

Rosewood trade: A case study of the imports into the United States

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Abstract

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The protection of endangered plant species is a shared goal for governments and environmental agencies around the world. Currently, the term Rosewood does not refer to a taxonomical category in particular, and the inclusion of different species or set of species into this denomination depends almost exclusively on the exporter and importer countries. This research illustrates, as a case study, the generalities of the species more commonly traded as Rosewood and the analysis of their imports into the United States from 2007 to 2021. Additionally, to get a better understanding of the challenges of tracking Rosewood trade, an overview of some of the advantages and limitations of the available trade data is presented. Significant differences in the

description of wood products by exporting countries and the recurrent ambiguity in the use of common and vernacular names appear to be the main issues to analyze Rosewood trade data, and one of the reasons why the report of this set of species is often included within the category of tropical hardwoods. The implementation of the 2008 amendment of the U.S. Lacey Act, which regulates wildlife trade, combined with the inclusion of all species of Dalbergia into the CITES appendices in 2017, showed a significant impact in the dynamics of rosewood imports into the U.S., and how exporter countries report their trade.

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1. INTRODUCTION

The set of hardwood species commonly known as Rosewood is distributed mostly in West and Central Africa, Southeast Asia, and Latin America and is largely used for luxury furniture, musical instruments, and flooring. Due to its special anatomical characteristics and durability, Rosewood species have been in the scope of traders, traffickers, researchers, and governmental authorities for decades (Forest Policy, Trade, and Finance program, 2020). The harvest of Rosewood from natural forests is usually performed at low cost by local workers and its commercialization is often associated with corrupt practices by domestic authorities, enabling a system that amplifies the inequality and poverty within the extraction areas, where the illegal traffickers have become significant actors in the future of the communities and the forest ecology of the territories (Duraiappah, 1998; Patel, 2017). Given the particular considerations of Rosewood trade and the high risk that over-exploitation represents for these species, the implementation of policies for their protection is crucial. Two important actions have been taken in the protection of Rosewood species that directly affect their import into the U.S.: (1) The latest amendment of the U.S. Lacey Act, signed in 2008, which regulates and restricts the imports into the US territory of species that are part of the CITES appendices and provides the description of subsequent legal consequences of violation of this regulation, which varies from financial penalties to the imputation of criminal charges; and (2) the inclusion in 2017 of all species within the genus *Dalbergia* into the Appendices I and II of the CITES, with the purpose of regulating their trade. Although these measures have changed some of the dynamics of the commercialization of Rosewood, their impact on the illegal importation of Rosewood into the U.S currently lacks conclusive evidence.

The implementation of policies for the protection of vulnerable species, including Rosewood, implies political, environmental, and social changes that cannot and should not be ignored by governments, environmental agencies, and academia. For many years, hundreds of species of valuable hardwoods have been over-harvested for financial return, putting populations at risk of disappearance, and changing the dynamics within the biological communities associated with these ecosystems. Strategies to promote forest legality in countries with high deforestation rates, do not always seem to be sufficient in areas where poverty and government corruption are cause and effect of the degradation of the territories. The application of bans for exports or imports of certain species needs to be analyzed from many perspectives within ecological, financial, social, and political disciplines; the success of its implementation and enforcement also varies based on geographical features, and their timeframe. The case of Ghana exemplifies how the application of new policies, the enforcement of the existing legislation, and the intents for international cooperation is very often reduced by corruption and poor forest legality practices, and shows the difficulty of successfully implementing bans in a country which governance issues puts excessive pressure in their natural resources (Hoare, 2014). The application and constant changes of felling and export bans of African Rosewood (*Pterocarpus erinaceus*) in Ghana signified an increase of 129% in the exploitation of such species from 2016 to 2018, showing challenges in the implementation and enforcement of these policies (Dumenu, 2019). The regulations imposed by some of the producing countries have repeatedly allowed illegal loggers and traffickers to benefit from exceptions to bans on exports, as is the case of the authorization for Rosewood exports from Madagascar during four months in 2010, where the government transition meant the

continuing loss of forest resources and degradation of the vital ecosystem necessary for the survival of rosewood (Bohannon, 2010; Phelps et al., 2011).

Trade regulation efforts made by individual countries and NGOs, including the 2008 amendment of the U.S. Lacey Act as the first ban on illegally traded timber, has been a significant step in recognition of a global problem in which cooperation between producer and consumer countries is indispensable to achieving common goals. However, the enforcement of the U.S. Lacey Act as the first complete ban on illegally harvested wood, does not depend exclusively on U.S. sovereignty; international regulations from exporter countries and the application of due care and due diligence standards in the trade processes by importer companies are key to its effective implementation and are often difficult to trace (Lee, 2014). A prior analysis of the impact of the Lacey Act in forest products has shown a reduction in the imports of wood in the rough from likely illegal sources. Unfortunately, there is also indication that potentially illegally sourced wood may be redirected from countries with stronger trade policy enforcement to countries with weaker implementation of environmental policies, where the wood is processed and exported back to the U.S. as a finished product. In such cases, the detection of species included in the CITES appendices or that is locally banned becomes more difficult due to the commingling of legally and illegally sourced wood during the processing of furniture or other wood products (Bridegam et al., 2015). The implementation of concepts as “Due care” and “Due diligence” in the tracing of imports into the U.S. is still a concern for private companies and environmental authorities given the challenges for the corroboration of such information in practice. The efforts in the control of trade of Rosewood species within the U.S. territory follow the premise of high levels of illegality affecting this set of hardwood at a global scale. However, the amount of illegal Rosewood

entering U.S. land is unknown and the data presented in this study relates the changes of most likely legal imports of Rosewood after the implementation of policies like the 2008 amendment of the U.S. Lacey Act and the inclusion of all species from genus *Dalbergia* into the Appendices I and II of CITES. The estimate of the total timber that enters the U.S. illegally, based on data gathered by Chatham House in 2014, seems to have increased from 2000 to 2006, declined from 2007 to 2011 and increased again from 2011 to 2013. Additional to these changes in the estimate in potentially illegally sourced wood, the number of seizures of shipments containing illegally sourced wood, including Rosewood, increased from 10 total shipments seized in 2010 to 142 in 2012, which could be due to a stronger implementation of forest policies by the U.S. Law Enforcement (Momii, 2014).

To develop general parameters for the trade of specimens of endangered species, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) was signed on 1973 and amended in 1979 and 1983 being currently one of the strongest tools for the protection of species, with 178 Member States and the regulation of international trade for over 35,000 species of plants and animals. As a fundamental principle, CITES divided the restrictions on international trade into three Appendices, depending on local and global parameters of the vulnerability of endangered species, and provides different restrictions and regulations within states. All species within genus *Dalbergia* are currently included in the CITES Appendices, with all but one species in Appendix II and one species in Appendix I. This inclusion process started in 1992 with the addition of *Dalbergia nigra* into Appendix I and continued after 2008 with the inclusion of threatened species from populations in Guatemala, Panama, and Madagascar. In 2017, given the complexity of the identification of species within the genus, CITES decided to

include the rest of species into the Appendix II, intending a substantial decrease in the global trade of endangered Rosewood (Barret et al., 2005; CITES, 2021). One of the fundamental reasons for the inclusion of all species of genus *Dalbergia* into the Appendices I and II of CITES is the complexity of the identification of species within the genus based on their anatomical characteristics. Despite the variety of methods for wood identification, the anatomical recognition of species seems to be preferred by environmental authorities for its accuracy and practicality. Given advances in computer science and machine vision techniques, the precision with which wood species can be identified is rapidly and continuously improving, thereby helping with the implementation of trade policies and law enforcement (Hermanson & Wiedenhoef, 2011).

With these considerations in mind, there is still uncertainty of how the implementation of policies to restrict illegally sourced wood into U.S. territory has affected the imports of Rosewood. For this reason it is the intent of this research to (1) Determine the most commonly traded species of Rosewood, (2) analyze Rosewood imports into the U.S., and identify any disruptions in Rosewood trade and whether these disruptions are related to the implementation of CITES designations, the Lacey Act, or country export bans, and (3) to offer an overview of the advantages and challenges of using the available Rosewood trade data, as well as to provide recommendations for better practices in the collection of trade data at the national level. This thesis will offer an overview of the advantages and challenges of using the available Rosewood trade data, as well as to provide recommendations for better practices in the collection of trade data at the national and global level, reveal the similarities and differences between Rosewood

species, analyze the potential reasons of the challenges in their identification, and present available tools to improve their recognition.

2. CHAPTER 1. ROSEWOOD CHARACTERISTICS, TRADE RESTRICTIONS, AND CONSERVATION STATUS

2.1. Introduction

Despite its extensive trade, particularly in the Asian market, there is not an absolute consensus on which species are included in the category of Rosewood. Under the denomination of “Hongmu”, as Rosewood is widely known in China and other Asian markets, and which translates “Red wood”, there are approximately 30 species from the genus *Dalbergia*, *Pterocarpus*, *Diospyros*, *Millettia*, and *Cassia* that have been targeted by importers for luxury furniture and flooring (**Table 1**) (Environmental Investigation Agency, 2016; UNODC, 2020). The conservation status of species considered as “Hongmu” and many of the species from the genus *Dalbergia* reveals major consequences of the insufficient implementation of policies and law enforcement by local and national authorities in both producer and consumer countries. Strategies taken by governments to promote forest legality in countries with high deforestation rates, including the adoption of the Forest Law Enforcement and the Governance and Trade (FLEGT) Action Plan, have been insufficient in areas with high rates of poverty and corruption (Hoare, 2014). According to information presented by Forest Trends, from 2012 to 2019 the countries that represent the highest risks for imports to the U.S. by their log export restrictions are located mostly in West and Central Africa, South and Central America, and Southeast Asia, usually associated with high levels of illegality in the trade of tropical hardwood (Forest Trends, 2021). With the adoption of the 2008 amendment of the U.S. Lacey Act, the process of verifying the legality of the imports of wood into U.S. territory became a more meticulous task for the environmental authorities given the complexity in the identification of species, and the dependence on international logging bans.

The Animal Plant Health Inspection Service (APHIS), U.S. Customs, and Border Protection and the U.S. Fish and Wildlife Services are the most relevant entities in charge of guaranteeing the compliance of national and international regulations of the imports of any plant or animal species that enters American territory, verifying the authenticity of the declared species and the compliance of the regulations.

The classification of Rosewood usually depends on the market needs and demographic characteristics of the consumer countries. Although there is no general agreement of all the species included in this category of hardwood, the objective of this research is to provide valuable information about the most commonly traded species for the last several decades and to contribute to their description and further protection through policy implementation. For the interest of this research, two systems of classification are analyzed: the species considered as “Hongmu” in the Asian market from genus *Cassia*, *Dalbergia*, *Pterocarpus*, and *Millettia*; and the classification that includes all species within genus *Dalbergia*, which is entirely protected by the 2017 inclusion into the CITES Appendices I and II.

2.2. Species commonly traded as Rosewood and their conservation status

To understand the importance of the classification of Rosewood -or Hongmu- within the Asian market, it is relevant to point out that more than 80 percent of the volume of hardwood that was traded globally in 2018 derived from the demand by Chinese companies. In some cases, the illegal import of Rosewood by these industries happens through the purchase of unprocessed wood products that arrive to the country as unidentified logs and which avoid the inspection of local authorities (UNODC, 2020; Wainwright & Zempel, 2017). The list of species presented in **Table 1** is a representation of the preferences within the Asian market and does not necessarily

correspond to a classification by biological or botanical patterns. As an example of this, is the inclusion of some species from genus *Diospyros*, commonly commercialized as Ebony, which botanical and anatomical classification are distinct from the species within the genus *Dalbergia*. Approximately 70 percent of the hardwood species within the “Hongmu” classification are threatened by overexploitation and are harvested in areas with weak policy implementation and law enforcement. More than half of these species are included in the CITES Appendices for the regulation of their international trade (CITES, 2021; IUCN, 2021). Even though this research focuses on Rosewood imports into the U.S., the categorization of species includes the ones recognized as Hongmu in the Asian market since are the most commonly traded and which information about their vernacular and scientific names is available.

Table 1. Species categorized as "Hongmu" in the Chinese market, including their scientific and vernacular name, their existing export bans (if applicable) and their conservation status. *Adapted from UNODC, 2020; IUCN, 2021; CITES, 2021; Forest Trends, 2021.

Rosewood species	Common name(s)	Export bans that apply - Date of implementation	Conservation status
<i>Cassia siamea</i>	Siamese Senna		Least Concern
<i>Dalbergia bariensis</i>	Burmese Rosewood, Tamalan	CITES Appendix II - 02/01/2017; Cambodia: ban on exports of endangered and rare species – 07/30/2002; Vietnam: ban on exports of specific products derived from protected species – 03/30/2006	Endangered
<i>Dalbergia cearensis</i>	Kingwood	CITES Appendix II - 02/01/2017; Cambodia: ban on exports of endangered and rare species – 07/30/2002; Vietnam: ban on exports	Near Threatened

Rosewood species	Common name(s)	Export bans that apply - Date of implementation	Conservation status
		of specific products derived from protected species – 03/30/2006	
<i>Dalbergia cochinchinensis</i>	Siamese Rosewood	CITES Appendix II - 02/01/2017; Cambodia: ban on exports of endangered and rare species – 07/30/2002; Thailand: Restriction on export of certain protected species – 10/14/1941; Vietnam: ban on exports of specific products derived from protected species – 03/30/2006	Vulnerable
<i>Dalbergia cultrata</i>	Burmese Blackwood	CITES Appendix II - 02/01/2017; Thailand: Restriction on export of certain protected species – 10/14/1941;	Near Threatened
<i>Dalbergia frutescens</i>	Brazilian Tulipwood	CITES Appendix II - 02/01/2017	
<i>Dalbergia fusca</i>	Black Rosewood, Yinzat	CITES Appendix II - 02/01/2017	Near Threatened
<i>Dalbergia granadillo</i>	Cocobolo	CITES Appendix II- 12/06/2013	Critically Endangered
<i>Dalbergia latifolia</i>	Indian Rosewood	CITES Appendix II - 02/01/2017	Vulnerable
<i>Dalbergia louvelii</i>	Violet Rosewood, Bois de Rose	CITES Appendix II- 12/06/2013	Endangered
<i>Dalbergia melanoxylon</i>	African Blackwood	CITES Appendix II - 02/01/2017; Mozambique: ban on exports of raw logs of species categorized as Class 1 – 06/06/2002; Senegal: ban on harvesting and exploitation of protected species – 01/08/1998	Near Threatened

Rosewood species	Common name(s)	Export bans that apply - Date of implementation	Conservation status
<i>Dalbergia nigra</i>	Brazilian Rosewood	CITES Appendix I - 11/06/1992; Brazil: ban on exports of endangered and vulnerable species - 09/23/2008	Vulnerable
<i>Dalbergia odorifera</i>	Huang Hua Li, Fragrant Rosewood	CITES Appendix II - 02/01/2017	Vulnerable
<i>Dalbergia oliveri</i>	Burmese Rosewood, Tamalan	CITES Appendix II - 02/01/2017; Vietnam: ban on exports of specific products derived from protected species – 03/30/2006	Endangered
<i>Dalbergia retusa</i>	Cocobolo	CITES Appendix II- 12/06/2013	Critically Endangered
<i>Dalbergia spruceana</i>	Amazon Rosewood	CITES Appendix II - 02/01/2017	
<i>Dalbergia stevensonii</i>	Honduras Rosewood	CITES Appendix II - 02/01/2017; Belize: ban on exports of Rosewood (<i>Dalbergia stevensonii</i>) – 03/16/2012	
<i>Diospyros crassiflora</i>	African Ebony, Gabon Ebony	CITES Appendix II- 12/06/2013	Vulnerable
<i>Diospyros discolor</i>	Kamagong		
<i>Diospyros ebenum</i>	Ceylon Ebony	Solomon Islands: ban on the export of logs of several species, and on the export of additional species except for scientific research purposes – 09/21/2012	Data Deficient
<i>Diospyros philippensis</i>	Kamagong		
<i>Millettia laurentii</i>	Wenge, Bokonge, Awoung	Cameroon: partial ban on exports of logs of 20 tree species from 1999-2004, complete ban of these species thereafter – 10/13/1999	Endangered

Rosewood species	Common name(s)	Export bans that apply - Date of implementation	Conservation status
<i>Millettia leucantha</i>	Sothon/Sathon		Least Concern
<i>Pterocarpus cambodianus</i>	Vietnamese Padauk, Th'nong		Endangered
<i>Pterocarpus dalbergioides</i>	Andaman Padauk, Andaman Redwood		Vulnerable
<i>Pterocarpus erinaceus</i>	Kosso, African Barwood, African Kino	CITES Appendix II - 02/01/2017; Gambia: ban on exports of Rosewood (Pterocarpus erinaceus) – 11/30/2012; Ghana: ban on exports of Rosewood (Pterocarpus erinaceus) – 07/15/2014; Mali: ban on exports of Pterocarpus erinaceus – 12/31/2014; Senegal: ban on harvesting and exploitation of protected species – 01/08/1998	Endangered
<i>Pterocarpus indicus</i>	Malay Padauk, Amboyna, Burmacoast Padauk	Papua New Guinea: ban on exports of logs of 15 species – 01/01/1990; Philippines: ban on exports of lumber and semi-finished products from prohibited species – 05/06/1989; Solomon Islands: ban on the export of logs of several species, and on the export of additional species except for scientific research purposes – 09/21/2012	Endangered
<i>Pterocarpus macrocarpus</i>	Padauk, May Dou	Thailand: restriction on export of certain protected species – 10/14/1941; Vietnam: ban on exports	Endangered

Rosewood species	Common name(s)	Export bans that apply - Date of implementation	Conservation status
		of specific products derived from protected species – 03/30/2006	
<i>Pterocarpus marsupium</i>	Malabar Kino, Indian Kino Tree		Near Threatened
<i>Pterocarpus pedatus</i>	Padauk, Th'hong		Endangered
<i>Pterocarpus santalinus</i>	Red Sandalwood	CITES Appendix II - 13/09/2007; India: export quota on red sanders, ban on exports of red sanders except in the form of finished handicraft products and furniture - 12/31/2012	Endangered

2.3. Rosewood anatomical characteristics – *Dalbergia* catalogue

The identification of species of Rosewood, and tropical hardwood in general, has represented a difficult task for law enforcement globally. In many cases, the environmental officials lack training on wood anatomy, and do not have the adequate equipment to realize a complete examination of the wood in the field. The methodologies used for the recognition of species of commercial or ecological importance are often reduced to the officials' experience in the local hardwood, and keys of wood anatomy of local species, if available. The amount of time available to correctly identify wood that is being transported between countries is not always enough for environmental officials given the anatomical complexity of many Rosewood species; the similarities and differences within and between genera, the variability in the sample preparation, as well as the variations of anatomical characteristics in same species from different origin can incorporate error and lead to a wrong identification.

As part of the development of new technologies for the identification of species, the use of machine vision techniques for identifying species of great commercial and ecological value has become a feasible and reliable alternative to traditional methods of wood identification in the field. Some of the most innovative and reliable tools for identifying wood through anatomical characteristics are provided by the XyloTron® system. Introduced in 2011, the XyloTron® offers field-deployable features and a large database of vouchered images of hardwood and softwood species, combining the elements of machine vision, optics, electric engineering, and software engineering, with the attributes contemplated in wood anatomy (Hermanson & Wiedenhoef, 2011).

The development of the XyloTron® system opens a new frontier to law enforcement, environmental authorities, and academia, whereby it is possible to quickly and accurately identify wood within a matter of seconds at the family, genus, and species level (Hermanson et al., 2019). With partners around the world uploading images constantly, the XyloTron® image library includes species from tropical and temperate forests, and its system attempts to also incorporate anatomical variations within species from different origins. The model for wood identification used by the XyloTron® is trained with high-quality, properly vouchered images of wood that has been prepared following a strict sample preparation protocol. The images displayed in **Figure 1** to **Figure 4** correspond to wood samples of some of the species of genus *Dalbergia*, collected and prepared by XyloTron® international partners. A general description of their anatomical characteristics and their conservation status is also included. These figures were selected to illustrate and highlight the anatomical characteristics of some of the most important species within the genus and are intended to be a useful instrument for recognizing Rosewood. The

samples selected have been prepared to avoid artifacts and enhance the observable taxonomic features from the cross-sectional surface (Kitin et al., 2021). However, the conditions in which images of wood anatomical features are obtained in the field by law enforcement will probably not always be ideal. The XyloTron® system is currently training its model to consider imperfections in the wood samples such as scratches, cracks, or sand or knife marks, and integrating these features into the identification model.

The species of Rosewood from genus *Dalbergia* cannot be recognized solely by descriptive comparative anatomy, as they share similar taxonomic characteristics (IAWA Committee, 1989). In most cases, like the examples presented in **Figure 1**, the anatomical descriptions of the species are the same despite the fact that the images look significantly different. The variation of color depends greatly on the position of the sapwood-heartwood and the preservation of the sample. In addition to the anatomical features that make color between species vary significantly, variations in color could be a result of slight changes in lighting conditions at the moment of capturing the image, or by alterations in coloration due to external factors like ink, dirt, or dust; therefore, color cannot be considered a reliable taxonomic characteristic.

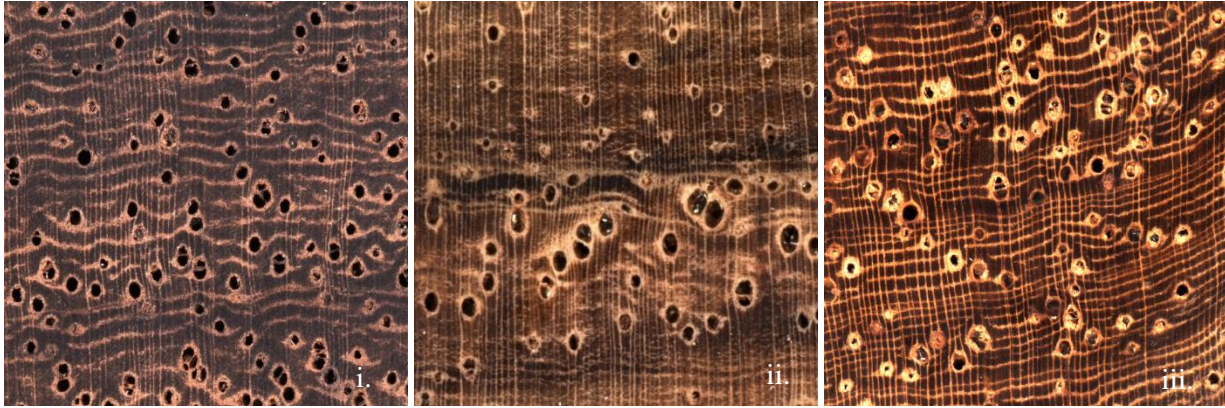


Figure 1. *Dalbergia* wood in cross sections. (i.) *Dalbergia latifolia* Roxb. Distributed in South and Southeast Asia. (ii.) *Dalbergia oliveri* Prain. Distributed in South and Southeast Asia. (iii.) *Dalbergia glomerata* Hemsl. Distributed in Mesoamerica. Common anatomic characteristics visible in cross-sectional surface: Pores are solitary or in small groups, narrow rays, axial parenchyma vasicentric, winged-aliform, reticulate, or terminal. *Images from the XyloTron® database

Anatomical differences between species or groups of species within the genus *Dalbergia* provide prospects for wood identification at the species level. Variations of axial parenchyma patterns and vessel size which potentially can be used for discrimination of species are displayed in **Figure 2** and **Figure 3**. Ongoing research with the XyloTron® system can develop a better understanding of what level of anatomical variation is species-specific. Differences in wood structure due to ontogenetic variations within species are also part of the factors considered in the construction of the XyloTron® database, as well as the variation driven by ecological and environmental dynamics such as water availability, climate, or seasonality.

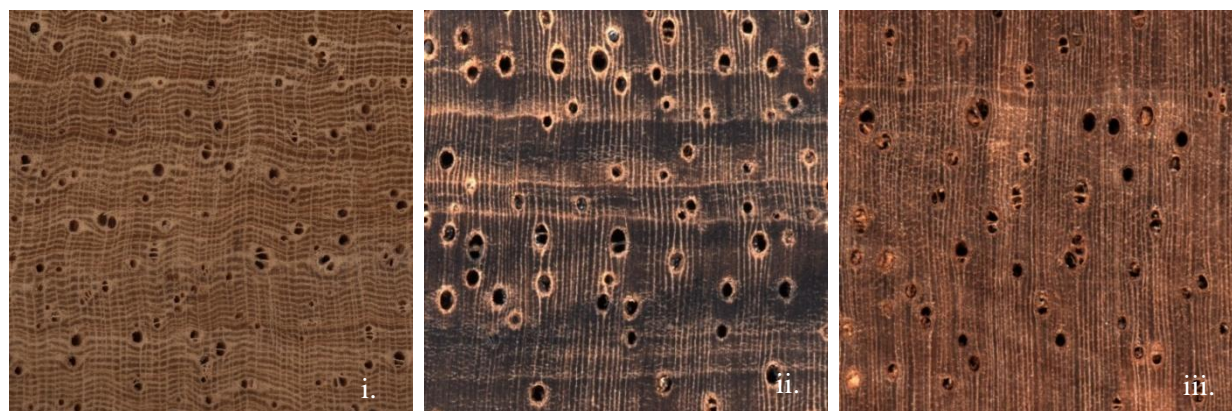


Figure 2. Variation of pattern of axial parenchyma in *Dalbergia* wood as visible in cross sections. (i.) *Dalbergia maritima* R.Vig. Distributed in Sub-Saharan Africa. **Winged-aliform, confluent, and reticulate parenchyma.** (ii.) *Dalbergia nigra* (Vell.) Benth. Distributed in South America. **Vasicentric paratracheal parenchyma and marginal bands.** (iii.) *Dalbergia retusa* Hemsl. Distributed in Mesoamerica and Sub-Saharan Africa. **Apotracheal and vasicentric paratracheal parenchyma.** *Images from the XyloTron® database.

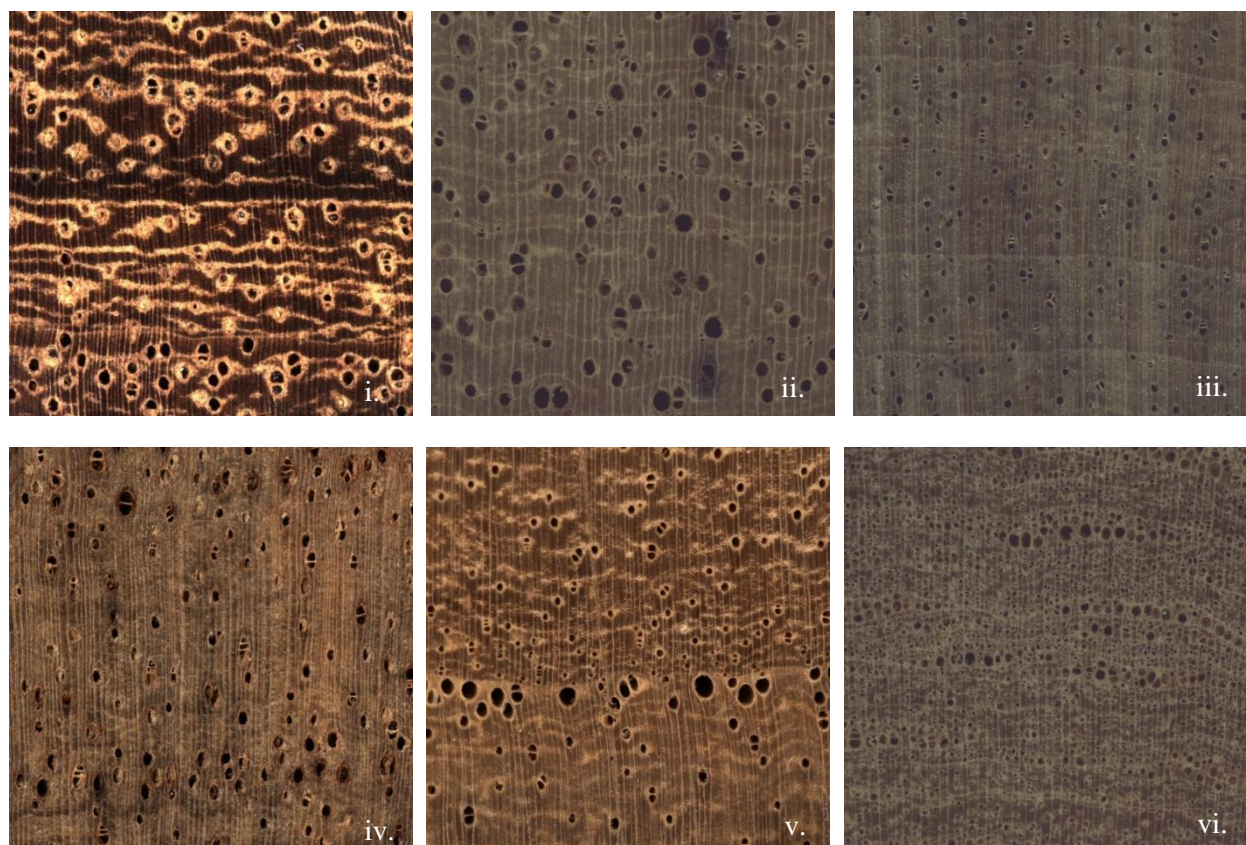


Figure 3. Variation of vessel size and distribution ~~and size~~ pattern in *Dalbergia* wood as visible in cross sections. (i. through iii.) Diffuse-porous. (iv. through vi.) Semi-ring or Ring-porous. (i.) *Dalbergia sissoo* DC. Distributed in South,

Southeast, West, and Central Asia. (ii.) *Dalbergia bemarivensis* Phillipson & N. Wilding. Distributed in Sub-Saharan Africa. (iii.) *Dalbergia capuronii* Bosser & R.Rabev. Distributed in Sub-Saharan Africa. (iv.) *Dalbergia calycina* Benth. Distributed in Mesoamerica. (v.) *Dalbergia greveana* Baill. Distributed in Sub-Saharan Africa. (vi.) *Dalbergia lemurica* Bosser & R.Rabev. Distributed in Sub-Saharan Africa. *Images from the XyloTron® database

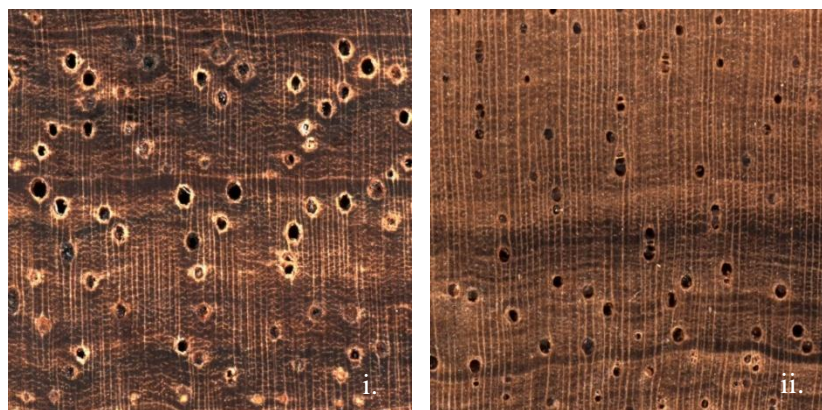


Figure 4. Within-species variation of wood in *Dalbergia stevensonii* Standl. Distributed in Mesoamerica. (i.) An area with evenly distributed same size-class vessels resulting in a diffuse-porous pattern. (ii.) A ring-porous pattern with two distinct areas of large-size and small-size vessels (see also the Appendix Figures 28 and 30). *Images from the XyloTron® database.

2.4. Policies affecting Rosewood trade into the United States

The 2008 amendment of the Lacey Act is undoubtedly one of the most important environmental policies within U.S. territory, being the first complete ban on illegal logging globally. According to the regulations of the U.S. Lacey act, a plant is illegally sourced if is “taken, harvested, possessed, transported, sold or exported in violation of an underlying law in any foreign country or the U.S.”. A fundamental principle, the Lacey Act requires to any individual or company importing plants or wood products into U.S. territory to implement the concept of “due care”, defined as the “degree of care which a reasonably prudent person would exercise under the same or similar circumstances”, in their processes. (U.S. Fish and Wildlife Service & Office of Law Enforcement, 2008). In practice, the implementation of a concept such as “due care” by hardwood importers

is difficult to corroborate for environmental authorities because it implies the assumption that companies are following protocols and are acting in good faith during the acquisition of wood species, until proved contrary. To comply with the Lacey Act regulations, the importers are required to fill an import declaration of their shipments, describing the basic information of the imported species, including their scientific names, country of origin, quantity and value (Lee, 2014). Every import of species which trade is somehow restricted in their country of origin - or included into any of the CITES Appendices- is required to be declared according to the Lacey Act regulations. This denotes that the Lacey Act is not meant to be applied only as a national environmental policy, but to contribute to the reduction of illegal trade of species through the validation of international regulations within U.S. territory. Before realizing any import Rosewood species into U.S. territory, the importer individuals or companies must be aware of the bans and regulations that apply specifically in the country of origin of the wood they are purchasing, following the principle of “due care” of the Lacey Act. The current local restrictions for some of the more important Rosewood species are shown in **Table 1**.

In 2017, after the implementation of the 2008 amendment of the Lacey Act, a crucial measure in the protection of Rosewood species was taken with the inclusion of all species of genus *Dalbergia* into the Appendices I and II of CITES. With this decision, all importers of hardwood of any species of *Dalbergia*, are required to provide a declaration certifying that the wood entering U.S. territory is legally harvested and traded, including the required information by the Lacey Act amendment, and verified by APHIS officials. This measure has had diverse responses by importers of Rosewood into the U.S., particularly musical instruments manufacturers. The trade restrictions applied to all species of genus *Dalbergia* have been considered by many as “too broad in scope” and the

annotation was described as “ambiguously written” by manufacturers like Taylor Guitars and Luthiers Mercantile International (LMI). These companies have declared millions of dollars in losses given the uncertainty this regulation created for Rosewood imports and the legality of products including Rosewood parts for guitar owners (Luthiers Mercantile International, 2022; Taylor Guitars, 2018).

3. CHAPTER 2. ROSEWOOD TRADE INTO THE UNITED STATES

3.1. Introduction

The ultimate goal of the implementation of policies for the protection of hardwood species is to decrease illegality in the harvest and trade of vulnerable species. Within the U.S. territory, the application of environmental laws such as the 2008 amendment of the Lacey Act, provides control over the species that are allowed into the country, and specify the particular circumstances when importers must declare the legality of their imports. Although this policy is the strongest tool for the control of incoming species within U.S. territory, it is not infallible, and the effects of its implementation must be analyzed from different perspectives. A prior analysis of the impact of the Lacey Act in forest products has shown a reduction in the imports of wood in the rough from likely illegal sources. Unfortunately, there is also indication that potentially illegally sourced wood may be redirected from countries with stronger trade policy enforcement to countries with weaker enforcement, where the wood is processed and exported back to the U.S. as a finished product, the species identification of which is more demanding and complex. In such cases, the detection of species included in the CITES appendices or that is locally banned becomes more difficult due to the commingling of legally and illegally sourced wood during the processing of furniture or other wood products (Bridegam et al., 2015). The redirection of illegally sourced species of Rosewood must not be underestimate and addressed while analyzing trade data. Even though there is no evidence of illegal trade of Rosewood into U.S territory, and that this study focuses on legally imported Rosewood into U.S. territory, it is relevant to mention that the majority of the trade reported using the BoL data system is indirect (Flaen et al., 2021). This

does not imply the illegality of the shipments containing Rosewood, but the potential inaccuracy in the information about their origin.

The use of vernacular names as the main method of commercialization of Rosewood makes the identification of species more challenging for environmental authorities and represents a major issue in the data treatment. One common problem in the management of species data is described as ‘many-names-for-one-species’, which in some cases, can prevent the collection and arrangement of data from specific species. The largely used term “Rosewood” does not refer to a specific category of species based on a botanical description, but to a broader concept of tropical hardwood timber, without much clarity on the species comprised under this name. Some of the available literature suggests that given the uncertainty in the quantity of species cataloged as “Rosewood” worldwide and their scientific identification, there is no official statistical analysis for legal and illegal trade of Rosewood. For this reason, researchers have focused their efforts on compiling the information of tropical hardwood trade provided from producer and consumer countries, and inferring from those data an estimate of the quantity and frequency of rosewood trade (UNODC, 2020).

3.2. Methods

3.2.1. Trade databases

In my analyses of Rosewood trade, I used the commercially available databases Panjiva® and Trade Data Monitor (TDM®). Both trade platforms provided valuable information about the trade of Rosewood goods from reporting countries and different insights into trade data. In addition, both platforms included trade data for the years that preceded and followed the 2017 listing of

the genus *Dalbergia* in CITES, 2007 to 2020 for Panjiva[®] and 2009 to 2020 for TDM[®]. The two platforms have different data sources and thus, require different input for the collection of Rosewood data.

The data within Panjiva[®] originate from the Bills of Lading (BoL) for imported and exported goods from 17 reporting countries: Bolivia, Brazil, Chile, China, Colombia, Costa Rica, Ecuador, India, Mexico, Panama, Pakistan, Paraguay, Peru, Sri Lanka, Uruguay, United States, and Venezuela. The trade data are collected through the report of BoL required for trading companies to introduce any product into U.S. territory, usually given in the standard measure of Twenty-foot Equivalent Units (TEU). These transactions are available through the U.S. Customs and Border Protection and are publicly accessible under the Freedom of Information Act (Flaen et al., 2021).

TDM[®], on the other hand, uses the Harmonized Coding System (HS Codes) for the categorization and report of products and includes information from 111 reporting countries. The acquisition of Rosewood import data using the HS codes system in the TDM[®] platform requires a higher level of specificity, so the search results descriptions do not offer the same level of detail as those provided by Panjiva[®]. However, this platform provides aggregated information of quantifiable data of value, weight, and/or volume of imports and exports provided by the reported countries.

Table 2. Glossary of terms and data definition in the Panjiva® and TDM® databases used for the treatment and analysis of the trade data.

Database	Data of interest	Data definition
Panjiva	Year	Date of arrival of imports of Rosewood into U.S. territory. Data analyzed from 2008 to 2020.
	Consignee	Importer companies that reported Rosewood trade in the analyzed years.
	Shipper	Exporter companies that reported Rosewood trade in the analyzed years.
	Shipment origin	Country of origin of the shipment including Rosewood.
	Region	Origin of shipment based on continental or national boundaries. (Africa, Asia, Australia, Europe, India, North America, South and Central America)
	Shipment destination	Destination of the shipment within U.S. territory.
	Goods shipped	Description of the shipment content provided in the bills of lading.
	Category	Categories of scientific or vernacular names how Rosewood is described within the shipments.
	HS code	4-digits HS codes referring to Rosewood imports
TDM	Year	Time period when the trade data was collected for each HS code. Data analyzed from 2009 to 2020.
	HS code	National-level 8-digits HS code relevant for Rosewood trade.
	Value	Value in USD of the total exports of Rosewood from India for each reported year.
	Weight	Total weight of the exports from India for each reported year in Metric Tonnes.

3.2.1.1. Panjiva® search terms and data collection

Within the Panjiva® database my initial search terms for Rosewood imports included vernacular and scientific names that are commonly used to commercialize Rosewood worldwide. In this study I used three common classifications of Rosewood: (1) species categorized as “Hongmu” in the Asian market, widely known for their extensive trade globally (**Table 1**); (2) all species within the genus *Dalbergia*, which is entirely included in Appendices I and II of CITES; and (3) all import data that include the term “Rosewood” in the shipment information. In addition to the searches by vernacular or scientific names, Panjiva® offers the possibility of searching by other product descriptions like HS Codes, country of origin, importer companies, or shipper. Once I narrowed down my searches using the vernacular and scientific names and obtained the filtered results, I continued my search using the 4-digit HS Codes used for trade of wood products (**Table 3**), which retrieved results for all Rosewood imports based on HS codes from all exporting countries. It is relevant to mention that the 17 countries reporting their trade data with Panjiva® share the information of all imports and exports of goods relevant to their jurisdiction. This, in practice, means that even if a partner country obtains goods from a non-reporting country, this information would be available within the platform, as is the case of the collection of Rosewood imports into the U.S.

While the BoL for each shipment consisted of 28 or more data fields, I was particularly interested in eight of these fields, which encompassed information on the timing of the shipment, importer and exporter companies and countries, HS codes, and various descriptions of the goods (**Table 3**). The trade report for Rosewood products in the BoL is integrated with the description of other goods included in the shipment. To get exclusively the information of vernacular and scientific

names, I filtered the information related only to Rosewood imports and created a new field for these categories of vernacular and scientific names.

Table 3. Internationally harmonized 4-digits HS codes of wood products relevant for Rosewood trade. Adapted from United States International Trade Commission, 2021.

4-digit HS code	Description of the wood product
4403	Wood in the rough.
4407	Wood sawn or chipped lengthwise, sliced, or peeled.
4408	Sheets for veneering.
4409	Wood continuously shaped.
4410	Particle board, oriented strand board (OSB) and similar board.
4412	Plywood, veneered panels, and similar laminated wood.
4414	Wooden frames for paintings, photographs, mirrors, or similar objects
4419	Tableware and kitchenware of wood.
4420	Wood marquetry and inlaid wood.

3.2.1.2. TDM[®] queries and data collection

The information provided by the TDM[®] platform is mostly based on the categorization created by the Harmonized Tariff Schedule of the United States (HTS), which provides the structure of trade data through the classification of goods using the HS coding system, and a brief description of the traded products. This classification starts with 2-digit codes and provides more specific information about the products with HS codes up to 10 digits. HS codes are internationally harmonized up to 6-digit codes; for 8 to 10-digit HS codes, every country has the freedom to

report their goods at their own convenience (United States International Trade Commission, 2021). TDM[®] aggregates the total reported data provided by partner countries using the HS codes system and delivers to the user national reports of the total quantities of a specific product based on their HS code.

To explore the available trade data reported in the TDM[®] platform, I started with the base information collected using the Panjiva[®] database. I examined the trade information for each exporting country reported in the BoL data within the Panjiva[®] database, starting with the 4-digits HS codes displayed in **Table 3**. I then filtered all available information at the harmonized (2 to 6-digits HS codes) and/or national level (8 to 10-digit HS codes) that could potentially indicate Rosewood trade. For most of the reporting countries analyzed within the TDM[®] database, there are no harmonized or national HS codes referring to particular trade of Rosewood, except for three national HS codes reported from India **Table 4**. Two of these codes belong to sheets for veneering and one code belongs to wood in the rough. This information includes the total value in USD of the exports of Rosewood for every analyzed year and the measures of weight and/or volume during the same timeframe. After the collection of the aggregated data provided by TDM, I compared the Rosewood exports data from India to the U.S. with the available information of the total exports of Rosewood from India to the world. Also, I analyzed the values of exports before and after the inclusion of genus *Dalbergia* into the Appendices I and II of CITES.

Table 4. 8-digits HS codes at the national level for the exports of Rosewood from India to the U.S, according to TDM® database.

HS Code	HS Code description	Attributed to
44083120	Rosewood, Dalbergia latifolia	Sheets for veneering
44039919	Dalbergia latifolia	Wood in the rough
44083920	Veneer sheets of rosewood	Sheets for veneering

3.2.2. Data treatment and analysis

For the data treatment and analysis, I divided the available information depending on their source: data collected using the Panjiva® database which in general provides descriptive features of the trade; and data collected using the TDM® database which offers quantitative information about value, weight and/or volume based on the available HS codes.

3.2.2.1. Data treatment using Panjiva® platform information

The information of shipments including Rosewood products gathered using the Panjiva® database, offers information of categories based on 4-digits HS Codes, shipment origin, importer and exporter companies, frequency of shipments, and includes further information about the trade. Even though there is no description referring to individual weight or volume values of Rosewood product, it is possible to determine some of the trends of the imports of Rosewood into the U.S. based on the frequency of the shipments, their categories, and their origin. There were in total 39 categories of vernacular and scientific names how Rosewood was imported into the U.S. in the analyzed years. To simplify the data treatment and analysis, I aggregated these names to create 6 broader categories of the most representative vernacular names, genus and species being traded, and performed the analysis based on their descriptions.

To determine the influence of the application of environmental policies for the protection of Rosewood species, I displayed the trends of U.S. Rosewood imports to visualize the changes to time and compared the changes in the average number of shipments per year before and after the inclusion of all species from genus *Dalbergia* into Appendices I and II of CITES in 2017. Based on the available information from the BoL data, I performed independent samples t tests to determine if the differences in the average number of shipments per year were statistically significant before and after 2017. This process was repeated for the data of interest **Table 2** including shipment origin, categories of Rosewood products and HS codes.

3.2.2.2. Data treatment using TDM® platform information

The treatment of the collected data from the TDM® platform was slightly different from the analysis of the data obtained through the Panjiva® database. For this case, I displayed the available information of weight and value of Rosewood exports from India to the U.S. and the world from 2009 to 2020 to observe the changes in the total weight and value of Rosewood being exported. Additional to the visualization of these trends, I calculated the prices based on the total weight and value of the wood exported every year for each available 8-digits HS code. To determine the impact of the inclusion of all species from genus *Dalbergia* into appendices I and II of CITES on the exports of Rosewood from India to the U.S. and the world, I performed independent samples t tests to the reported weight for each analyzed year for every 8-digits HS code, comparing the observations before and after 2017. This analysis determines if there is a significant difference between the average weight of Rosewood imports per year before and after the implementation of such policy.

3.3. Results

3.3.1. Results from the Panjiva® database

3.3.1.1. *Categories of Rosewood imports into the United States*

After gathering all data from Panjiva®, the categories of Rosewood were divided in 4 different subcategories: (1) by vernacular and scientific name reported in the BoL data collected by this platform; (2) by HS codes classification, which describes if the wood is shipped as wood in the rough, wood sawn or chipped, sheets for veneering, wood continuously shaped, particle boards, plywood, wooden frames, tableware or kitchenware, or wood marquetry; (3) by Region of origin, depending on the number of Rosewood shipments the exporting countries made to U.S. territory; and (4) by importer and exporter companies, when available through the reports of the BoL. For all subcategories the decrease of imports after 2017 is evident; in average, the total imports of Rosewood from 2007 to 2016 was 193.2 shipments per year, while the average of imports from 2017 to 2020 was 131 per year.

3.3.1.2. *By vernacular and scientific name*

All Rosewood shipments using vernacular or scientific names are presented in **Error! Reference source not found.** Two categories of shipments are the most commonly imported into U.S. territory: shipments labeled as “Indian Rosewood” followed by the ones described as “Rosewood”. The use of vernacular names as the main way companies imports Rosewood makes the analysis of the Rosewood trade data more challenging, given that the same species can be assigned to several vernacular names, and vice versa depending on location, language, and the preferences established throughout the trade. There is no complete certainty of the scientific names attributed to the shipments labeled as “Indian Rosewood”. In theory, this description

could be attributed to any species with specific anatomical features and appearance attributed to Rosewood, and that is potentially grown and harvested in India. However, and based on the available information from importing and exporting companies, the term “Indian Rosewood” is most likely attributed to *Dalbergia latifolia* or *Dalbergia sissoo*, two very common species for the manufacture of musical instruments and very often exported from India, where usually grows in plantation setups. In the other hand, the description of the species included in the shipments labeled as “Rosewood”, is indeed more complicated, since it could refer to any species included in the Hongmu list or to any species within genus *Dalbergia*. In both categories there is a decrease in the imports after 2017, very likely due to the inclusion of genus *Dalbergia* into Appendices I and II of the CITES, which requires to importers to declare the legality of their Rosewood imports. A reduction in the number of shipments entering U.S. territory is evident after 2017. However, not all the categories had a statistically significant decrease in the imports of Rosewood in the studied timeframe. The shipments categorized as “Indian Rosewood”, “Rosewood”, and “Rosewood Substitute” showed a significant decrease in their imports. However, the categories “*Dalbergia*” and “*Pterocarpus*” did not show statistically significant reductions in the imports to the U.S. The average number of shipments categorized as “*Diospyros*” increased significantly after 2017. In **Table 5** are displayed the average number of shipments per year before and after the implementation of CITES restrictions in 2017, and the values of the performed t tests.

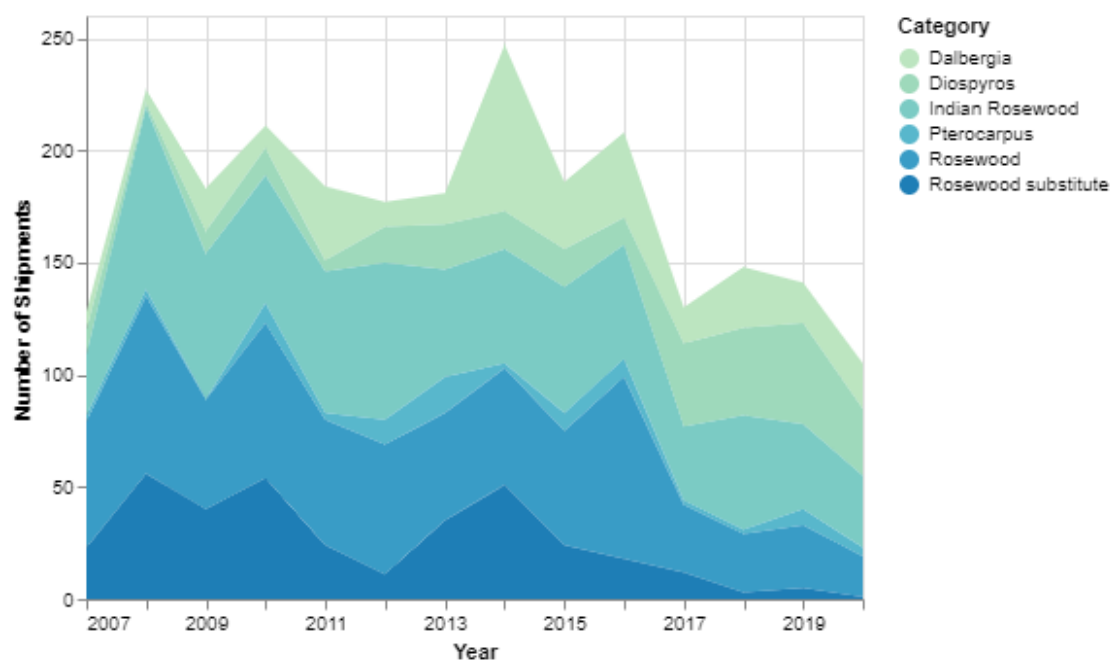


Figure 5. Categories of shipments including Rosewood products from 2007 to 2020. Based on the Panjiva® database.

Table 5. Average number of shipments per year by categories of vernacular and scientific names before and after the 2017 inclusion of all species from genus *Dalbergia* into CITES appendices I and II. Results from the independent samples *t* tests, according to Panjiva® database. *Categories with a statistically significant increase in their average number of shipments per year after 2017.

Category	Avg shipments per year (pre-CITES)	Avg shipments per year (post-CITES)	Statistically significant	
			decrease after 2017 (P-value>0.05)	P-value
Dalbergia	24.30	20.25	No	0.287
Diospyros	12.20	37.75	No	0.9996
Indian Rosewood	56.9	38.5	Yes	0.0083**
Pterocarpus	6.30	3.75	No	0.1097
Rosewood	59.9	25.5	Yes	4.858 e-06**
Rosewood substitute	33.60	5.25	Yes	0.00015**
All imports	193.2	131.0	Yes	0.00064**

*Implies statistical significance at alpha: 0.05

* Implies statistical significance at alpha: 0.01

3.3.1.3. By HS codes

The second way of measuring the shipments imported into the U.S. in this research is through the H.S codes reported by importing and exporting companies in bills of lading. The greatest number of shipments in the analyzed timeframe corresponds to the H.S code 4407, described as “wood sawn or chipped lengthwise, sliced or peeled” with 36.3% of the total shipments of Rosewood into the U.S., followed by the H.S. code 4408, described as “sheets for veneering” with 34.1% of the total imports of Rosewood into the U.S. territory. Both of these denominations are often part of the construction of musical instruments, especially high-end guitars. Guitars backs and sides, finger boards and bridges are common imports for manufacturing companies, and the shipping methods used by exporters could easily adapt to the needs of these companies. The details of the distribution of the imports, according to their H.S codes and vernacular and scientific names, are displayed in **Figure 6**.

The results of the independent samples t test based on the number of shipments per year categorized by their HS code classification showed a significant reduction in the imports of wood sawn or chipped lengthwise, sliced, or peeled (HS code 4407), sheets for veneering (HS code 4408), and wood continuously shaped (HS code 4409). For the rest of HS codes there was no evidence of a significant reduction after 2017. The average number of shipments per year before and after the implementation of CITES restrictions in 2017, and the values of the performed t tests are displayed in **Table 6**.

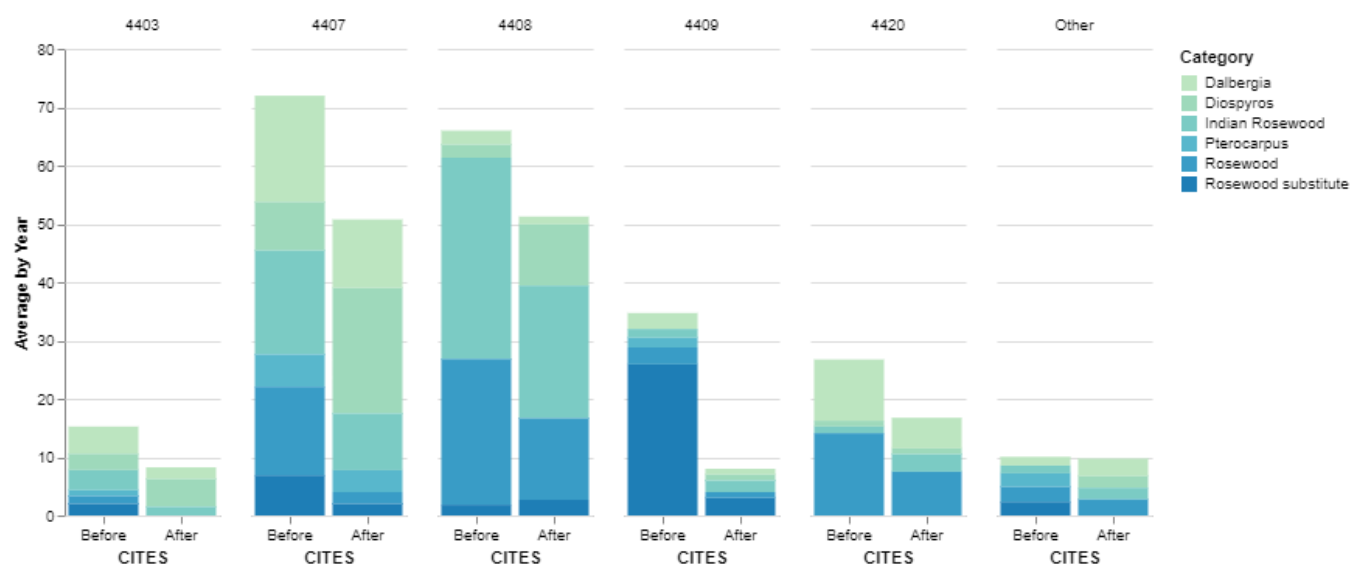


Figure 6. Average number of shipments of all categories of Rosewood imports into the U.S. from 2007 to 2020 by HS codes classification. According to Panjiva® database

Table 6. Average number of shipments per year by HS codes categories before and after the 2017 inclusion of all species from genus *Dalbergia* into CITES appendices I and II. Results from the independent samples t tests, according to Panjiva® database.

HS code	Avg shipments per year (pre-CITES)	Avg shipments per year (post-CITES)	Statistically significant decrease after 2017 (P-value < 0.05)	P-value
4403	8.2	6.0	No	0.1493
4407	69.20	48.75	Yes	0.0097**
4408	63.60	50.25	Yes	0.0446*
4409	30.7	4.5	Yes	4.374e-05**
4412	1.091	2.0	No	0.8383
4414	2.2	2.0	No	0.4458
4419	1.091	2.25	No	0.84
4420	17.723	15.25	No	0.31.65

*Implies statistical significance at alpha: 0.05

* Implies statistical significance at alpha: 0.01

3.3.1.4. By Region of origin

According to the BoL information required for the import of products into the U.S., and available in the Panjiva® platform, 39.2% of the U.S. imports of Rosewood in the period from 2007 to 2020 had India as their country of origin, followed by Brazil with 5.7%, Argentina with 4.7%, Germany with 4.3%, and Singapore with 3.7% of the total imports of Rosewood. As shown in **Figure 7** there is no evidence of great amounts of imports from countries with high levels of illegality of Rosewood, such as of African countries like Ghana, Madagascar, or Senegal. As is displayed in **Error! Reference source not found.**, the main category of imported Rosewood into the U.S. corresponds to Indian Rosewood, likely attributed to *Dalbergia latifolia* and/or *Dalbergia sissoo*. Both of these species grow mostly in plantation setups in Indian territory and are widely commercialized for the manufacture of high-end furniture and musical instruments with trade permits provided by CITES.

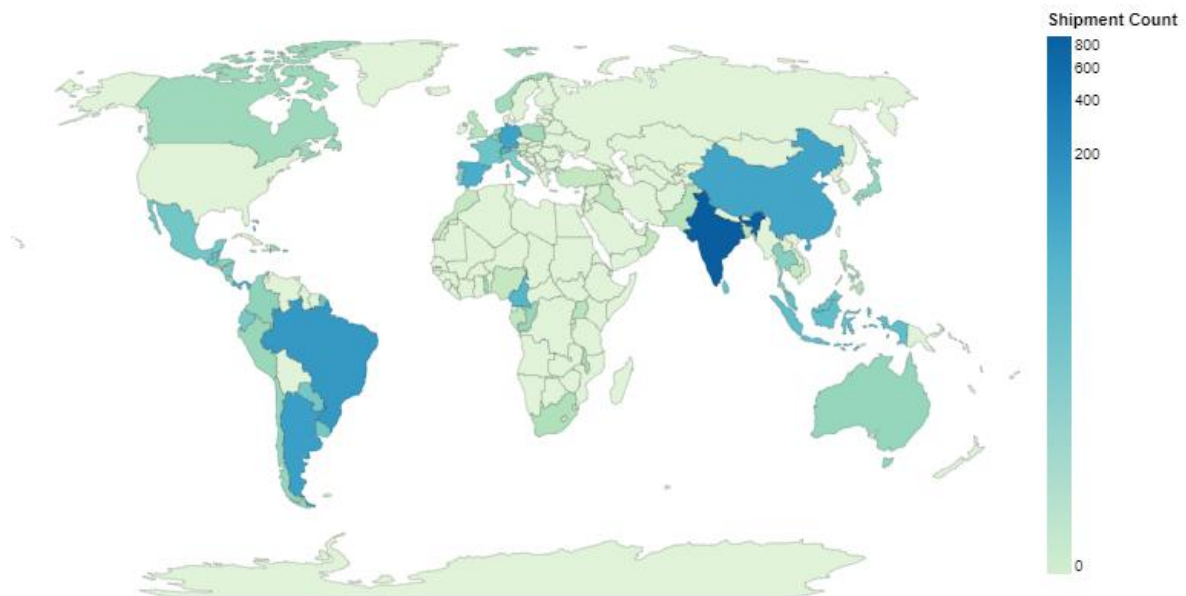


Figure 7. Distribution of countries reporting Rosewood exports to the U.S. based on the number of shipments per year from 2007 to 2020. According to the Panjiva® database

The changes in the imports of Rosewood from the main importer countries are presented in **Error! Reference source not found.** India, as the country with the most reported shipments of Rosewood to the U.S., is responsible for the greatest number of shipments per year for all studied years, compared with countries like Brazil or Singapore, where the shipments were fewer, more irregular and, in some cases, inexistent during a period of time. This variation through time and between countries of origin could be due to the application of local bans, presented in **Table 1.**, the application of the Lacey Act, and the inclusion of all species of genus *Dalbergia* into Appendices I and II of the CITES in 2017. For India, Singapore, and Brazil there is a reduction in the number of shipments exported to the U.S in 2017, probably due to the restriction of imports of genus *Dalbergia* in compliance with the Lacey act amendment of 2008. The imports reported from Argentina from 2008 to 2013 were mostly reported as “Patagonian Rosewood” or “Bolivian Rosewood”, which were included in the category of “Rosewood substitutes”. In this case, the information of the BoL does not provide enough details to specify the species these vernacular names refer to, being possible that they correspond to South American species that are not included in the list of species traded as Hongmu in the Asian market or belong to genus *Dalbergia*, referring to the species with the scientific names of *Anadenanthera colubrina* and *Machaerium villosum*, respectively. However, the shipments were labeled as “Rosewood” for the importers at the moment of their report and must be included into the analysis. The application of local bans may be also a factor affecting the import of Rosewood species into the U.S. India, for example, imposed a local restriction of *Pterocarpus santalinus* in 2012, being one of the most relevant policies affecting Rosewood trade from this country, however, there are no reports of trade of this species from India to the U.S. within the analyzed timeframe. The reports of imports of

Rosewood from Germany to the U.S. may be an indication of indirect trade of Rosewood through a third-party country, which is a very common practice in the imports of all sorts of products to the U.S., but the BoL data does not provide further information of this indirect trade.

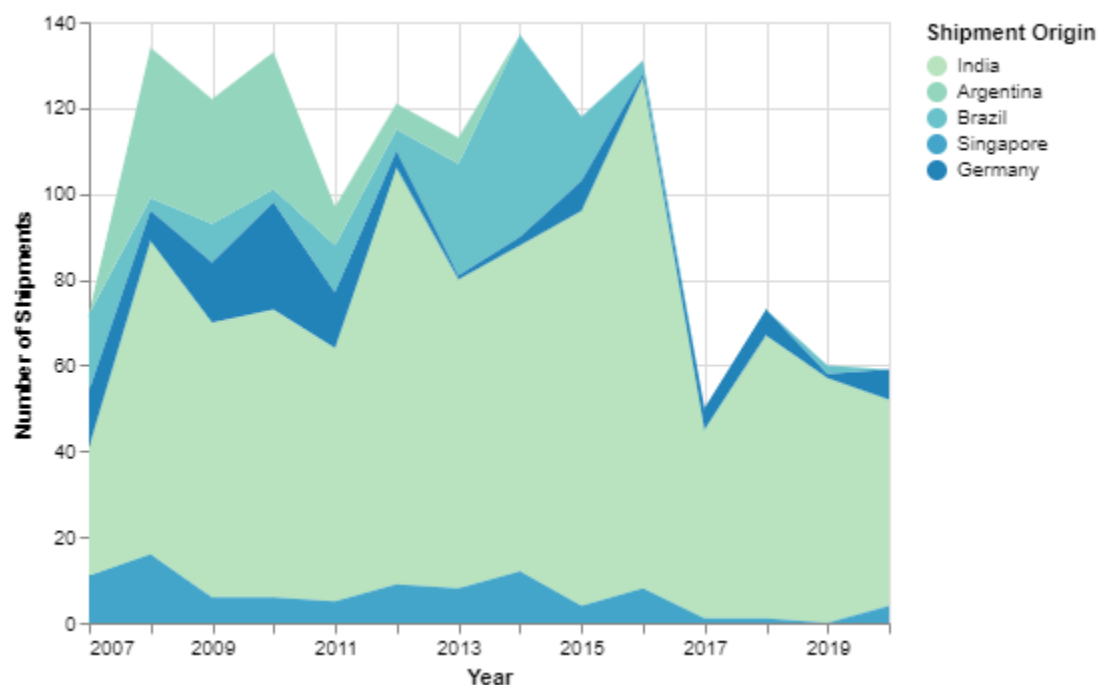


Figure 8. Number of shipments including Rosewood by country of origin for the five main exporter countries from 2007 to 2020. According to Panjiva® database.

In **Figure 9** are displayed the total number of shipments by region before and after the inclusion of all species from genus *Dalbergia* into appendices I and II of CITES. Based on their location, all countries, except India, were aggregated into 7 continental or regional categories with the purpose of simplify the analysis of the trade. Imports from Asia, India, North America, and South and Central America showed significant reductions in their average number of shipments per year after 2017. Australia did not show a significant reduction in their average number of shipments per year after the implementation of CITES, and Europe showed an increase in the average number of imports after 2017. The average number of shipments per year before and

after the implementation of CITES restrictions in 2017 for each analyzed region, and the values of the performed t tests are displayed in **Table 7**. Average number of shipments per year by region of origin before and after the 2017 inclusion of all species from genus *Dalbergia* into CITES appendices I and II. Results from the independent samples t tests. According to Panjiva® database.

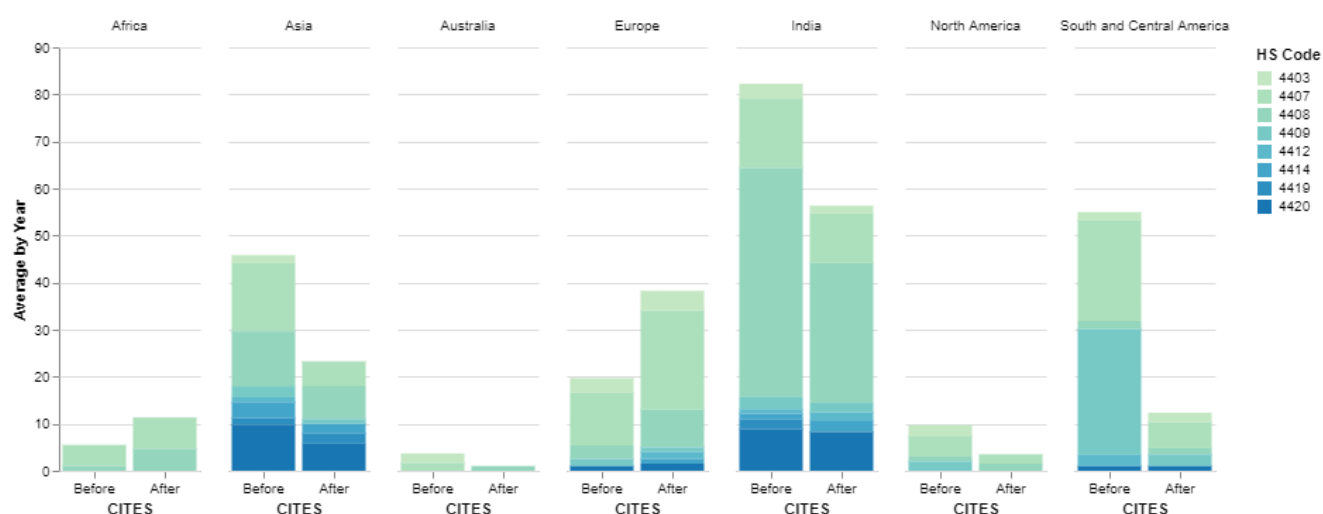


Figure 9. Comparison of the Average number of shipments per year including Rosewood products by region of origin and HS code before and after the inclusion of genus *Dalbergia* into CITES appendices I and II in 2017. According to Panjiva® database.

Table 7. Average number of shipments per year by region of origin before and after the 2017 inclusion of all species from genus *Dalbergia* into CITES appendices I and II. Results from the independent samples t tests. According to Panjiva® database.

Region	Avg shipments per year (pre-CITES)	Avg shipments per year (post-CITES)	Statistically significant decrease after 2017 (P-value>0.05)	P-value
Africa	3.64	8.5	No	0.7433
Asia	40.4	8.5	Yes	0.0032**
Australia	0.70	0.25	No	0.1889
Europe	17.00	25.24	No	0.8084
India	74.90	53.75	Yes	0.0118*
North America	5.70	2.25	Yes	0.0206*
South & Central America	50.6	10.00	Yes	0.0002**

*Implies statistical significance at alpha: 0.05

* Implies statistical significance at alpha: 0.01

Figure 10 shows the categories of vernacular and scientific names of all imports with India as region of origin. Given that India accounts for 39.2% of the imports of Rosewood into the U.S. and that the U.S. imports of Rosewood from India showed a significant reduction after the inclusion of all species of genus *Dalbergia* into appendices I and II of CITES, these categories are relevant for the overall analysis of Rosewood trade. About 60% of the total imports from India were categorized as “Indian Rosewood”, followed by the shipments catalogued as “Rosewood”, with approximately 37% of their shipments. Following the general trend observed in previous categories, there is a preference for the report of Rosewood using vernacular names instead of a botanical or scientific identification of species.

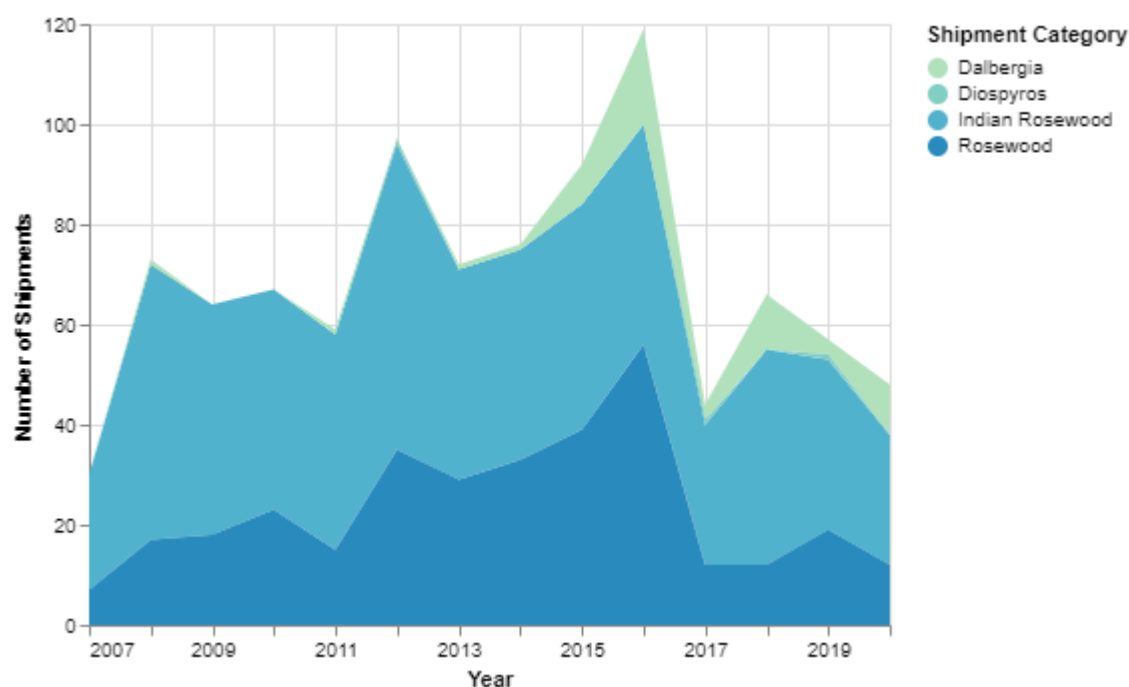


Figure 10. Number of shipments per year by categories of vernacular or scientific names of imports with India as region of origin from 2007 to 2020. According to Panjiva® database.

3.3.1.5. By exporter companies

There is a common trend in the quality and quantity of information related to exporter companies; most of the BoL associated with the shipments do not provide information that allows the identification of foreign companies exporting Rosewood products, **Figure 11**. According to the collected data, the most common denomination of Rosewood into the U.S. is “Indian Rosewood” very likely associated to *Dalbergia sissoo* and *Dalbergia latifolia*, both species distributed in India. The main companies exporting these categories of Rosewood, giving the number of shipments to the U.S are listed below, followed by information about their operation activities, location, and their offer of Rosewood products.

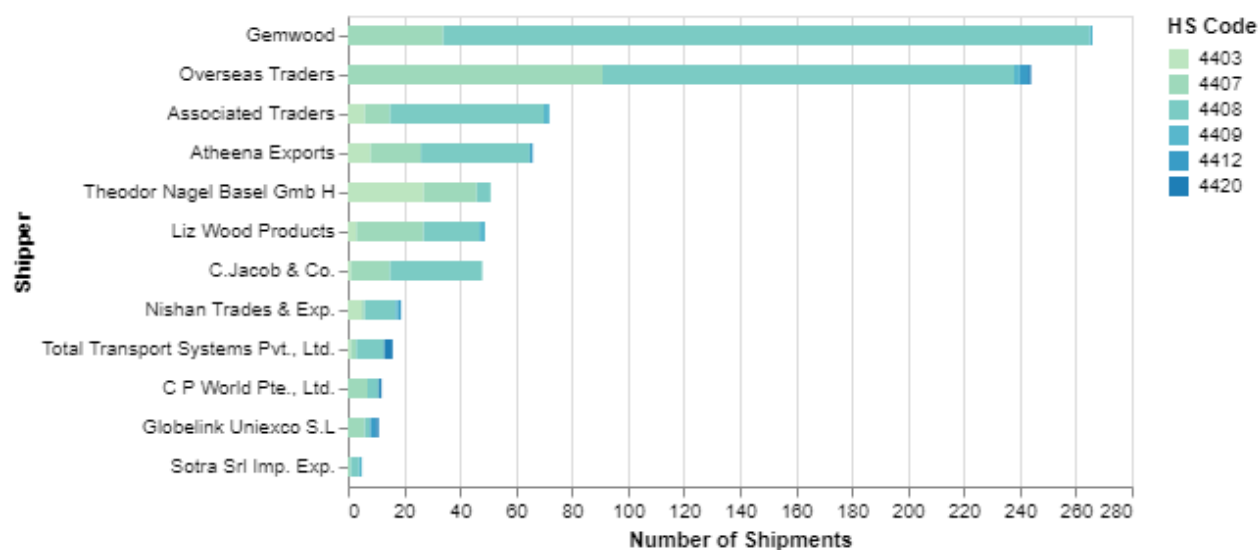


Figure 11. Main companies exporting Rosewood to the U.S. by number of shipments per year from 2007 to 2020. HS codes categories of their exports*According to the Panjiva® database.

Gemwood: Located in Kerala, India, is a family run exporting company specialized on tonewood for musical instruments and other wood products from Rosewood, Ebony, Teak, Mahogany, Bubinga, Red Cedar, Sapele, and Rubberwood species. The products offered by the company vary from parts for musical instruments as backs and sides for guitars and violins, finger boards, bridge

blanks, head stock, peg head, chin rests, to other wood products as benches, counter tops, flooring, bathmats, chopping boards, turning squares, knife handles, pool cue banks, pen blanks, bow blanks. In 2002 the company decided to manufacture what they define as “eco-friendly” wood through chemical processes. The new branch of the company is known as Uniwood, and seeks to supply a larger segment of customers (Gemwood, 2021). According to the data collected from the Panjiva® database, Gemwood is responsible for supplying about 10.80% of the total imports of Rosewood into the U.S during the timeframe of the analysis. Most of the exports of Rosewood made by Gemwood are sheets for veneering, followed by sawnwood.

Overseas Traders: Located in Karnataka, India, is a major supplier of high-quality East Indian rosewood, mostly for parts of electrical and acoustic guitars such as backs, sides, fingerboards, figured wood, necks and bridges. The trade of Rosewood from Overseas Traders to U.S. companies started in 1969 after the total ban of Brazilian Rosewood (*Dalbergia nigra*), being East Indian Rosewood a suitable alternative to cover the musical instruments market. Some of the frequent buyers of their products reported by the company are Martin & Co., Fender Guitars, Gibson Guitars, Paul Reed Smith Guitars, Santa Cruz Guitar Company, Two Old Hippies, Lowden, Raimundo, Godin Guitars, Bourgeois Guitars, Cordoba, Scott Walker Guitars, Van Bergeijk. According to information shared by the company, the company purchases Rosewood logs through auctions of only dead or fallen trees, following the restrictions stipulated in the Karnataka Forest Act of 1963, which controls and restricts the harvest of trees within natural forests in the state of Karnataka. To comply with CITES requirements, the company counts with a Legal Procurement Certificate, which is required for exporter companies and is acquired after the verification of the harvesting processes that take place for the obtention of the traded logs

(Overseas Traders, 2021; State of Karnataka, India, 1964). According to the collected data from the Panjiva® database, Overseas traders accounts for the supply of about 9.95% of the total imports of Rosewood into the U.S during the analyzed years. Most of the exports of Rosewood made by Overseas Traders are sheets for veneering, followed by sawn wood.

Associated Traders: Founded in 1974 with the intention of exporting logs of Rosewood and Ebony. After the ban for export of round logs in 1979, following the U.S. Code of Federal Regulations (Hines, 1987), the company turned into the manufacture of parts for musical instruments and handicrafts, particularly high-quality guitars as classical, dreadnaught, western, jumbo, and ukuleles. The company assures that the timber used for their products is sourced mainly from forests with international certification by Forest Stewardship Council (FSC). The main species used by the company for the construction of parts of musical instruments are Rosewood, Ebony, Mahogany, Mangowood, and Walnut (Associated Traders, 2016). Associated Traders, according to the information collected in the Panjiva® database, accounts for supplying approximately 3.0% of the total imports of Rosewood into the U.S in the analyzed years. Most of the exports of Rosewood made by Associated Traders are sheets for veneering, followed by sawn wood and wood in the rough.

3.3.1.6. By importer companies

According to the data obtained through BoL information of shipments reported by Panjiva®, most of the reported Rosewood imports into the U.S. do not provide the information about the importer companies. However, and based on the available descriptions included in the BoL and presented in **Figure 12**, the main importers of Rosewood into the U.S. are musical instruments manufacturing companies, particularly high-end guitars brands. Some of the most relevant

companies according to the gathered data are presented below followed by a brief description of their operations and Rosewood preferences:

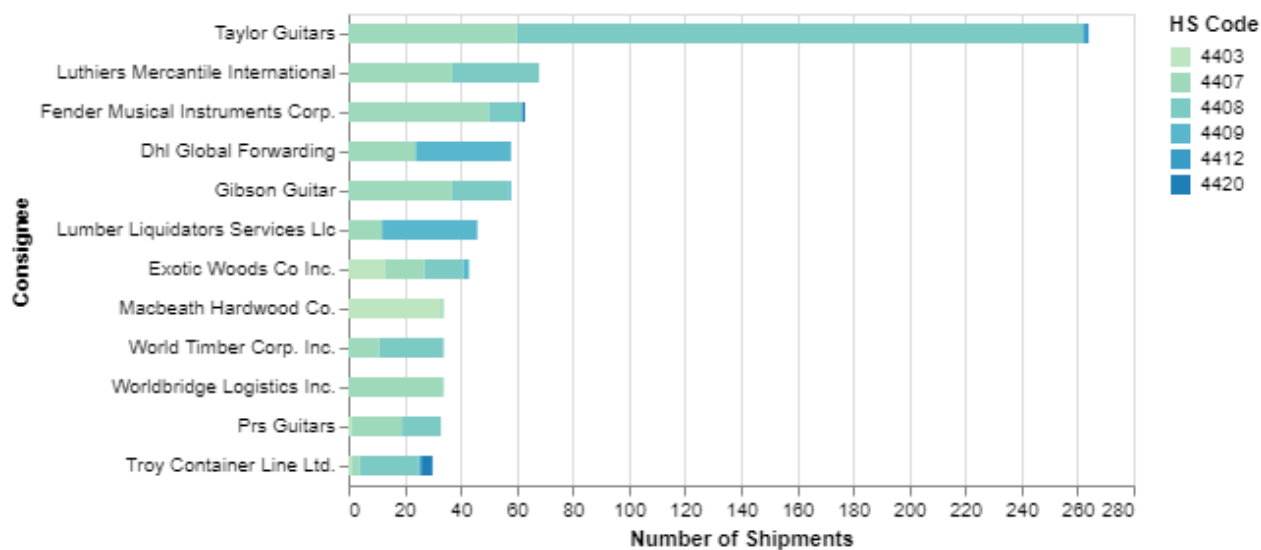


Figure 12. Main companies importing Rosewood to the U.S. by number of shipments per year from 2007 to 2020. HS codes categories of their imports. According to the Panjiva® database.

Taylor guitars: Founded in 1974 by Bob Taylor and Kurt Listug, is an entirely employee-owned company, widely known for the manufacturing of quality music instruments within the U.S. and around the world. Currently, the company manufactures guitars in two facilities in Mexico and the U.S.: Tecate, Baja California, Mexico and El Cajon, California, U.S., where are located the headquarters of the company. The use of Indian Rosewood in the construction of electric and acoustic guitars represents the wish of the company to preserve traditional sounds and bring a sense of authenticity to their products. The appearance and sensorial quality of Rosewood species is appreciated by musicians and guitar enthusiasts (Taylor Guitars, 2022). According to the information gathered through the Panjiva® database, Taylor guitars has imported 10.84% of the total imports of Rosewood in the analyzed years, being the company with the highest number

of reported shipments into U.S. territory. Most Rosewood imports made by Taylor Guitars are sheets for veneer, followed by sawn wood.

Luthiers Mercantile International (LMI): Located in Windsor, California. Commercializes materials for the manufacture of musical instruments as well as sheets for veneering of different species of hardwoods. Within the offered hardwood species offered by the company are Indian Rosewood, American Linden, Bloodwood and European Maple; however, according to information shared by the company, the offer of hardwood species varies constantly. LMI ensures proficiency in the processes related to chain of custody of all of their products, as well as wide knowledge in imports documentation. The company stopped the commercialization of any products containing *Dalbergia nigra* when the species was included in the Appendix I of CITES and was part of the discussion for the implementation of the 2008 Amendment of the U.S. Lacey Act (Luthiers Mercantile International, 2022). LMI accounts for 2.75% of the total imports of Rosewood into the U.S. in the analyzed years, according to the BoL data provided by Panjiva®. The imports made by LMI are sheets for veneering and sawn wood.

Fender Musical Instruments Corporation: Founded in 1943 in Fullerton, California. One of the most recognized guitar brands in the U.S. and around the world. Their international administration and sales office is located in Scottsdale, Arizona, with international satellite offices in Australia, England, France, Germany, Japan, Mexico, and Sweden. Their signature guitars, as the Telecaster, and the Stratocaster have become iconic symbols of the Fender legacy for musicians and guitar enthusiasts (Fender Musical Instruments Corporation, 2022). After the inclusion of all species of genus *Dalbergia* into the Appendices I and II of the CITES, Fender expressed their intention of continuing using Rosewood for the American-made guitar models,

following the regulations implied by the Lacey Act amendment of 2008. However, the company also shared that their Mexican-made guitar models would transition the manufacturing of some of their parts from Rosewood to pau ferro, a South American species potentially attributed to genus *Machaerium*, with similar acoustic characteristics (The Stratosphere, 2017). Fender Musical Instruments Corporation accounts for 2.54% of the total imports of Rosewood into U.S. territory during the analyzed years according to the BoL data collected in Panjiva®. Most of the imports made by Fenders Musical Instruments Corp. are wood sawn or chipped, followed by sheets for veneering.

3.3.2. Results from the Trade Data Monitor database – based on India exports data

The collection of Rosewood trade data using the TDM® database, which information is based on the HS codes system classification, is quite different to the gathering of BoL data. As the main source of information, TDM® uses the HS codes of the trade reports from their partner countries, and its searching criteria is more limited for the users since it requires specific knowledge of the H.S codes for every specific product. However, the information provided by this platform is aggregated, and offer valuable quantifiable information about the value and/or weight of the total trade between partner countries. These data do not provide details about frequency of the shipments, information referring to the exporter or importer countries, or specific dates when the shipment took place, like Panjiva® platform does.

The results of the search for Rosewood trade data using HS codes exclusively are indeed more limited. Given the differences in the way reporting countries decide to include Rosewood trade information into their trade data, the availability of specific information about Rosewood is limited to the HS codes at the national level. Based on the results of the analysis of the BoL data

from Panjiva[®], India is the largest Rosewood exporter to the U.S., which could be also the reason why Indian authorities decided to assign to Rosewood HS codes to report their trade. The 8-digit HS codes available for India are presented **Table 4** as well as their categorization based on their HS codes show some of the changes in the values through time for such categories of Rosewood trade from India to the U.S.

3.3.2.1. Exports of *Dalbergia latifolia* in the rough from India to the United States

The exports reported as *Dalbergia latifolia* in the rough from India have a great variability through the analyzed timeframe, with the highest value of Rosewood exports in 2012 for the U.S. around \$700,000 and in 2010 for the world with about \$1 million worth of Rosewood. The values in thousands of dollars and Metric Tonnes under this category are small compared with the values for the U.S. of sheets for veneering during the same period of time (**Figure 13** and **Figure 14**). A notable decrease after 2015 is observable, and the exported quantity from India to the U.S. and the world remains low after this decrease. However, the graphs of value and weight differ given the changes in the value of the wood; for example, the total weight corresponding to the exports from India to the world of 2020 is quite small (zero for the U.S.), compared to the value of the wood for the same year. This inference provides valuable information about the speculation of prices of Rosewood, where apparently, some importer countries were paying much more for less volume of wood (**Figure 15**). There is a significant decrease in the average weight of *Dalbergia latifolia* in the rough exported from India to the world and to the U.S. after the inclusion of all species of genus *Dalbergia* into appendices I and II of CITES in 2017, as is presented in **Table 8**.

Table 8. Average total weight per year by HS codes categories before and after the 2017 inclusion of all species from genus *Dalbergia* into CITES appendices I and II. Results from the independent samples t tests, according to TDM® database.

HS code	Exports to	Avg weight per year pre- CITES (MT)	Avg weight per year post- CITES (MT)	Statistically	
				significant decrease after 2017 (P- value>0.05)	P-value
44039919	World	1418.01	314.78	Yes	0.0233*
	U.S.	502.89	88.39	Yes	0.0275*
44083120	World	643.49	604.29	No	0.3907
	U.S.	179.83	105.46	Yes	0.0252*
44083920	World	207.18	43.19	Yes	0.002**
	U.S.	6.47	4.69	No	0.3718

*Implies statistical significance at alpha: 0.05

* Implies statistical significance at alpha: 0.01

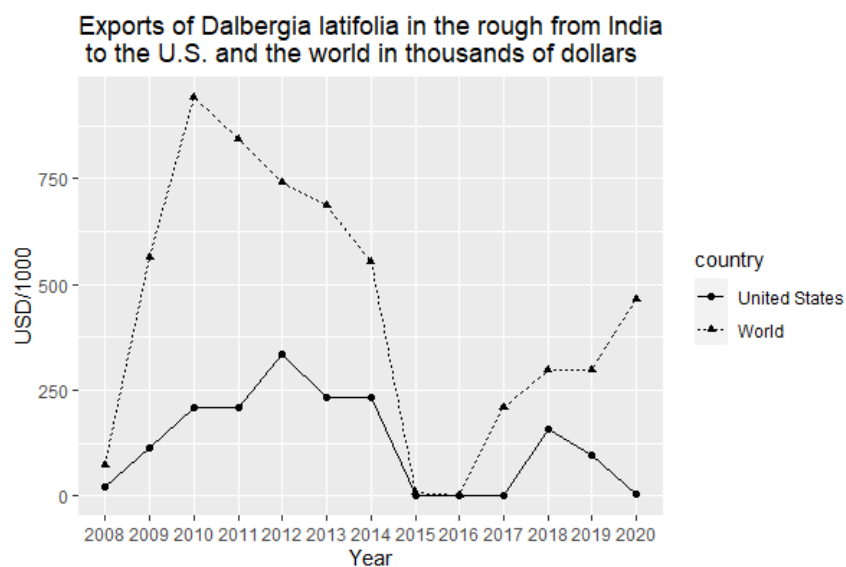


Figure 13. Exports of *Dalbergia latifolia* in the rough (HS code: 44039919) from India to the U.S. and the world in thousands of dollars from 2008 to 2020. According to TDM® database.

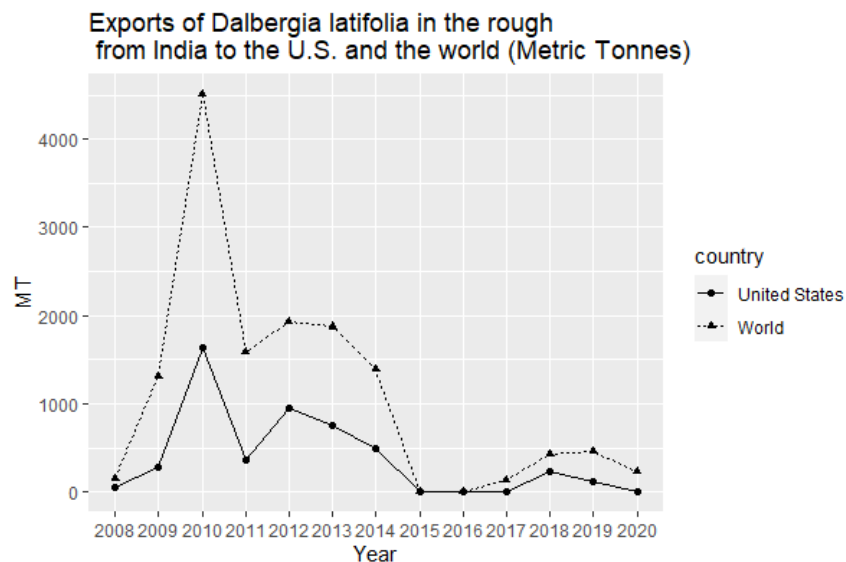


Figure 14. Exports of *Dalbergia latifolia* in the rough (HS code: 44039919) from India to the U.S. and the world in Metric Tonnes from 2008 to 2020. According to TDM® database.

Changes in the price of *Dalbergia latifolia* in the rough exported from India to the U.S. are presented in **Figure 15**. The values in prices during the period from 2008 to 2014 are similar for the exports to the U.S. and the world. After 2015 the prices of this category for the U.S. and the world vary drastically, perhaps due to the implementation of policies for the protection of species as is the inclusion of all species from genus *Dalbergia* into appendices I and II of CITES. The data of the prices from 2015 to 2017 are not available due to the absence of reported exports during those years.

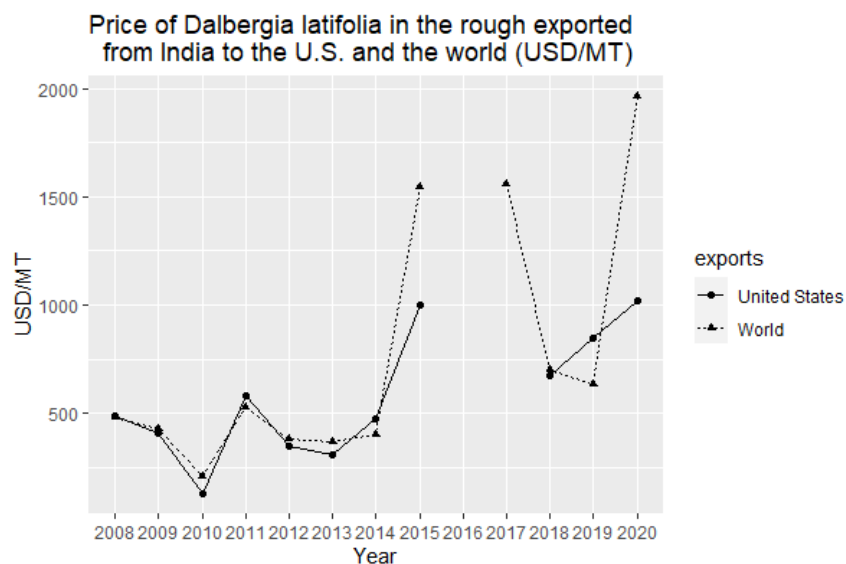


Figure 15. Changes in prices of *Dalbergia latifolia* in the rough (HS code: 44039919) exported from India to the U.S. and the world in USD/MT from 2008 to 2020. According to TDM® database.

3.3.2.2. Exports of sheets for veneering of Rosewood from India to the United States

The exports of sheets for veneering from India to the U.S. reported using the H.S. code system is presented in **Figure 16**. Most of the exports of sheets for veneering of Rosewood from India to the U.S. are classified with the H.S. Code 44083120, described as “Rosewood *Dalbergia latifolia*” followed by the category labeled as “Veneer sheets of Rosewood” (H.S. code 44083920). Both 8-digit HS codes correspond to national description of export products, where the Indian authorities have the autonomy of reporting the details of the export of their goods as their convenience after 6-digit H.S. codes. For this case, the description of the H.S. code 44083120 offers more specific information about the scientific name of the exported species than the H.S. code 44083920, both codes potentially referring to sheets for veneering of Indian Rosewood. These differences in the reports of exports from India could represent inaccuracy in the quantity of Rosewood that has been exported into the U.S., additional to the uncertainty of the amount of Rosewood that could be exported as within the tropical hardwood category. Although the

values of Rosewood exports from India to the U.S. do not necessarily represent the behavior of the general trade of all species of Rosewood trade during those years, it is interesting to note that the years immediately after the implementation of the 2008 amendment of the Lacey Act, the imports of Rosewood to the U.S. from India did increase; however, after the inclusion of genus *Dalbergia* into Appendices I and II of CITES in 2017, the average weight exported per year decreased significantly for the HS code 44083120 labeled as “sheets for veneering of *Dalbergia latifolia*”. This is an example of how the Lacey Act amendment does not work as an individual policy within the U.S. but combined with international policies as is the case of the inclusion of all species *Dalbergia* into the Appendices of CITES. The values of the average weight exported per year before and after CITES, as well as the P-values obtained through the independent samples t test are presented in **Table 8**.

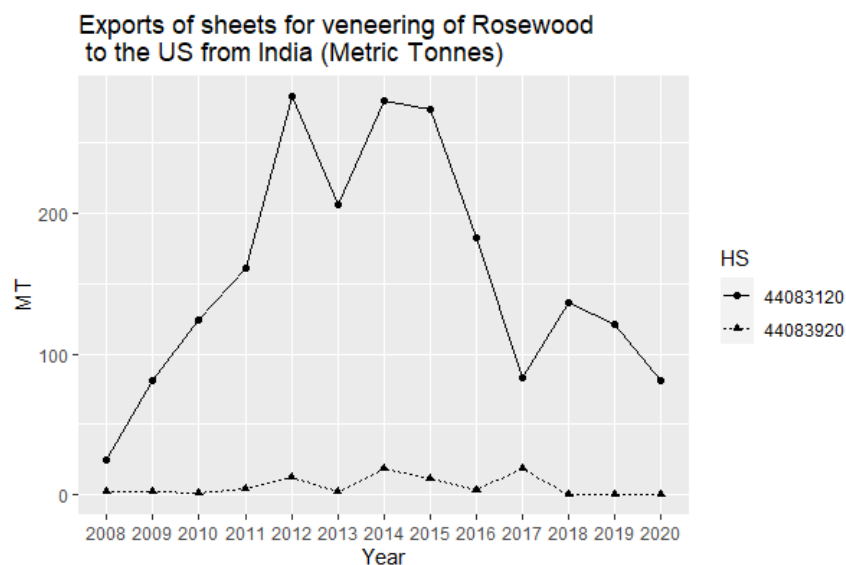


Figure 16. Exports of sheets for veneering of Rosewood to the U.S. from India Metric Tonnes from 2008 to 2020. According to TDM® database.

The prices of sheets for veneering of *Dalbergia latifolia* exported from India to the U.S. and the world had a similar trend until 2017. After 2017 there is evidence of discrepancies between the

prices of this category of Rosewood for the U.S. importers in comparison to the rest of the world. This could be due to the inclusion of all species from genus *Dalbergia* into Appendices I and II of the CITES.

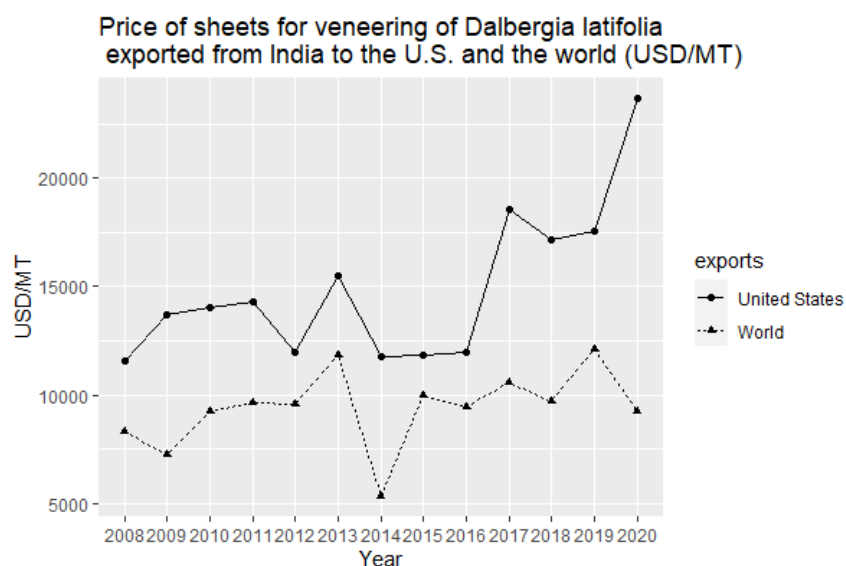


Figure 17. Exports of sheets for veneering of Rosewood to the U.S. from India metric tonnes from 2008 to 2020. According to the TDM® database.

3.3.2.3. *A comparison between the exports of sheets for veneering of Rosewood and Tropical Hardwood from India to the United States*

A noteworthy element in the exploration of the available export data provided by reporting countries is the lack of detail in the description of wood products. For most of the countries with reported Rosewood transactions with the U.S., based on the BoL information, it was not possible to establish the HS codes referring specifically to Rosewood trade by scientific or vernacular names. Such interactions were presumably included within the category of tropical hardwood, which is internationally harmonized. India, as an exception, reported Rosewood trade using three HS codes at the national level corresponding to wood in the rough and sheets for veneering, as

discussed previously. In **Figure 18** there is a comparison between two HS codes, both referring to sheets for veneering with 6 and 8-digits respectively. The 6-digits HS code (440839) is internationally harmonized and corresponds to sheets for veneering of tropical hardwood, and the 8-digits HS code (44083920) refers to the same category of sheets for veneering specifically for Rosewood. Following the rationale of the HS code system, the 8-digits HS code at the national level should provide more specific information about the trade than the internationally harmonized 6-digits HS code and would be expected that the value of exports reported using the 6-digits HS code should be greater than the values of the 8-digits HS code, since the 8-digits HS code is a subset within the 6-digits HS code. However, in this case, both values were relatively similar for most years, and in some cases, the value of exports of Rosewood (8-digits HS code) exceed the total value of the exports of tropical hardwood reported with 6-digits HS code, which is inconsistent with the logical configuration of the HS codes system.

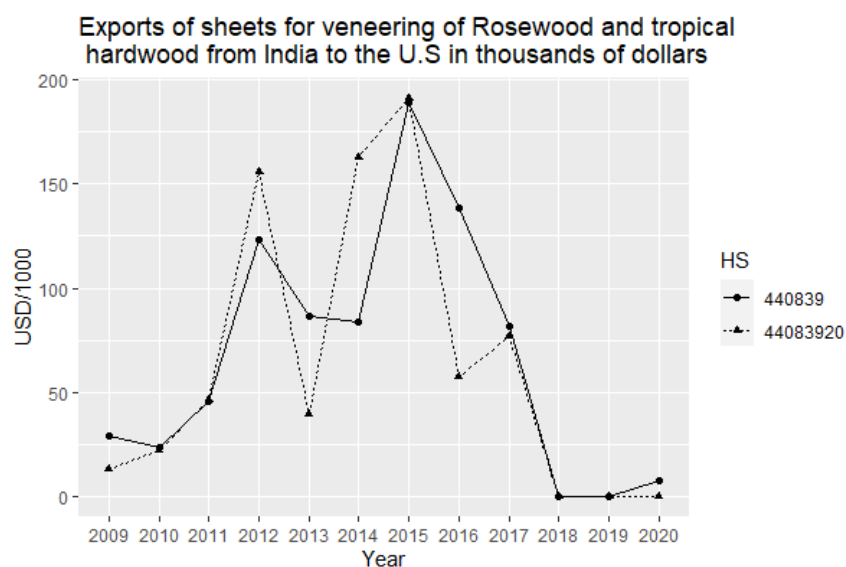


Figure 18. Exports of sheets for veneering of Rosewood and tropical hardwood from India to the U.S. in thousands of dollars from 2008 to 2020. *According to TDM® database.

3.4. Conclusions and discussion

The results presented in this chapter show the trends of Rosewood trade using publicly available sources of data. This study does not consider the trade of illegally sourced Rosewood, which analysis could show different trends than the ones described here and would imply a broader set of data. According to the Panjiva® platform, based on BoL data, there was a significant decrease in the average number of shipments of Rosewood per year coming into the U.S. after the inclusion of genus *Dalbergia* into Appendices I and II of CITES in 2017. The categories “Indian Rosewood”, “Rosewood”, and “Rosewood Substitute” had significant decreases after the implementation of such policy, however, the shipments reported using the scientific names from genus *Dalbergia* did not have a significant reduction in the trade after 2017. The use of vernacular names seems to dominate the categories of trade, and the methodology used by exporter and importer companies does not seem to prioritize the description of species by scientific names. The ambiguity in the reports from exporter countries represents a significant challenge in the data analysis for trade purposes and the potential miscalculation of the actual values of imports and exports. The use of vernacular names makes the identification of Rosewood shipments ambiguous and leaves the door opened for the trade of illegally sourced wood. This uncertainty in how Rosewood is categorized also appears to be relevant to the use of HS codes, where there is no clarity in the methodology used for the classification of HS codes at the national level, as is the case of the values of hardwood exports reported with 6-digits HS codes having lesser values than its subset 8-digit HS code referring to Rosewood exports.

An interesting fact to note in the trends of the trade data is that the application of the Lacey Act Amendment in 2008 does not seem to cause a reduction in Rosewood imports into the U.S. The total shipments per year containing Rosewood imported into the U.S. according to the available data appear to be fairly constant from 2007 to 2017 and decrease significantly after 2017. This behavior in the imports of Rosewood shows that the Lacey Act needs to be aligned with international policies of protection of species to have an impact on U.S. territory, as is shown by the results of this case study. It is also relevant to mention that the decrease of legal trade during the analyzed period does not necessarily imply the reduction of extraction and commercialization of Rosewood from the producer countries; the changes in legal trade are easily detected, however, the changes on illegally sourced Rosewood are likely to be unknown for the authorities and are not evaluated in this study. The significant reductions in the number of shipments including Rosewood products after 2017 from the main exporting Regions (India, South and Central America, and Asia) show that the application of policies as the inclusion of all species of genus *Dalbergia* into appendices I and II of CITES, combined with national policies for the restriction of protected species as the 2008 amendment of the U.S. Lacey Act have an impact in the trade of Rosewood.

Even though the category defined as sawn wood (HS code: 4407) represents the greatest number of shipments during the studied years according to the BoL data, there are not harmonized or national HS codes referring to this category by any of the reported countries exporting Rosewood to the U.S.. India, as the main exporter of Rosewood to the U.S. is the only country reporting national HS codes of Rosewood, for the categories described as sheets for veneering and wood in the rough. The information collected using the TDM[®] database show a significant decrease in

the exports of sheets for veneering of *Dalbergia latifolia* from India to the U.S. after the inclusion of genus *Dalbergia* into appendices I and II of CITES in 2017, but the analysis of the number of shipments including sheets for veneering according to the BoL data from Panjiva® does not show a significant decrease after 2017, which shows differences in the results between the two analyzed platforms.

The collection of BoL data within the Panjiva® platform shows the inconsistency in the quality of the report of Rosewood trade by exporter and importer companies, as well as the lack of detail in the report of weight and/or volume information while using this type of publicly accessible data. The absence of data about the indirect trade for the reported shipments reduces the confidence in the accuracy of the information presented by BoL-based platforms like Panjiva®. These flaws in the report of Rosewood data could also allow irregularities in the compliance of international regulations. The values of Rosewood trade presented in this case study, are relatively low compared to the total imports of wood products to the U.S. According to data from TDM®, the U.S. imported around USD 2 billion worth of wood products from China, followed by Brazil with about USD 1.5 billion. Apparently, and according to the evidence provided from the analyzed data, the imports of Rosewood does not represent a significant percentage of the total imports of wood products.

4. CHAPTER 3. THE CHALLENGES OF ANALYZING ROSEWOOD DATA

4.1. Introduction

The collection and analysis of trade data depends on several factors, including the objective of the research, the availability of resources, and the estimation of benefits and constraints provided by such data. In a globalized market, where the exchange of goods and services is performed in a daily basis, the traceability of transactions between countries implies the compilation of large amounts of data. The classification and visualization of these data can be performed by different platforms, which will ultimately determine the quality and quantity of information a user may be able to obtain from a specific search. Open data visualization intends to create user-accessible platforms to understand and display information. Panjiva® and TDM® platforms are two of the contemporary resources that offer visualization of trade data like images, maps, and graphs as part of this business archetype, making the obtention and analysis of trade data understandable and accessible for a larger portion of the population (Duan & Noda, 2019).

The trade of tropical hardwoods, and particularly Rosewood is conditioned by diverse factors, as the application of bans for the protection of species, changes in their level of vulnerability, and market preferences. Illegality in the trade of Rosewood has been studied and attacked by environmental authorities around the world and may be one reason why the U.S. is certainly setting a precedent in the regulation of imports of protected species with the implementation of the 2008 amendment of the Lacey Act. The inclusion of international bans within U.S. legislation promotes the cooperation between countries and the integration of policies for the protection of Rosewood species and their ecosystems. Throughout this case study, the analysis of Rosewood

trade into the U.S. using the available import data offers valuable information not only about the categories of the trade, the exporter countries, and the intrinsic values of the trade, but also about the impact of policies such as the 2008 Lacey Act amendment, and the inclusion of genus *Dalbergia* into Appendices I and II of the CITES,

As a result of the recurrent changes in the classification of species and the lack of integration between the systems used by environmental agencies to report trade among countries, there is evidence of significant discrepancies between wildlife trade data reported by CITES and the import data reported by the U.S. Customs. In some cases, the CITES reports have indicated volumes up to 50 times greater than the ones reported by the U.S. Customs. These differences in the estimation of trade could signify serious inconsistencies in the protection of local species, conflict in the assignation of resources, and potential difficulties in the implementation and enforcement of trade policies (Blundell & Mascia, 2005). An additional issue related with wildlife trade is the authenticity of products across countries. With the implementation of trade policies and the inaccuracy on wood identification by environmental authorities, it is not uncommon for traffickers to commercialize endangered species naming them with the scientific names of lookalike wood products that are not threatened or protected. The use of new technologies intends to address this issue. The International Barcode of Life, for example, seeks to reduce the trade of endangered species and the behavior of traffickers by testing the authenticity of the wood in the borders, decreasing the amount of protected species that are traded illegally and increasing the confidence in the legal imports (Ugochukwu et al., 2018).

The practice of shipping protected species to countries with deficient or absent implementation of trade policies and re-exporting the wood products using vernacular names or trading them as

lookalike species, has been performed by some exporters to avoid the application of local bans. In some cases, the traffickers substitute tropical wood species for temperate species, or even for non-wood products (Lawson, 2014; Pepke et al., 2015). The circumstances of the trade as well as the outcomes of the implementation of policies or protection of species should, undoubtedly, be considered at the moment of analyzing Rosewood trade data.

4.2. An overview of Rosewood illegality in the United States

The implementation of policies as the Amendment of 2008 of the Lacey Act and the inclusion of genus *Dalbergia* into the Appendices I and II of CITES has awoken criticism by some of the main Rosewood importers into the U.S. given the unintended consequences of the restrictions for various sectors, in particular the musical instruments market. Taylor Guitars, as one of the leaders of the guitars market, consider that the scope of the listing of the Rosewood species included in Appendix II of the CITES in 2017 is too broad for its implementation and lacks clarity on the reasoning behind the inclusion of all species within genus *Dalbergia*. They sustain that the CITES Rosewood Annotation that went into force in 2017 did not consider the tremendous impact these regulations would produce for the musical instrument industry, particularly companies specialized in the manufacturing of high-end guitars. This decision by CITES, they sustain, combined with the application of the Lacey Act Amendment of 2008, made the musical instruments industry lose millions of dollars on imports and exports of products including Rosewood in any of their parts, as well as delays, seizures, and even destruction of musical instruments. Taylor guitars declares that the main source for their Rosewood parts for guitars comes from Indian Rosewood (*Dalbergia latifolia*), which populations were not a matter of concern for environmental authorities at the moment of the inclusion of the genus within the

Appendix II of the CITES, and that the application of such policies does not align with the actual purpose of protecting these species. There is also confusion among owners of musical instruments that include Rosewood parts about the legality of their purchased instruments within U.S. territory as well as the traveling restrictions implied by the application of policies as the inclusion of all species from genus *Dalbergia* into Appendices I and II of CITES. There are reports of cases of musical instruments being seized or destroyed by environmental authorities (Luthiers Mercantile International, 2022; Taylor Guitars, 2022).

One of the most widely known application of the Lacey Act amendment of 2008 on illegal Rosewood trade into U.S. territory was made to the guitar manufacturer, Gibson Guitars Corp. for the illegal purchase and import of ebony from Madagascar and Rosewood and Ebony from India. The company was accused of importing these protected species, with prior knowledge about the bans imposed by the exporter countries, Madagascar and India, and the subsequent illegality of the imports into the U.S. according to the 2008 amendment of the Lacey Act. The shipments of illegally sourced wood had a value of approximately USD 260,000 and arrived at U.S. territory between October 2008 and September 2009. The company was accused of not implementing due care practices at the moment of acquiring the illegally sourced wood and was demonstrated that Gibson employees had first-hand information about the implementation of such policies in the export countries and the implications of such purchases within U.S. territory. In August 2012, the U.S. Department of Justice agreed to resolve the investigation, and Gibson Guitar Corp. was required to pay a penalty of USD 300,000 for their criminal violations of the Lacey Act, as well as to provide community service payment of USD 50,000 to the National Fish and Wildlife Foundation. The company also was demanded to implement a program to

strengthen their compliance control procedures and their claims to the seized wood was withdrawn (Hagerty & Maher, 2011; U.S. Department of Justice, 2012). According to the data analyzed in this case study, Gibson Guitar Corp. is not one of the main importers of Rosewood in the U.S. and there are not reports of imports of Rosewood prior to 2012 from this company.

4.3. The use of vernacular and scientific names in the trade reports

Continuous changes in the scientific classification of species, as well as frequent ambiguity in the use of vernacular names for trade purposes, have created additional issues in the categorization of wood products and in the identification of species in the field. With heightened uncertainty in the accuracy of scientific and vernacular names, more advanced systems that can improve confidence in the detection of illegally traded wood are required by law enforcement and the private sector and the better application of policies. The changes in the denomination of Rosewood species depends on a variety of factors such as botanical categorization, color, language, location, time, and market preferences (Tuominen et al., 2011). The information gathered about Rosewood trade reveals the lack of uniformity in the use of vernacular and scientific names in the trade data reported for tropical hardwood. In general, exporter companies decide to categorize their shipments with vernacular names, leaving room for misclassification of species and inaccuracy in the analysis of trade data. The apparent lack of detail in the collection of the species information causes, very often, mistakes in the descriptions leading to imprecision in the inclusion of species in the trade data. The changes within botanical families in the categorization of species is also an issue for the report of wood products in general, reason why the implementation of new technologies that provide certainty in the identification of wood

species is an urgent matter for the enforcement of environmental policies, collection and treatment of trade data, and academic research.

4.4. Opportunities for future research and other possible sources of information

Some of the analysis provided in this case study show the necessity of a more integrated system for the control of Rosewood trade data. Both sources of information used for tracking the imports of Rosewood are valuable in different ways and depending on the objective of the research. However, there are additional sources of information to track the entry of protected species into the U.S territory as the declarations of imports of protected species provided by the importers to the Animal and Plant Health Inspection Service (APHIS), the entity that controls the legality of species trade, whereby importers are required to demonstrate the origin and authenticity of the wood, under the conditions stipulated by the Lacey Act. The access to this information is restricted to U.S. officials and its release has not been granted to the general public. As future work relevant for policy makers, it could be useful to compare trade data using publicly available tools such as the ones presented in this case study, and the trade permits presented by importers to the APHIS. The implementation of new systems of species recognition is also vital for a better control and monitoring of species of high commercial and ecological value. Implementation of policies such as the inclusion of all species from genus *Dalbergia* into Appendices I and II of CITES can be, in part due to the inaccuracy of the actual methods of identification of species. Systems that are accurate, fast, and accessible to law enforcement are urgent for a better application of environmental measures and to strengthen the authenticity of species within the hardwood market.

The use of the HS codes as the main trade monitoring system between partner countries offers several advantages for international trade and considerably simplifies the data collection and subsequent statistical analyses. However, for the management and collection of Rosewood trade data, there is ambiguity around the species included in international trade as well as in the national descriptions of Rosewood products within countries (International Trade Administration, 2021). Independence and variability in the standards of different trade national reports lead to great uncertainty in the quantity and classification of import and export data for Rosewood at a global scale. The implementation of new systems that requires wood importers and exporters to report the scientific information of the species included in their trade with could signify a dramatic change in the accuracy of the analysis of imports data, as well as a better control of the species that enter the country by the environmental authorities.

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APPENDIX

Many of the species within genus *Dalbergia* are catalogued as Endangered or Critically Endangered by the IUCN Red List due to overexploitation and the degradation of their ecosystems. Some of these species are displayed in Figure 19 to Figure 33 as an intent to create a guide of images with anatomical features of threatened species within the genus, as well as their geographical distribution. *Dalbergia* wood is typically diffuse-porous with confluent axial parenchyma. However, vessels of two-size classes can be formed which may result in a ring-porous pattern. The frequency and visibility of parenchyma may greatly vary from very abundant to scarce.

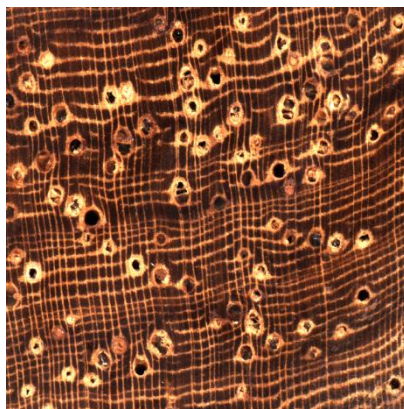


Figure 19 *Dalbergia oliveri* Prain.

Distributed in South and Southeast Asia.

Anatomic characteristics from cross-sectional surface: Solitary and short multiple pores, reticulate parenchyma.

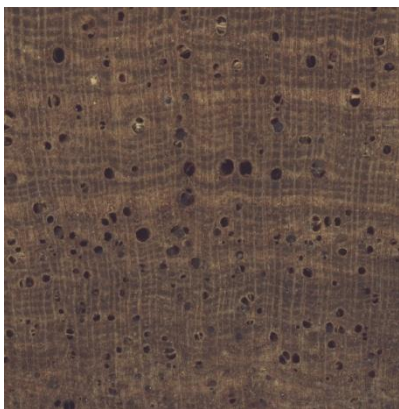


Figure 21. *Dalbergia bathiei* R.Vig.

Distributed in Sub-Saharan Africa

Anatomic characteristics from cross-sectional surface: Solitary and short multiple pores, confluent tangential parenchyma.



Figure 23. *Dalbergia brachystachya* Bosser & R.Rabev.

Distributed in Sub-Saharan Africa

Anatomic characteristics from cross-sectional surface: Ring pores, vasicentric paratracheal parenchyma.

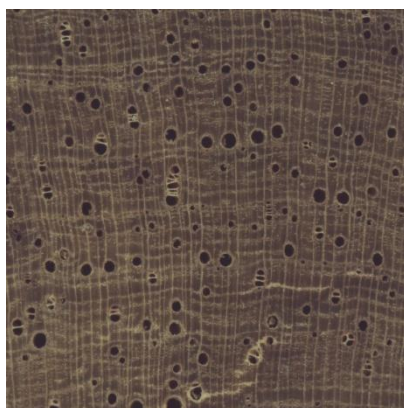


Figure 20. *Dalbergia abrahamii* Bosser & R.Rabev.

Distributed in Sub-Saharan Africa.

Anatomic characteristics from cross-sectional surface: Solitary and short multiple pores, confluent paratracheal parenchyma.



Figure 22. *Dalbergia capuronii* Bosser & R.Rabev.

Distributed in Sub-Saharan Africa

Anatomic characteristics from cross-sectional surface: Small, solitary pores, winged-aliform parenchyma



Figure 24. *Dalbergia erubescens* Bosser & R.Rabev.

Distributed in Sub-Saharan Africa.

Anatomic characteristics from cross-sectional surface: Solitary pores, winged-aliform parenchyma.

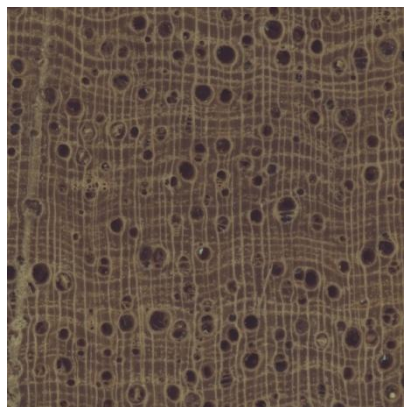


Figure 25. *Dalbergia hirticalyx* Bosser & R.Rabev.

Distributed in Sub-Saharan Africa.

Anatomic characteristics from cross-sectional surface: Solitary and short multiple pores.



Figure 27. *Dalbergia normandii* Bosser & R.Rabev.

Distributed in Sub-Saharan Africa

Anatomic characteristics from cross-sectional surface: Small, solitary pores, reticulate parenchyma.

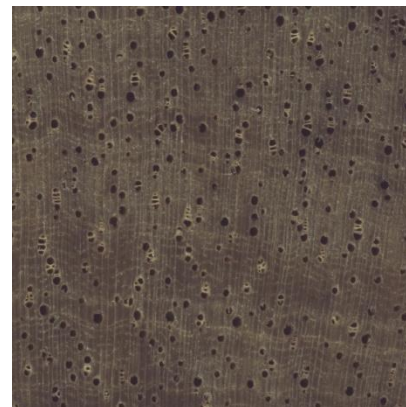


Figure 29. *Dalbergia tsiandalana* R.Vig.

Distributed in Sub-Saharan Africa.

Anatomic characteristics from cross-sectional surface: Small, solitary and multiple pores, confluent paratracheal parenchyma.



Figure 26. *Dalbergia maritima* R.Vig.

Distributed in Sub-Saharan Africa.

Anatomic characteristics from cross-sectional surface: Multiple pores, reticulate parenchyma.

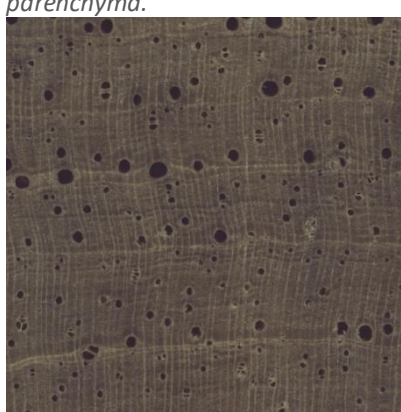


Figure 28. *Dalbergia suaresensis* Baill.

Distributed in Sub-Saharan Africa

Anatomic characteristics from cross-sectional surface: Diffuse pores, reticulate parenchyma.

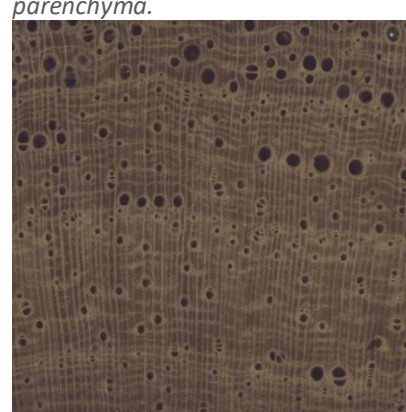


Figure 30. *Dalbergia urschii* Bosser & R.Rabev.

Distributed in Sub-Saharan Africa

Anatomic characteristics from cross-sectional surface: Diffuse pores, confluent paratracheal parenchyma.



Figure 31. Dalbergia retusa Hemsl. Distributed in Mesoamerica and Sub-Saharan Africa. Anatomic characteristics from cross-sectional surface: Solitary and short multiple pores, vasicentric paratracheal parenchyma.

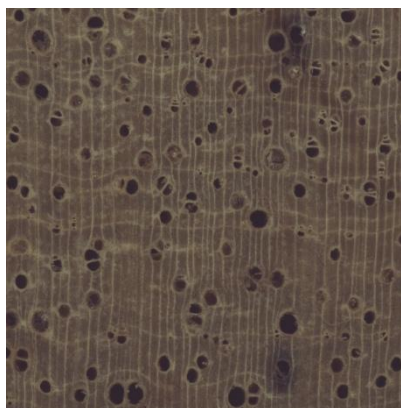


Figure 32. Dalbergia bemarivensis Phillipson & N. Wilding. Distributed in Sub-Saharan Africa. Anatomic characteristics from cross-sectional surface: Solitary and short multiple pores, confluent paratracheal parenchyma.



Figure 33. Dalbergia occulta Bosser & R.Rabev. Distributed in Sub-Saharan Africa. Anatomic characteristics from cross-sectional surface: Solitary pores, confluent paratracheal parenchyma.