2016)	Termites: not durable (S) Mushrooms: moderately to slightly durable (3-4v) Cerambicids, lipids and anobids: durable
Impregnability (EN 350 2016)	Heartwood: not impregnable with variation Sapwood: easily impregnable with variation

Cork characteristics

Cork is extracted without felling the tree. Once the cork is removed, the original phellogen cells die but another layer of active phellogen differentiates in the outer phloem, maintaining the production of cork. The cork oak tree is unique in its high capability to regenerate a new outer bark after harvest (Pausas 1997). The first cork harvest is conducted when the tree is approximately 30 years old. Thereafter, harvests are practiced at 9- to 12-year intervals, the time necessary for trees to grow a new layer of bark of ca 30 mm thick. Cork is extracted in summer in the form of semi-tubular planks that are withdrawn from the trunk and branches of the cork tree, at a minimum legal periodicity of nine years in Portugal and Spain. But in some producing regions debarking periods are longer such as in Catalunya or southern France, where cork extraction is carried out every 12-14 years. This activity is mainly carried out manually, with the aid of an axe (Figure 10) although it can be done also mechanically using saws specifically adapted for cutting cork without damaging the tree (https://www.gosuber.es).

Figure 10. Harvesting cork on *Quercus suber* (source: ASECOR)

The first harvesting produces cork called "*virgin cork*" characterized by a very irregular exterior surface. It is mainly used for grinding to obtain granules for the subsequent production of agglomerated cork. The second cork harvest produces material with a regular structure, less hard, but still not suitable for cork stoppers. This cork is known as "*secondary cork*". It is from the third and subsequent harvests that the cork with the best properties is obtained. This cork is already suitable for the production of quality

corks stoppers, since its structure is regular with a smooth outside and inside. This is the so-called "*amadia*" or *reproduction cork*.

The visual aspect of cork is characterised by the presence of annual rings, a light-brown colour and the presence of lenticular channels. They constitute the porosity of cork. Cork is a light material due to its hollow cells and thin walls (Figure 11).

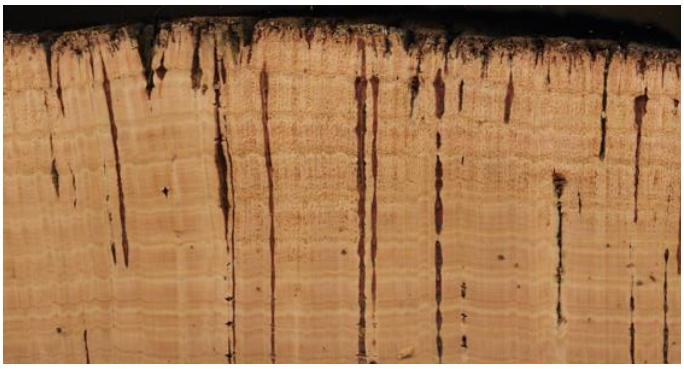

Figure 11. Cork plank

Because of its structure and chemical composition, cork has a series of properties that allow it to occupy a very competitive position in numerous applications, among which wine corking stands out. These properties include low density, impermeability, viscoelastic behaviour and high thermal insulation.

Mechanical properties: Cork is elastic and allows large deformations under compression without fracture, with substantial dimensional recovery when stress is relieved. Cork fracture happens only when it is stressed under tensile or torsion forces and the deformation overcomes the material's strength. Cork is also a light material, due to its hollow cells and thin walls, rather impermeable to water and other liquids.

Thermal insulation: This property is based on the high volume of air contained in cork structure, and can be remarkably improved in industrial processing, manufacturing so-called "black" agglomerates (or pure expanded). The coefficients of thermal conductivity of cork are around 0.04 W / m °C, rising to 0.6–1 W / m °C in the case of "white" (or composite) agglomerates, commonly used in floors and walls cladding.

Cork is an industrial raw material that supports an integrated chain from production to the consumer with an important impact at economic, social and environmental

levels in the corresponding regions of production and transformation. The industrial production is organised following basically two streamlines:

- The production of stoppers of natural cork and the production of discs of natural cork.
- The production of agglomerates of cork particles, with or without the addition of binding materials.

Natural cork stoppers and discs are produced from corkboards of suitable thickness and quality and production of cork agglomerates from the granulation of by-products and waste from corkboards and other cork raw materials. Figure 12 shows a flow diagram of products and wastes associated with the cork value chain.

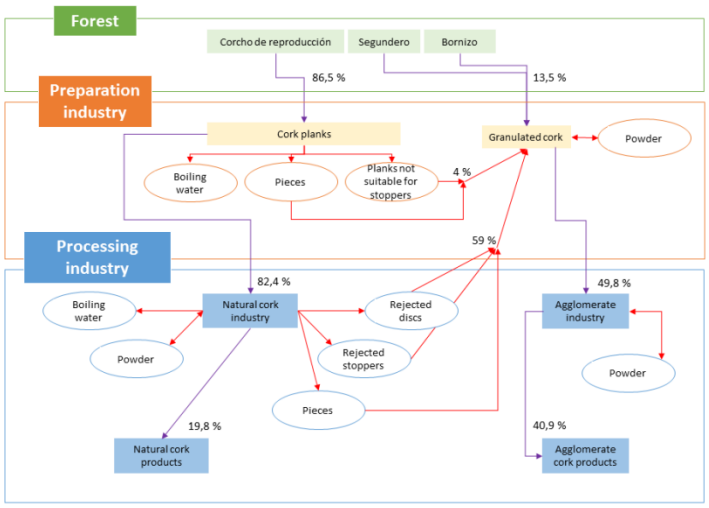

Figure 12. Flow diagram of products (purple arrows) and waste (red arrows) associated with the cork value chain. The rectangles represent products and by-products, and the ellipses wastes. (Sánchez-González et al. 2019).

First transformation processes

Wood industries

Some conifer trees are logged, and logs are transported at full length directly to sawmills where will be cut at final lengths. Instead, Maritime pine trees are first logged, selected and classified according to diameters and singular characteristics.

Then, logs are cut to different lengths at forest side, normally between 2 and 2.5 meters, and finally transported to sawmills.

This practice limits the structural use of this species because this use requires longer lengths (normally above 2.6 m). Maritime pine logs are cut to short lengths on forest sides because the log characteristics (e.g., log curvatures, cone shape) increases the costs of transportation and the material efficiency when timber is cut at full log length.

Traditionally, sawmills working with Maritime pine were prepared to employ several sawing systems to obtain the utmost profitability from the raw material, even in those cases of standing wood with heterogeneous qualities. By considering as a priority the raw material profitability instead of the sawing plant productivity, many sizes and qualities were obtained. Thus, the processes automatization and, above all, the grading and handling of sawn timber is more difficult.

In the last decades, there has been an increase in companies changing their classical sawing methods and specialising in the production of some products. This practice demands specific requirements of roundwood, according to the product type to be obtained. In this way, it is possible to increase productivity and automatize the grading and stacking operations, although the plant becomes most dependent on raw material supply.

Pallet Industries

There are billions of pallets circulating through global supply chain, with 80 % of all commerce carried on pallets. Wooden pallets dominate the markets with 90 to 95% market share. Overall annual industry production in 2016 was estimated at 849 million wood pallets (508 million new and 341 million recycled). This output represents an overall 14% (22% increase for new pallets and 5% for recycled) increase compared to 2011 results – previously the most recent data available.

The pallet market size in Europe has the potential to grow by 407.4 million units during 2020-2024, and the market's growth momentum will accelerate during the forecast period. Pallets are manufactured to standards or custom-made. There is a high degree of standardization in Europe based on the modular size of 600 x 400 mm. The major pallet footprints in Europe are 800 x 1,200 mm and 1,000 x 1,200 mm, but half-pallets (600 x 800 mm) and quarter-pallets (400 x 600 mm) are also produced;

these tend to be used on full-sized pallets, especially for small shops ordering small quantities. The UK and Benelux export markets, where 1,000 x 1,200 mm pallets were previously the standard, are switching to the EUR pallet of 800 x 1,200 mm. In Europe, four-way-entry block pallets (meaning the forklift can enter from any of the four sides of the pallet) are used most commonly (ECE, 2016).

Wood for pallet production is transported from the forest to the sawmill and the pallet production site. After logging, the logs are first sorted according to diameter. The wood is debarked and cut into the respective desired sizes using. For production of a wood pallet, logs are cut to lengths of 2.5 or 4.0 m from the base of the tree. In the next process, the sorted wood is transported into the interior of a semi-automatic production line. Subsequently, the length and shape of the logs are selected and adjusted for the individual parts of the pallet, and then cut. On average, 1 m^3 of wood is sufficient to produce 22.6 pallets. The yield from the starting raw logs is roughly 60–70%. The resulting cuts go to the pick-up machine, which uses three types of nails to produce a functional pallet. The last step of the semi-automatic line is to straighten the pallets. The pallets are then transported into the drying room. For use, the pallet wood must not have a moisture content in excess of 22%. The dried pallets are then transported and stored in a warehouse, protecting them from undesirable environmental events. Kočí (2019).

When it comes to categorizing and distinguishing pallets, it can be done in a variety of ways by style (entry points), design (block vs. stringer pallets) and by material. One significant way to distinguish pallets is by the number of entry points for forklift forks. Another noticeable difference is the deck. Gap deck and solid wood deck pallets (Figure 13).

In an attempt to control the spread of invasive pests, the FAO-based Interim Commission on Phytosanitary Measures adopted a global standard for wood packaging material in 2002: International Standard for Phytosanitary Measures No. 15 (ISPM No. 15), "Guidelines for regulating wood packaging used in international trade". Wood packaging is defined in ISPM No. 15 as “wood or wood products (excluding paper products) used to hold, protect or transport a commodity... including pallets, dunnage, cages, blocks, barrels, drawers, load boards, pallet collars and chocks.

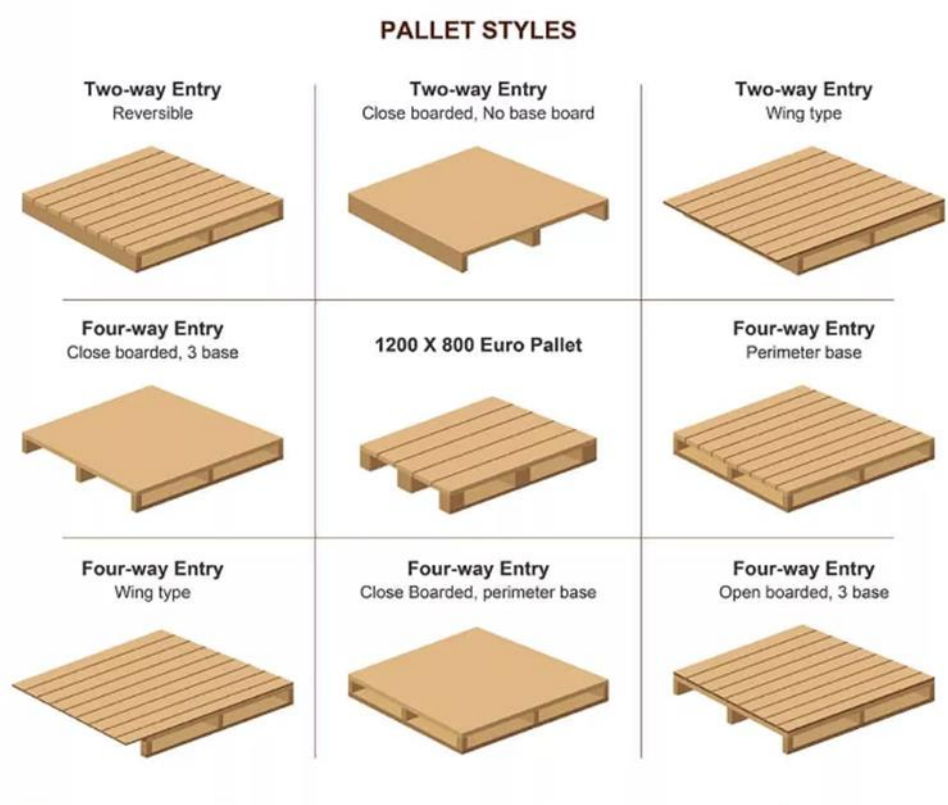

Figure 13: Different types of Pallets on the market

Two treatments are recognized in the standard: heat treatment, in which the wood must be heated to a temperature of 56 °C for a period of 30 minutes, and fumigation with methyl bromide. The heat treatment was chosen taking into account its commercial viability and the diverse range of pests for which mortality has been documented, although some organisms may have a higher thermal tolerance. Methyl bromide is recognized as having negative atmospheric effects. Its use in connection with quarantine and pre-activities will be exempted from the ban to the expedition. However, the fumigation of wooden packaging with this substance has raised environmental concerns. The National Plant Protection Organizations (NPPOs) are encouraged to promote the use of alternative treatments approved in this standard. Use of methyl bromide should take into account the CPM recommendation on the replacement or reduction of the use of methyl bromide as a phytosanitary measure (CPM, 2008).

International Plant Protection Convention (IPPC) stamp to Pallets

If a pallet is going to travel outside the EU or to Portugal it must bear an International Plant Protection Convention (IPPC) stamp showing a few key details (Figure 14):

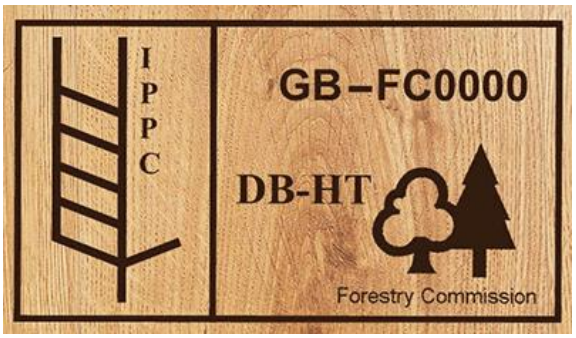

Figure 14. Components that are integrated into a unit of wood pallet.

We can break this stamp down into 3 sections to better understand what it's telling us about this particular pallet. The IPPC logo should always be present. The IPPC logo (Figure 15) exists to prevent and control the spread or introduction of pests of plants/plant products around the world. So right away this tells you something about this pallet – the logo is present because this wooden pallet will be moving between countries and its purpose is to advise of the measures that have been taken (if any) to prevent pests from also moving between countries.

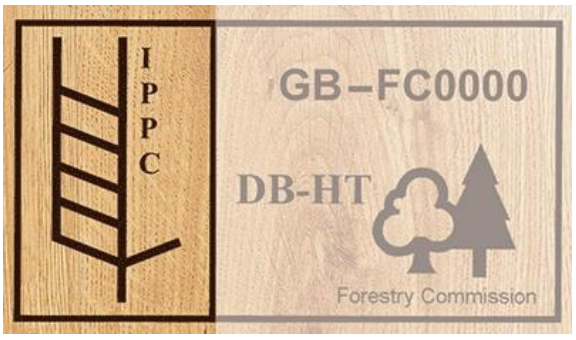

Figure 15. The IPPC logo

The second section that each of these IPPC stamps will include is a geo-specific identifier. The first two letters will indicate which country the pallet is from (as per ISO 3166), followed

by a regional identifier. After these geo-specific codes, the pallet will receive a unique registration number (Figure 16)

Figure 16. Geo-specific identifier

The final section of the pallet's stamp is a little more variable. This section is used to display the treatment stamps. There may be one, two or three depending on the treatments a particular pallet has received. Please refer to the 2 character letters below for each of the codes (Figure 17). For pallets originating from Great Britain, the Forestry Commission logo may be present as the standard GB phytosanitary certificate, however these are no longer required and are often missed off if space is limited. But you may see some other national phytosanitary certificates on pallets originating from other countries.

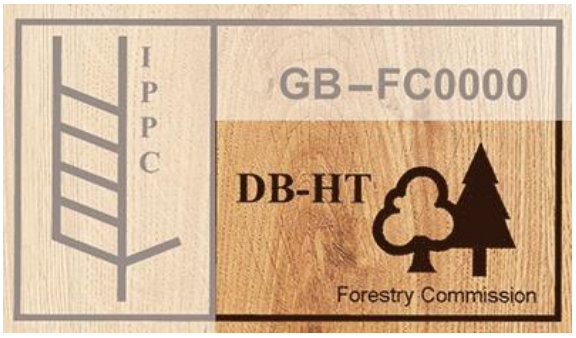

Figure 17. The treatment stamp

Cork industries

Geographical localisation of cork industry is linked to the area where the cork raw material is extracted and for this reason the cork industry sector is mainly

concentrated in the Iberian Peninsula. The cork industry in Portugal is concentrated mainly in the north-western region; especially in Aveiro district, while raw cork material extraction is mainly concentrated in the central-south region; Alentejo region produces 72% of the resource (APCOR 2019). A similar trend is observed for Spain, where the industry is mainly located in the north-western region (Catalonia), while the south of the country, the regions of Andalusia and Extremadura concentrate most cork extraction, 85% (Pérez et al. 2015).

The cork industry structure is composed by a supply chain with different links: forestry, the half-manufactured cork industry and the cork processing industry. In Portugal the main production activities are preparation, manufacture – production of stoppers, agglomeration and granulation. Spain has specialized in unmanufactured cork, mostly going to Portugal; but Catalonia, a region in the northwest of Spain, has an important cork-processing industry, that is world leader in champagne stoppers (Rives 2012). The main sector for which cork products are destined is the wine bottling, which absorbs 70% of all production, followed by the building industry with 22% which includes thermal, acoustic, and vibration insulation, wall and floor coverings, cubes, plates, sheets, strips, and even some products from the "other cork products" category.

International Cork Market: Portugal is the world leader of the cork sector in terms of exports. It had a market share of 62.4 % in 2017, followed by Spain with 18.5 % and France with 5.1%. Total world exports in 2017 were 1,578.2 million euros (Portugal 985.2 million euros and Spain 292.9 million euros) (APCOR 2019),

The cork industry integrates all types of activities related to the processing of cork, which could be also divided into two production groups: the natural cork industry and granulate-agglomerate industry. The main production activities are: Preparation, Manufacture production of stoppers, Granulation and Agglomeration.

The main activity of Cork Preparation Industries is to transform the raw cork slabs from the forest into an intermediate product (prepared cork slabs), that will be transformed into and end product. Cork planks leave the forest in trucks and are placed on a yard where, for six months, it shall stabilize and develop even moisture content. After stabilization, the cork planks are subjected to selection and pre-

processing operations, where the material not suitable for the production of stoppers is eliminated. The next step of the industrial process is boiling. Cork planks are boiled in stainless steel tanks for an hour. When the planks are taken out, their volume has increased by 20%, making them more regular and easier to handle (Figure 18). After boiling, the planks are again stacked for stabilization in an area with good ventilation. After two days, they are ready to be processed. The edges of the planks are prepared and the corners trimmed. Based on key characteristics like appearance, thickness and porosity the planks are separated into quality categories. Only good quality planks are selected for producing cork stoppers. Those with defects are sent to be ground and will be turned into other cork products.

Figure 18. Cork preparation

Natural cork producers generate products directly from the prepared cork slabs, without triturating the material. The two main products made as individual pieces of cork are the natural cork stoppers that is an end product, and natural cork discs that is an intermediate product that is used to produce technical stoppers joined with cork body agglomerates (Figure 19). The selected planks used for top-of-the-range - natural - cork stoppers are cut into strips and punched with a machine to extract the cylindrical stoppers. The stoppers are separated and classified based on visual quality. Many cork stoppers are rejected and will be used to make cork granulate for technical stoppers. The manufacture of natural cork discs is performed in a very similar manner to that of the natural cork stoppers.

Figure 19. Natural cork stoppers and natural cork discs

The main activity of the Granulate cork producers is the transformation of forestry cork by products that result from cork production and from the natural cork industry, into small particles of cork of between 0.25 nm and 8 mm. Granulated cork is used for the manufacture of cork agglomerates (Figure 20).

Figure 20. Cork granulate

Agglomerate cork producers: Cork agglomerates are divided into two types: compound agglomerate (white agglomerate) and pure agglomerate (black agglomerate).

The white agglomerate is made of cork granules mixed with a binder and/or other additives. The process begins by mixing the corks granulate usually with glue and an agglutinant. The mixture is inserted into moulds, pressed, and then the moulds are placed in a curing or cooking oven to initiate the agglomeration or agglutination process (where the glue added to the cork granulate is polymerized). After this stage, the material is removed from the mould and stabilized by to form a block of agglomerated cork. Then, the mechanical rectification of the block is performed to finish the product through cutting and sanding operations. The main applications are

for wall and floor coverings, and agglomerated cork stoppers. Technical stopper producers: This subsector uses white cork granulate and natural cork disks to generate cork stoppers. The process of manufacturing agglomerated cork stoppers can be considered quite similar to the process described for the production of the composite cork blocks, although the agglomeration operation is done by extrusion or by tube moulding. In both methods (extrusion and tube molding), agglomerated cork "sticks" are obtained, which, after a stabilization period, suffer a correction in diameter and are cut according to the desired final product (Figure 21). The most famous technical stopper is the champagne cork stoppers.

Figure 21. White agglomerate; agglomerated cork stoppers and Technical stopper (champagne cork stopper)

The Black Agglomerate or Expanded Cork Agglomerate use undervalued corks e.g. virgin cork, or low quality reproduction cork. They are produced in blocks by heating the cork granules in autoclaves with superheated steam at 300-350°C. Under these process conditions expansion of the cork cells occur and thermo-chemical degradation of the extractives and structural components of cork with the release of by-products that act as natural adhesives between the granules to form the agglomerate (Figure 22). The black agglomerate is intended to non-alimentary uses such as insulator panels mainly used in thermal, acoustic and vibration applications.

Figure 22. Expanded cork agglomerate

CONCLUSIONS

The aim of D1.1.1 is to identify and provide information of availability of wood of autochthonous pines species (*Pinus pinaster, Pinus halepensis, Pinus nigra*) and cork in the SUDOE space (Spain, France and Portugal).

Forests in the SUDOE region

The SUDOE Space comprises the entire territory of Spain and of Portugal and the Southwestern regions of France. Forests in Spain occupy about 18.6 million ha. The native pine species, the Maritime pine (*Pinus pinaster*) occupies approximately 1.1 million ha, widely distributed in large areas in Galicia and the Central Iberian and Baetic mountain systems. The growing stock volume is estimated in 153.6 million m^3 and the annual production of industrial roundwood is approx. 3.3 million m^3. The Aleppo pine (*P. halepensis*) occupies approximately 2.1 million ha distributed in the western Mediterranean. The estimated annual roundwood production is approx. 82.9 million m^3 and the mean annual saw timber volume is approx. 0.23 million m^3. The forests of Laricio pine (*Pinus nigra* Subsp. *salzmannii*) cover an area of 0.71 million ha and the estimated standing tree volume is approximately 77.1 million m^3 and the estimated annual production of industrial roundwood is 0.54 million m^3.

The French forest occupies about 17.3 million ha. The native pine species, the Maritime pine occupies an area of 1.0 million ha in Southwest of France. The growing stock volume is estimated in 143.0 million m^3 and the annual production of industrial

roundwood is approx. 6.9 million m^3. The Aleppo pine covers 3.5 million ha, mainly located in Provence-Alpes-Côte d'Azur region. The growing stock volume is estimated in 0.3 million m^3. In France Black pine is found in a few isolated populations in the Pyrenees and Cévennes regions.

Forest in Portugal occupy about 3.3 million ha. The native pine species, the Maritime pine is the third most important native forest species, occupying approximately 0.7 million ha mainly located at the Central, Northern, Lisbon and Tagus Valley regions. The average growing stock volume is 63.9 million m^3 and the annual production of industrial roundwood is approx. 3.8 million m^3.

The evergreen Cork oak (*Quercus suber*) grows in the Western Mediterranean Basin, occurring spontaneously in Portugal and Spain and in restricted areas of France. In Portugal, cork oak forests occupying approximately 0.74 million ha with a strong geographical concentration in the south of the country in the Alentejo region. In Spain, Cork oak woodlands, covers extensive areas in the autonomous regions of Andalusia, Extremadura and Catalonia, which occupies 0.55 million ha. In France, Cork oak forests, occupy 0.07 million ha.

Cork production. Portugal produces about 100 ktons of cork per year (49.6% of the worldwide global cork production). Spain produces about 60.1 ktons of cork per year (30.5% of the worldwide cork production). France produces about 5 200 tons/year of cork (2.6% of the worldwide cork production).

Wood and cork industries

The Sawn wood industry produce a wide range of products ranging from wood construction products, packaging, furniture, etc. France holds the largest production of Maritime pine sawn wood with a mean annual sawn timber volume of 1.1 million m^3, followed by Portugal (1.1 million m^3) and Spain (0.8 million m^3). In Nouvelle Aquitaine (France) 28 300 industries employed 56 300 workers. In Spain about furniture and timber sector register 36.781 companies and 212.900 workers. In Portugal, more than 248 sawmills employ 4 592 persons.

Geographical localisation of cork industry is mainly concentrated in the Iberian Peninsula. In Portugal the main production activities are preparation, manufacture –

production of stoppers, agglomeration and granulation. Spain has specialized in unmanufactured cork, and in champagne stoppers industry. International Cork Market: Portugal is the world leader of the cork sector in terms of exports. It had a market share of 62.4 % in 2017, followed by Spain with 18.5 % and France with 5.1%. Total world exports in 2017 were 1,578.2 million euros (Portugal 985.2 million euros and Spain 292.9 million euros).

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PARTNERS

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