Universidade Federal do Paraná
Setor de Ciências Agrárias
Pós-graduação em Engenharia Florestal
Revista Floresta

PHYSICAL-MECHANICAL WOOD PROPERTIES FROM INVASIVE EXOTIC SPECIES OF ATLANTIC FOREST

Carolina Nogueira Xavier[1*], Raphaelly de Oliveira Ferreira[2], Pedro Henrique de Paula Silva[3], José Reinaldo Moreira da Silva[4], Andrea Vanini[5], Alexandre Monteiro de Carvalho[6]

[1*]Universidade Federal de Lavras, Programa de Pós-Graduação em Ciência e Tec. da Madeira, Lavras, MG, Brasil – ncarolx@gmail.com
[2]Universidade Federal de Lavras, Curso de engenharia florestal, Lavras, MG, Brasil - raphaelly.oliveira.f@gmail.com
[3]Universidade Federal de Lavras, Curso de engenharia florestal, Lavras, MG, Brasil - pedrohpgalo@gmail.com
[4]Universidade Federal de Lavras, Departamento de Ciências Florestais, Lavras, MG, Brasil - jreinaldoms@gmail.com
[5]Fundação Oswaldo Cruz, Campus Mata Atlântica da Fiocruz, Rio de Janeiro, RJ, Brasil - vanini.andrea@gmail.com
[6]Universidade Federal Rural do Rio de Janeiro, Departamento de Produtos Florestais, Seropédica, RJ, Brasil - amcarvalho.ufrrj@gmail.com

Received for publication: 17/08/2020 – Accepted for publication: 24/12/2022

Resumo

Propriedades físico-mecânicas de madeiras de espécies exóticas invasoras da mata atlântica. Árvores de espécies exóticas invasoras causam diversos problemas à biota mundial. A remoção destas árvores é importante para o restabelecimento do equilíbrio do ecossistema. Entretanto, esta retirada implica em dar destinação ao material gerado. O desconhecimento das características das madeiras torna difícil indicar seus usos mais adequados, o que dificulta a valorização do material. O objetivo do estudo foi avaliar as propriedades físicas e mecânicas e indicar as alternativas de uso das madeiras oriundas de espécies exóticas invasoras da Estação Biológica Fiocruz Mata Atlântica, Rio de Janeiro - RJ. Foram estudadas três espécies, *Artocarpus heterophyllus* Lamarck (Jaqueira), *Syzygium cumini* (L.) Skeels (Jamelão) e *Clitoria fairchildiana* R.A. Howard (Sombreiro). As propriedades físicas e mecânicas foram determinadas, analisadas em três regiões distintas no sentido medula-casca, denominadas central, intermediária e externa. A madeira de *Artocarpus heterophyllus* apresentou densidade básica baixa, as contrações foram menores na região central, sendo a região intermediária a que apresentou maior resistência mecânica. A madeira de *Syzygium cumini* apresentou densidade média, as propriedades mecânicas aumentaram no sentido medula-casca e as contrações radiais e volumétricas foram menores na região central. A madeira de *Clitoria fairchildiana* apresentou densidade média e foi a espécie que apresentou a menor resistência mecânica. As três espécies possuem propriedades físicas apropriadas para serem empregadas no setor moveleiro e a madeira de *Syzygium cumini* apresentou resistência mecânica adequada para ser utilizada na construção civil.
Palavras-chave: Artocarpus heterophyllus, Syzygium cumini, Clitoria fairchildiaxsna, Qualidade da madeira.

Abstract

Physical-mechanical wood properties from invasive exotic species of Atlantic Forest. Invasive exotic tree species cause several problems to the world biota. Removing these trees is important for restoring ecosystem balance. However, after the removal, there is a concern regarding the proper destination of the generated materials. The lack of knowledge about the wood characteristics makes it difficult to recommend for the most appropriate uses, which leads to a low added value of the product. The aim of the study was to assess the physical and mechanical wood properties and indicate the alternatives for using wood from exotic invasive species at the Fiocruz Mata Atlântica Biological Station, Rio de Janeiro - RJ. The three species studied were *Artocarpus heterophyllus* Lamarck (Jackfruit), *Syzygium cumini* (L.) Skeels (Java plum) and *Clitoria fairchildiana* R.A. Howard (Sombreiro). The physical and mechanical wood properties were determined in three distinct regions, denominated central, intermediate and external, ranging from pith-bark direction. The wood of *Artocarpus heterophyllus* had low basic density, retractions were lower in the central region, and the intermediate region had the highest mechanical resistance. The *Syzygium cumini* wood had medium density, the mechanical properties increased in the pith-bark direction, and the radial and volumetric retractions were lower in the central region. *Clitoria fairchildiana* wood had medium density and had the lowest mechanical resistance from the species evaluated. The three species have appropriate physical properties for the furniture sector, and the *Syzygium cumini* wood presented adequate mechanical resistance for civil construction.
Keywords: Artocarpus heterophyllus, Syzygium cumini, *Clitoria fairchildiana*, Wood Quality.

INTRODUCTION

According to the Convention on Biological Diversity (CDB) at the sixth session of the Conference of the Parties (COP-6, 2002), the definition of exotic species is that once it has been established in a new habitat, it expands its distribution and starts to threaten the endogenous biological diversity. Invasive exotics species contribute to the homogenization of the landscape, reducing biodiversity and altering the ecosystem flow in an undesirable manner (CARDINALE *et al.*, 2012; GAERTNER *et al.*, 2011). They are one of the main causes of native species extinction. Thus, they must be removed from areas designated for ecosystem conservation

Universidade Federal do Paraná
Setor de Ciências Agrárias
Pós-graduação em Engenharia Florestal
Revista Floresta

(DECHOUM *et al.*, 2018). Actions aiming to remove invasive exotic species are necessary to reestablish the biodiversity balance. Nevertheless, the suppression of such tree species is challenging regarding the proper destination of the ligneous material.

As specified by the orientation guide to the management of invasive exotic species in the federal conservation units from ICMBio (2019), the most usual practice is to leave the felled tree at the ground field site for decomposition. However, it is necessary to explore other alternative ways to transform this material into a more added-value product. Thus, the development of studies concerning the technological characterization of wood from invasive species aims to make its use viable as a raw material for timber purposes. Once, the basic research of biological invasions is focused on the management and control of invasive species (ZENNI *et al.*, 2016).

In India, where *Artocarpus heterophyllus* Lamarck (Jaqueira) is considered a native species, its wood has chemical compounds used in the fabric dyeing process (SAMANTA; AGARWAL; DATTA, 2009). On the other hand, in Indonesia, *Artocarpus heterophyllus* wood is utilized in shipbuilding, and it is classified as a strong and durable wood requisite according to the standards for building ships (THAIB *et al.*, 2019).

Ramananantoandro *et al.* (2016) state that *Syzygium cumini* wood can be used as an alternative to replacing high-added-value species in Madagascar. However, there are necessary studies related to the aesthetics and mechanical properties of this species. In India, its center of origin, the wood of the genera *Syzygium* is utilized for construction, furniture, flooring, poles, and *Syzygium cumini* is considered a species with higher economic importance (WANGKHEM; SHARMA; SHARMA, 2020).

Therefore, this work aimed to assess the physical and mechanical wood properties of invasive exotic species to indicate use alternatives.

MATERIAL AND METHODS

Study material, site location and sampling method

In this study, the wood from the following invasive species: *Artocarpus heterophyllus* Lamarck (Jaqueira), *Syzygium cumini* (L.) Skeels (Jamelão) and *Clitoria fairchildiana* R.A.Howard (Sombreiro) were evaluated. The trees were obtained from the Biological Station of Fiocruz Atlantic Forest (EFMA), located at the buffer zone of the State Park of Pedra Branca, west zone of the municipality of Rio de Janeiro. According to the Köppen classification, the climate in the region is *Af*, presenting a humid tropical climate without dry season, with maximum precipitation during summer and minimum during winter season. Generally, pluviosity ranges from 1.500 to 2.500 mm.

Nine trees for each species were selected to be felled. Before being felled, they were georeferenced and later, the wood samples were stored at the Xilotec of the Department of Forest Products of the Forest Institute of the Federal Rural University of Rio de Janeiro (UFRRJ). The suppression of the trees was authorized by the tree cutting license number 002929, expedited by the Municipal Secretariat of Environment and Culture of the Rio de Janeiro – SMAC.

Physical and mechanical properties of wood

The selected logs were removed from the basal area of the tree, which were sectioned in a central plank and the wood specimens were sampled considering three distinct regions from pith-bark direction: central, intermediate and external region; each region was delimited by ⅓ of the log diameter (Figure 1).

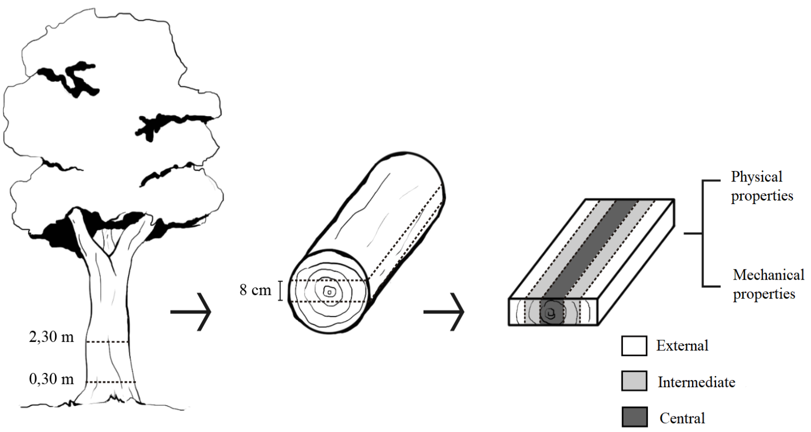

Figure 1 – Diagram of the log selection and removal of samples from the central plank according to the external, intermediate, and central regions.

Figura 1 – Esquema da seleção da tora e retirada dos corpos-de-prova do pranchão central em função das regiões externa, intermediária e central.

Nine trees of each species were utilized to determine the physical properties of wood. Three replicates were performed for each region, resulting in a total of 81 wood specimens per species. According to ASTM D143 standard (ASTM, 2014), the wood specimens were cutted following the standard dimensions of 100 x 25 x 25 mm, in the radial, tangential and axial directions, respectively. The wood specimens were submerged in water and they were saturated with the aid of a vacuum pump. A digital scale with a precision of 0.01g was used to measure the masses (dry and wet), and the dimensions were measured with a digital caliper with a precision of 0.01 mm. The wood specimens were placed in an oven at a temperature of 103°C ± 2°C for drying, and their dimensions were measured, until they reached a constant weight. After data collection, the radial, tangential and volumetric shrinkage, the anisotropy coefficient and the basic density of the wood specimens were calculated according to NBR 7190 standard (ABNT, 1997).

Seven trees of each species were used to analyze the mechanical properties of wood. Four mechanical tests were performed: compressive strength parallel to the grain, shearing strength, hardness parallel and perpendicular to the grain and static bending test, according to ASTM D143 standard (ASTM, 2014), with four replicates for each sampled region (external, intermediate and central). According to ASTM D143 standard (ASTM, 2014), the wood specimens were cutted from the central plank resulting in 84 wood specimens for each species and mechanical test. Then, they were stored in a controlled chamber at a room temperature of 22°C ± 2°C and relative air humidity of 60% ± 5%, until they reached the equilibrium moisture content at 12%.

During the Janka hardness test, a sphere with a diametral area of 1 cm² was inserted six times in the central area of the analyzed surface (section) for each wood specimen: twice parallel to the grain (transversal section) and four times perpendicular to the grain (radial and tangential sections).

The wood specimens utilized for the bending test had the growth rings positioned parallelly to the applied load and a span of 360 mm.

Statistical analysis

Statistical analyzes were performed using the R CoreTeam 3.4.3 software. Data normality was verified using the Shapiro-Wilk test and homogeneity using the Barlett and Levene test (α=0.05). After meeting the requirements, ANOVA was applied to evaluate the effect of basic density, shrinkage indexes, anisotropy coefficient, strength, stiffness and hardness of the woods, in the three radial regions (external, intermediate and central). Tukey test (α=0.05) was applied to determine differences between treatment mean values.

RESULTS

Physical properties

The results of the physical properties of the wood of *Artocarpus heterophyllus, Syzygium cumini,* and *Clitoria fairchildiana* in three regions in the pith-bark direction are shown in Table 1.

Table 1 - Physical properties of the wood of *Artocarpus heterophyllus, Syzygium cumini, and Clitoria fairchildiana,* in three regions in the pith-bark direction.

Tabela 1 - Propriedades físicas da madeira de *Artocarpus heterophyllus, Syzygium cumini* e *Clitoria fairchildiana*, em três posições no sentido medula-casca.

Physical properties	Region	*Artocarpus heterophyllus*	*Syzygium cumini*	*Clitoria fairchildiana*
Radial Shrinkage	External	3,73 (29,22) a	5,60 (17,57) a	4,96 (24,41) a
	Intermediate	3,40 (28,13) ab	5,81 (18,50) a	4,72 (34,29) a
	Central	2,86 (40,23) b	4,72 (19,93) b	4,69 (23,69) a
Tangential Shrinkage	External	6,19 (14,49) a	8,52 (13,16) a	6,90 (13,71) a
	Intermediate	5,98 (16,28) a	8,80 (14,02) a	7,02 (17,50) a
	Central	5,27 (21,52) b	9,11 (12,85) a	7,62 (19,96) a
Volumetric Shrinkage	External	11,15 (11,16) a	13,99 (9,87) ab	14,02 (12,88) a
	Intermediate	10,56 (13,39) a	14,89 (9,24) a	13,87 (18,88) a
	Central	9,00 (21,74) b	13,61 (7,69) b	14,38 (16,42) a

Anisotropy Coefficient	External	1,66 (35,66) a	1,52 (26,50) b	1,39 (27,56) a
	Intermediate	1,76 (38,92) a	1,51 (27,08) b	1,49 (30,69) a
	Central	1,84 (40,35) a	1,93 (34,29) a	1,62 (18,38) a
Basic Density ($g.cm^{-3}$)	External	0,458 (9,68) a	0,621 (4,21) a	0,540 (11,30) a
	Intermediate	0,461 (8,14) a	0,628 (4,47) a	0,520 (8,33) a
	Central	0,480 (8,53) a	0,622 (4,01) a	0,510 (14,22) a

Mean values followed by the same letters are not statistically different according to the Tukey test at 5% significance level. Coefficients of variation are represented in parenthesis.

It was noticed in the wood of *Artocarpus heterophyllus* that the radial, tangential, and volumetric shrinkage increases in the pith-bark direction. The anisotropy coefficient and basic density did not show significant differences between the regions studied.

Syzygium cumini wood showed lower radial and volumetric shrinkage in the central region. The anisotropy coefficient was higher in the central region. In the tangential shrinkage and in the basic density, no significant difference was observed between the regions.

For the wood of *Clitoria fairchildiana*, it was observed that the radial, tangential, volumetric shrinkage, the anisotropy coefficient, and the basic density did not have significant differences between the external, intermediate, and central regions.

Mechanical properties

Table 2 displays the mean values and the coefficients of variation of the mechanical properties of the wood of *Artocarpus heterophyllus, Syzygium cumini,* and *Clitoria fairchildiana* in the three distinct regions (external, intermediate and central).

Table 2 – Mechanical properties of the wood of *Artocarpus heterophyllus, Syzygium cumini, and Clitoria fairchildiana,* according to the pith-bark direction.

Tabela 2 – Propriedades mecânicas da madeira de *Artocarpus heterophyllus*, *Syzygium cumini* e *Clitoria fairchildiana* em função da posição medula-casca.

Mechanical properties (MPa)	Region	*Artocarpus heterophyllus*	*Syzygium cumini*	*Clitoria fairchildiana*
Compression strength parallel to the grain (f_{c0});	External	41 (12,67) b	53 (8,36) a	37 (16,19) a
	Intermediate	48 (12,72) a	52 (10,16) a	33 (28,02) a
	Central	44 (15,84) b	50 (12,94) a	32 (28,59) a
Modulus of Elasticity in compression strength (E_{c0})	External	5787 (12,74) b	7269 (9,60) a	5389 (19,93) a
	Intermediate	6510 (12,34) a	7210 (12,69) ab	4849 (33,50) a
	Central	5749 (17,42) b	6627 (16,41) b	4658 (36,06) a
Shear strength (f_v)	External	12 (17,28) b	15 (9,26) a	11 (23,36) a
	Intermediate	13 (18,56) a	14 (14,03) b	11 (23,46) a
	Central	12 (22,49) b	14 (14,80) b	10 (22,86) a
Janka Hardness parallel to the grain (f_{H0})	External	56 (18,07) a	90 (10,39) a	60 (20,76) a
	Intermediate	59 (10,61) a	88 (11,32) ab	58 (19,89) ab
	Central	57 (18,46) a	85 (13,45) b	54 (29,39) b
Janka Hardness perpendicular to the grain (f_{H90})	External	45 (21,48) a	78 (14,08) a	56 (26,23) a
	Intermediate	48 (18,43) a	75 (13,91) ab	55 (25,77) ab
	Central	46 (24,78) a	73 (14,39) b	50 (36,04) b
Modulus of Elasticity in bending test (MOE)	External	10656 (13,04) a	12940 (12,08) a	9105 (22,95) a
	Intermediate	11112 (12,19) a	12692 (21,44) a	7781 (30,18) a
	Central	10288 (13,36) a	12462 (19,38) a	8006 (30,16) a
Modulus of Rupture (MOR)	External	82 (16,65) a	105 (15,22) a	75 (25,04) a
	Intermediate	89 (15,00) a	102 (20,51) a	62 (38,54) a
	Central	81 (19,88) a	103 (16,35) a	94 (33,89) a

Mean values followed by the same letters are not statistically different according to the Tukey test at 5% significance level. Coefficients of variation are represented in parenthesis.

Artocarpus heterophyllus wood had a significant difference between regions regarding compressive strength, modulus of elasticity, and shear strength, with the intermediate region being the most resistant. Hardness strength, modulus of elasticity, and modulus of rupture did not differ significantly between regions. The hardness strength parallels to the grain (transverse section) was 24% higher than the hardness strength perpendicular to the grain (radial and tangential sections).

The modulus of elasticity in compression strength and the resistance to hardness strength parallel and perpendicular to the grain in *Syzygium cumini* wood had significant differences between the regions; its external region had the greatest resistance. This wood species also tended to increase the values of its mechanical properties in the pith-bark direction. The transverse sections of *Syzygium cumini* wood were 16% more resistant to hardness strength, demonstrated by the greater resistance to hardness strength parallel to the grain compared to hardness strength perpendicular to the grain.

Clitoria fairchildiana wood had the greater resistance to hardness strength observed in the external region. The other mechanical properties showed no statistical difference between the analyzed regions.

DISCUSSION

Physical properties

The basic density of *Artocarpus heterophyllus* wood is classified as low density (≤0.50 g.cm^{-3}), whereas the woods of *Syzygium cumini* and *Clitoria fairchildiana* are classified as medium density (0.50 - 0.72 g.cm^{-3}) (CORADIN, 1991).

Radial (2.86 - 3.73%) and tangential (5.27 - 6.19%) shrinkage of *Artocarpus heterophyllus* wood can be assimilated to Mahogany wood (*Swietenia macrophylla*) 3.2% (radial) and 4.5% (tangential) (IPT, 1989). The radial shrinkage from the wood of *Syzygium cumini* ranged from 4.72 to 5.60% and tangential shrinkage ranged from 8.52 to 9.11%. These values are close to the radial (4.40%) and tangential (8.5%) shrinkages of Garapa wood (*Apuleia leiocarpa*) (IPT, 2013). The radial (4.69 - 4.96%) and tangential (6.90 - 7.62%) shrinkage of *Clitoria fairchildiana* wood had similar values to Tauari wood (*Couratari oblongifolia*), whose radial and tangential shrinkages are 4.2% and 6.6%, respectively (ANPM, 2015). Hence, the woods of *Artocarpus heterophyllus*, *Syzygium cumini* and *Clitoria fairchildiana* have good performance in the shrinkage parameter, and they have the potential for the furniture manufacturing, since they have shrinkage indexes compatible with woods indicated for furniture use.

Wood shrinkage is an important attribute for use in the furniture industry because it indicates the possible orientation of cracks and gaps that may occur between wooden pieces of a furniture, and that harm wood joints (LOPES *et al.*, 2011).

The ratio between tangential and radial shrinkage is called the anisotropy coefficient. This value demonstrates the dimensional stability of wood; the closer to value one, the more dimensionally stable is the material (DURLO; MARCHIORI, 1992). This provides less warping and cracking during the drying process. The following criteria are used in the classification of anisotropy coefficient: values ranging from 1.2 to 1.5 represents woods with excellent stability; 1.5 to 2.0 values are woods considered with normal dimensional stability; and values above 2.0 are woods that present poor dimensional stability, meaning they have dimensional instability (DURLO; MARCHIORI, 1992).

The anisotropy coefficient in the external and intermediate region of *Clitoria fairchildiana* wood was classified as having excellent dimensional stability (1.2 to 1.5). That indicates this wood species for fine furniture, window frames and musical instruments manufacturing. For the three regions of the wood of *Artocarpus heterophyllus* and *Syzygium cumini*, and for the central region of *Clitoria fairchildiana*, they were classified as having normal dimensional stability (1.5 to 2.0). Thus, they can be utilized for tables, shelves and cabinets manufacturing. In the three species studied, the wood of the central region of the tree has the lower dimensional stability, as it has the highest anisotropy coefficient values.

Mechanical properties

According to the resistance classes of NBR 7190 standard (ABNT, 1997), *Artocarpus heterophyllus* and *Clitoria fairchildiana* are classified as C20 and *Syzygium cumini* is classified as C30. Among the three studied species, *Clitoria fairchildiana* wood had the lowest values of mechanical resistance.

The transverse sections of the wood of *Artocarpus heterophyllus* and *Syzygium cumini* showed greater resistance to hardness. This wood behavior is similar to that observed in the wood of *Eucalyptus benthamii*, a fact associated with the disposition of the fibers according to the axial direction of the trunk, since it is the anatomical element responsible for the support and mechanical resistance of the wood (BENIN *et al.*, 2017).

The wood of *Artocarpus heterophyllus* is mechanically similar to the wood of Cedrinho (*Erisma uncinatum*), which is indicated for light external civil construction and light internal structural construction (IPT, 2009). The mechanical properties presented by *Syzygium cumini* wood indicates its use for heavy civil construction and light external, internal and light structural. The wood of *Clitoria fairchildiana* had the lowest mechanical resistance compared to the other species, which indicates light internal civil construction use.

The wood of *Artocarpus heterophyllus*, *Clitoria fairchildiana* and the intermediate and central regions of *Syzygium cumini* were considered of medium hardness strength and were equivalent to wood of Cedrinho (*Erisma uncinatum*). The wood of the external region of *Syzygium cumini* was classified as high hardness strength, according to the classification of hardness strength perpendicular to the grain of the National Association of Wooden Floors - ANPM (2015), and resembles the species of Cupiúba (*Goupia glabra*) in terms of hardness strength.

Syzygium cumini wood has adequate mechanical strength and density to be used as a fence pole, as it meets the minimum requirement of NBR 9480 standard (ABNT, 2009) which determines the minimum static flexural strength of 52 Mpa and basic wood density greater than or equal to 0.540 g.cm^{-3} for this use. In addition, further studies of natural durability are necessary in order to suggest a suitable preservative treatment for fence poles.

CONCLUSIONS

- Regarding the physical properties, the wood from the three species studied have potential to be utilized in the furniture sector.
- In relation to the mechanical properties, the three wood species studied have suitable hardness to be utilized in flooring, but it is fundamental to perform flooring tests to verify other requisites according to standards.
- The wood of *Syzygium cumini* has suitable mechanical resistance to be utilized in structural use and as fence pole, but it is necessary to perform further studies aiming its natural durability and treatability with preservatives compounds.

ACKNOWLEDGEMENTS

We would like to acknowledge the staff of Fiocruz Atlantic Forest for all the support and material donation. The present study was done and supported by the Coordination for the Improvement of Higher Education Personnel – Brasil (CAPES) – Financial code 001. We also would like to thank the Federal University of Lavras and the Federal Rural University of Rio de Janeiro for all the laboratory infrastructure to perform the experimental tests.

REFERENCES

AMERICAN SOCIETY FOR TESTING AND MATERIALS. **ASTM D-143:** Standard methods of testing small clear specimens of timber, Philadelphia, USA, 32 p., 2014.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. ABNT. **NBR 9480*:*** peças roliças preservadas de eucalipto para construções rurais - Requisitos. Rio de Janeiro: ABNT; 2009. 12 p.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **NBR 7190:** Projeto de Estruturas de Madeira. São Paulo, 1997. 107p.

ASSOCIAÇÃO NACIONAL DOS PRODUTORES DE PISOS DE MADEIRA - ANPM. **Pisos de madeira: características de espécies brasileiras**. Piracicaba: ANPM, 2015. 184p.

BENIN, C. C.; WATZLAWICK, L. F.; HILLIG, É. Propriedades físicas e mecânicas da madeira de *Eucalyptus benthamii* sob efeito do espaçamento de plantio. **Ciência Florestal**, Santa Maria, v. 27, n. 4, p. 1375-1384, 2017.

CARDINALE, B. J.; DUFFY, J. E.; GONZALEZ, A.; HOOPER, D. U.; PERRINGS, C.; VENAIL, P.; NARWANI, A.; MACE, G. M.; TILMAN, D.; WARDLE, D. A.; KINZIG, A. P.; DAILY, G. C.; LOREAU, M.; GRACE, J. B.; LARIGAUDERIE, A.; SRIVASTAVA, D.S.; NAEEM, S. Biodiversity loss and its impact on humanity. **Nature**, London, v. 486, n. 7401, p. 59-67, 2012.

CONFERENCE OF THE PARTIES TO THE CONVENTION ON BIOLOGICAL DIVERSITY – COP-6 da CDB. 2002. **Report of the Sixth Meeting of the Conference of the Parties of the Convention on Biological Diversity**. 341p. Disponível em: <https://www.cbd.int/doc/meetings/cop/cop-06/official/cop-06-20-en.pdf>. Acesso em 28 de abril de 2020.

CORADIN, V. T. R. **Normas de procedimentos em estudos de anatomia de madeira: I. Angiospermae. II. Gimnospermae**. IBAMA, Laboratório de Produtos Florestais, 1991.

DECHOUM, M. D. S.; SAMPAIO, A. B.; ZILLER, S. R.; ZENNI, R. D. Invasive species and the Global Strategy for Plant Conservation: how close has Brazil come to achieving Target 10?. **Rodriguésia**, Rio de Janeiro, v. 69, n. 4, p. 1567-1576, 2018.

DURLO, M. A.; MARCHIORI, J. N. C. **Tecnologia da madeira: retratibilidade.** Santa Maria: CEPEF/FATEC, 1992. 33p. (Série Técnica, 10).

GAERTNER, M.; RICHARDSON, D. M.; PRIVETT, S. D. J. Effects of alien plants on ecosystem structure and functioning and implications for restoration: insights from three degraded sites in South African fynbos. **Environmental management**, New York, v. 48, n. 1, p. 57-69, 2011.

ICMBio - Instituto Chico Mendes de Conservação da Biodiversidade. **Guia de orientação para o manejo de espécies exóticas invasoras em unidades de conservação federais.** 135p. 2019.

IPT - INSTITUTO DE PESQUISAS TECNOLÓGICAS DO ESTADO DE SÃO PAULO. **Fichas de Características das Madeiras Brasileiras**. 2a ed. São Paulo: IPT, 1989. 418p. (publicação IPT Nº 1791).

IPT - INSTITUTO DE PESQUISAS TECNOLÓGICAS DO ESTADO DE SÃO PAULO. **Madeira: uso sustentável na construção civil**. São Paulo: IPT, 2009. 103p. (publicação IPT Nº 3010).

IPT - INSTITUTO DE PESQUISAS TECNOLÓGICAS DO ESTADO DE SÃO PAULO. **Catálogo de madeiras brasileiras para a construção civil**. São Paulo: IPT, 2013. 104p. (publicação IPT Nº 4371).

LOPES, C. S. D.; NOLASCO, A. M.; TOMAZELLO FILHO, M.; DIAS, C. T. D. S.; PANSINI, A. Estudo da massa específica básica e da variação dimensional da madeira de três espécies de eucalipto para a indústria moveleira. **Ciência Florestal**, Santa Maria, v. 21, n. 2, p. 315-322, 2011.

RAMANANANTOANDRO, T.; RAMANAKOTO, M. F.; RAJOELISON, G. L.; RANDRIAMBOAVONJY, J. C.; RAFIDIMANANTSOA, H. P. nfluence of tree species, tree diameter and soil types on wood density and its radial variation in a mid-altitude rainforest in Madagascar. **Annals of forest science**, France, v. 73, n. 4, p. 1113-1124, 2016.

SAMANTA, A. K.; AGARWAL, P.; DATTA, S. Studies on color interaction parameters and color fastness properties for dyeing of cotton fabrics with binary mixtures of jackfruit wood and other natural dyes. **Journal of Natural Fibers**, Filadélfia, v. 6, n. 2, p. 171-190, 2009.

THAIB, R.; LUBIS, R. Z.; RUSYDI, I.; CHALILUDDIN, C.; AFFAN, J. M.; PUTRA, D. F.; YUSRIZAL, Y. The assessment of wood utilization rate at UD. Karya Lomba Shipyard, Aceh Besar, Indonesia. **IOP Conference Series: Earth and Environmental Science.** v. 348. n.1, 2019.

WANGKHEM, M.; SHARMA, M.; SHARMA, C. L. Comparative wood anatomical properties of genus *Syzygium* (family Myrtaceae) from manipur, India. **Indonesian Journal of Forestry Research,** Jakarta, v. 7, n.1, p. 27-42, 2020.

ZENNI, R. D.; DE SÁ DECHOUM, M.; ZILLER, S. R. Dez anos do informe brasileiro sobre espécies exóticas invasoras: avanços, lacunas e direções futuras. **Biotemas**, Santa Catarina, v. 29, n. 1, p. 133-153, 2016.