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Guitar-Makers' Woods — Worldwide Biodiversity, Functionality and Aesthetics in a Craft Culture

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Abstract

Among contemporary woodcrafts, guitar-making is particularly ubiquitous and diversified. This work aimed at providing an extensive landscape of woods used by guitar-makers and mapping this worldwide biodiversity according to functions, reputation, conservation status, floristic composition, and wood features. A specific database was built through a meta-analysis of academic and professional sources. Detailed information was obtained by original surveys with guitar-makers and analysis of specialised wood trade. Specimens of 90 species were collected. In total, nearly 450 species cited in guitar-making were surveyed. Analyses of the results allow the categorisation of which species are in “main”, “common”, “occasional” or “rare” uses. Some functions are more focused on the number of species (“commonly” used diversity ranks as: acoustic top-plates < necks < bridges and fingerboards < electric bodies << acoustic back and sides) and/or regions of origin, and some are widely diversified and ubiquitous. Species or regions can concern rather specialised functions, or multifunctional woods. The total and regional biodiversity is analysed in terms of floristic composition: all cited woods belong to 234 genera in 64 families, “common” ones to 43 genera in 23 families, but 6 families concentrate many citations of uses. This study also allows to examine the issue of threatened species (which is of high concern in guitar-making communities and literature) with greater details and points of comparison. Both the proportions, and the levels, of threats on employed woods vary greatly depending on the regions of origin, the reputation or frequency of use, and the trade value. A visual mapping of collected wood specimens was built to highlight the links between wood reputation, origin (geographic and botanic), quantitative trade value, and wood characteristics

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that are most esteemed. These semi-quantitative results are set into perspective with artisanal values and relation with wood expressed by artisan guitar-makers, and with literature on the craft culture of guitar-makers. Future publications will extend this including material properties.

Keywords

artisanal values – bio-cultural diversity – biodiversity conservation – biogeography – craftsmanship – trade value – wood characteristics

1 Introduction

Among cultural woodcrafts, musical instrument making embodies particularly well the intimate knowledge of wood through hand-working and the combination of functional and sensorial approaches to wood. For studying the relation between craft cultures and wood diversity, guitar-making is an interesting field as it combines cultural diversity, functional diversity (types and components of guitars), and biodiversity in employed species.

Regarding cultures and organology, guitars are among the most ubiquitous and diversified families of musical instruments. Today emblematic of contemporary global cultures (Gibson & Warren 2021), guitars originate from centuries-long historical pathways (Applegate 2021) and ramify into many place-specific guitar cultures (Dawe 2013; Kies 2013). Both the produced instruments and their musical cultures, and the material cultures of instrument makers, are highly diversified. There are very different communities of guitar-makers: some are very traditional and emblematic of places (Dawe 2013; 2016), some are multigenerational with a strong sense of community (Kies 2013), and some are linked to classical culture yet based on high independence and frequent autodidacticism (Winn 2019, 2020). Some guitar-making cultures (e.g. Spanish guitars) emphasise their local heritage of handicraft artisans' skills (Dawe 2016). Some others (e.g. North American steel-strings or electric guitars) originate in industrial mass production (Dudley 2014; Gibson & Warren 2021) but have subsequently been the scene for an emergence of new communities of artisan luthiers, underlying strong movements for the reappropriation of work, techniques and trades, and sharing of knowledge, including on wood (Dudley 2014). Confronted with industrial mass production, individuals and/or communities of artisan luthiers promote the handcrafted status in the value of the guitars they produce (Dawe & Dawe 2001; Kies 2013; Dudley 2014).

Guitar-makers often emphasise the importance of their relation to wood, highlighting the intimate knowledge of working with wood and the imbrication of dimensions that are technical, sonic, aesthetic, and more generally sensorial and relational to wood (Dudley 2014; Dawe 2016). Johnson (2007) argued that the concept of “aesthetics of wood” should encompass the sensorial (not just visual) and the relational (to the “second-life of trees”, to woodworking, to communities). One of the essences of craft is in the synthesis of aesthetics and functionality (Risatti 2009). There are different “functionalities” in guitars, associated to the different parts/components, e.g. the neck should support the strings' tension (and be comfortable to play), the fingerboard should resist wear (and be stable), the top-plate (“soundboard”) should radiate sound, the back and sides (“soundbox”) should act as a reflector. Classical guitar examples of woods, often called “tonewoods”, in these components include cedar (*Cedrela odorata*), ebonies (genus *Diospyros*), European spruce (*Picea abies*), Western red cedar (*Thuja plicata*), and rosewoods (genus *Dalbergia*). These broad outlines are, however, simplistic, both on functions and species. The functionalities are more complex and varied, and they combine geometry/design, making processes, and wood material (Gore 2011; Merchel *et al.* 2019). In this craft, much of the attention is often focused on the single functions/notion of “acoustics” — where it is not always simple to isolate a wood's contribution (LGRP 2012–2017; Paté *et al.* 2015; Carcagno *et al.* 2018) — and this may be to the detriment of other functions and notions. The functionality may also interact with bio-cultural diversity (Brémaud 2012).

Regarding wood utilisations, Applegate (2021) reviewed different historical trends. For example, in the back and sides, some earlier (16–17th century) guitar-making wood utilisations were closely inspired by their contemporary cultures in cabinet-making and marquetry, with a variety of the early importations of precious tropical materials (Applegate 2021). Some periods (18th to mid-19th century) seemed closer to the wood utilisations of the violin family, i.e. with frequent uses of maple (*Acer pseudoplatanus* or sp.) (Applegate 2021). Since the mid-19th century, the “Spanish” (gut- then nylon- strung) types of guitars have focused on a few “iconic species” for each of the different components, especially Brazilian rosewood (*Dalbergia nigra*) and later Indian rosewood (*D. latifolia*) for classical guitars back and sides, and Mediterranean cypress (*Cupressus sempervirens*) for flamenco guitars (Applegate 2021). Steel-strung (sometimes called simply “acoustic”) types of guitars additionally focus on “mahoganies” (*Swietenia mahagoni* and *S. macrophylla*), koa (*Acacia koa*, syn. *A. koaia*), or maples (Bennett 2016; Gibson & Warren 2021). Investigating the historical developments of tonewoods, Applegate (2021) and Gibson and Warren (2021) also underlined the difficulty of tracing individual

species accurately, as both written sources specific to guitar-making and scientific identifications of species in preserved instruments may be lacunar or missing. Still, at present, a very high diversity is used by guitar-makers. For example, Bennett (2016) reviews 90 species currently in use in acoustic guitars. Although “iconic” woods are fewer (Bennett (2016) cites 20 considered the most traditional), this is already much more diversified than in violin-making, where wood selection is very specialised in a near-exclusive predominance of two species — European spruce and “fiddleback” maple (Carlier *et al.* 2018) — except for the “accessory” components (Fouilhé *et al.* 2012). Many professional sources, media, and research conducted by guitar-makers (Taggart 1989; Olsen & Burton 1998; Jahnel 2000; TonewoodDataSource 2005–2024; Gore 2011; LGRP 2012–2017; Carbonneaux & APLG 2019–2021) demonstrate the guitar luthiers’ interest in wood diversity. The inherent strong curiosity of artisans to creatively explore wood diversity could also be conjugated with cultural diversity between communities, or individuals, in guitar-making of different types, places, schools of thought, or technical styles.

Obtaining a comprehensive overview of guitar-making woods seems also of topical concern in the context of the erosion of tree biodiversity, which is one urgent issue that the contemporary epoch is facing (Rivers *et al.* 2022), far beyond guitar- or instrument-making. Among the ≈60,000 world tree species currently identified, 29.9% are threatened, and a further 7.1% are possibly threatened (BGCI 2021). The causes of threats are multiple (BGCI 2021; Rivers *et al.* 2019), and estimations of exact volumes harvested are difficult to assess even for general timber uses (Hills *et al.* 2022), and even more so for very specialised uses such as guitar-making (although some sources suggest the latter would represent a small proportion only (Carbonneaux & APLG 2019–2021; Gibson & Warren 2021)). Still, the situation is that, over the past decades, several “iconic” tonewood species have become increasingly threatened, provoking very high concern among guitar-making communities (Taggart 1989; Curtis 1993; Dudley 2011; Dawe 2016; Gibson 2019; Applegate 2021). In 1992 the most iconic *Dalbergia nigra* was listed under Annex I (the strictest regulation) of the Convention for International Trade on Endangered Species (CITES 2024; Greenberg 2016; Lichtenberg *et al.* 2025). Since then, a growing list of guitar-making (and other instrument-making) species has been included in CITES trade regulation, usually Annex II (Carbonneaux & APLG 2019–2021; Calvano *et al.* 2023; Kusnick *et al.* 2024). Thus, luthiers are torn between their attachment to species with specific wood characteristics — an attachment usually constructed through the relational way of working with wood, through a historical and/or personal experience with a given material — and their often-high ecological consciousness (Dudley 2011; Dawe 2016; Gibson 2019). Although changes in wood species selected for a given use have always occurred

through history, the time-scales of changes should be regarded together with the time-scales of craftsmanship experience and knowledge-building (Brémaud *et al.* 2023). Furthermore, the wood reputation contributes very significantly to the expectations of customer-musicians, and to the trade values of produced guitars (Kies 2013; Bennett 2016; Gibson & Warren 2021; Zhou *et al.* 2022). A growing body of academic research has reported on the topic of “sustainability” of uses in instrument-making, either from the perspective of humanities and social and environmental sciences (Dudley 2011; Bennett 2016; Dawe 2016; Gibson & Warren 2016, 2021; Greenberg 2016; Gibson 2019; Zhou *et al.* 2022; Calvano *et al.* 2023; Kusnick *et al.* 2024; Lichtenberg *et al.* 2025) and/or of wood material and physical sciences — this often on topics of “substitute” or “alternative” materials or “diversification” (LGRP 2012–2017; Krüger *et al.* 2018; Ahvenainen 2019; Shirmohammadi *et al.* 2020; Applegate 2021; Kahn & Brémaud 2022; Cotton & Wolodko 2023; Quintanar-Isaías *et al.* 2025). Still, the different perspectives often remain compartmentalised.

Recently, literature on guitar-making and tonewoods has been rapidly growing; however, before, it had received less attention from academic research than violin-making and its woods. Although there are a few wide surveys of the diversity of woods used in instruments generally (Brémaud *et al.* 2007; Brémaud 2012; Kusnick *et al.* 2024), or in guitar-making specifically (Bennett 2016; Ahvenainen 2019; Calvano *et al.* 2023), they cover different fields and scales of study. Hence, it appears there is still a need for a comprehensive overview of woods used by guitar-makers.

Therefore, the objectives of the present paper were to examine together, in the specific case of guitar-making woods, the extent of biodiversity in wood used and some elements of functionality and aesthetics relevant to guitar-makers' craft culture. For this, a meta-analysis of academic and professional sources was conducted, and detailed information was obtained through surveys and the collection of wood specimens with artisan luthiers and wood suppliers. Surveyed species were categorised between biodiversity (floristic, biogeographic, conservation status), functional diversity (more or less common uses, different guitar types and components), and aesthetic diversity, which is discussed in the perspective of elements of luthiers' wood and craft culture.

2 Materials and Methods

2.1 *Grasping a Wide Diversity: Meta-analysis of Scientific and Professional Literature*

In order to obtain a wide view of the bio-cultural diversity of woods in guitar-making, species and uses cited in several published sources, scientific

and professional, were surveyed. Not all possible sources were compiled: the focus was on sources that listed the most significant wide range of wood diversity. Several of the sources compiled in the present meta-analysis were themselves based on meta-analyses.

For scientific surveys, information was retrieved from three main sources. Bennett (2016) reviewed published literature and websites of major guitar manufacturers, luthiers, and tonewood suppliers, focusing on acoustic guitars. This source categorised species between “traditional” and “new” guitar woods and listed 90 species used for the different parts of acoustic guitars, both artisanal and industrial, but it does not include a quantitative indication of frequency of use. Calvano *et al.* (2023) also focused on acoustic guitars by reviewing materials in all guitar models from the 14 major industrial manufacturers over the world. This source listed 55 binomial names of species used as solid wood (plus woods used in plywood, but these were not compiled in the present work), with the frequency of use for the different parts of industrial acoustic guitars. Ahvenainen (2019) focused on electric guitars (pinpointing that most research has concentrated on acoustic ones) by reviewing makers’ literature, commercially available electric guitars, and tonewood suppliers, and by interviewing Finnish luthiers. This source listed 50 species, with indicators of frequency of use for the various parts of industrial or artisanal electric guitars.

Three main sources were also compiled regarding professional guitar-making information. Jahnel (2000), in a well-known “Manual of guitar technology”, listed 309 species that can be used in a guitar-making workshop (including woods for tools, jigs, plywood, veneers, and inlays). For the structural parts of acoustic guitars studied in the present paper, this source listed 226 species, but with no indication of frequency of use, and for some woods it seems unclear if they were used or simply suggested. Carbonneaux and APLG (2019–2021) surveyed actual uses by artisanal makers of acoustic and electric guitars by asking luthiers to list all species used in the guitars they exhibited at a guitar salon in 2019, France. This source listed 69 common names corresponding to ca. 80 species, with frequency of use (Carbonneaux 2019). The online publication of this listing was subsequently expended, from various sources, to 123 species, but only the first list was compared in the present work. TonewoodDataSource (2005–2024) was built by “a guitar enthusiast and wood lover” by browsing various information “mostly from the internet”. This source listed common names and descriptions corresponding to ca. 230 species, mostly used for acoustic backs and sides, also some used for top-plates and other components, and a few used in electric guitars.

2.2 *Obtaining Deeper Information: Original Surveys on Wood Uses by Guitar-Makers*

In order to better grasp not only the global biological and functional diversity of wood uses by guitar-makers, but also some more detailed and in-depth information, two original surveys were conducted: one directly with artisan guitar-makers/luthiers and one exploring the “market” of tonewood suppliers.

The names of ca. 55 woods used for acoustic and/or electric guitars, together with the discourses, descriptions, and appreciation of these woods, as well as the ways of material procurement/wood supply, were collected from 16 luthiers through questionnaires or interviews. A list of 48 species (for which uses for different guitar components were detailed by 10 luthiers, with associated wood specimens) was implemented in the database. Interviews with six luthiers provided preliminary elements for some more anthropologically relevant information such as life and professional trajectories, ways of learning and of working, relation to time, artisanal values, relation and attachment to wood, and environmental concern.

To get more broad and quantitative information, a survey was conducted on the global market of wood traded for guitar-makers by specialised tonewood vendors. This was used to evaluate the representativity both of the information collected in our surveys with 16 French luthiers and of the different sources compiled in the meta-analysis, as only some of these sources provided information on the frequency of use and none provided information on the quantitative trade value of wood supplies from different species. This survey was conducted from websites of specialised tonewood vendors from Western cultural areas (Europe, North America, Australia). It focused on woods sold for acoustic guitar backs and sides, given that this function covers, by far, the highest biodiversity in wood uses and includes multifunctional woods that can be found in less diversified functions. Implemented data came from 43 suppliers, from the most prominent companies to very small-scale ones. The common name, botanical name when cited, wood description, appreciation when provided, and the retail price (as of 2023, converted into euros from the different currencies and years) were listed for each wood supply. This survey recorded 188 species.

Beyond the data included in the present article, these two original surveys are planned to be continued.

2.3 *Materialising “Materiality”: Collection of Wood Specimens*

Specimens were collected from two sources. One was participatory research with 10 French guitar-makers, who generously donated 245 wood pieces

(usually small workshop offcuts) from 48 species used in acoustic and/or electric guitars. The main one was bought from several European vendors who specialise in guitar tonewoods. The focus was on plate shapes, in order to be representative of wood appearance and to allow characterisations of anisotropy. Given the prices of full-scale supplies (see Section 3.4 on trade value), specimens were often bought as supplies for guitar headplates, guitar sides, or ukuleles. A total of 285 plates from 75 species were gathered.

These collections of wood specimens were done with two objectives. One was to characterise their properties (physical, vibro-mechanical, and optical); the results were not presented here but will be in future articles. For the present article, the objective was to obtain a wide collection of woods representative of the diversity of uses in this craft, in order to relate cultural and trade values with wood characteristics that can be involved in the descriptions by guitar-makers. This is presented in the form of a visual mapping of 71 species, categorised on the basis of results from my survey of specialised vendors. Wood pictures were obtained on specimens all prepared in the same way: sanding at grit #180 and imaging with an optical scanner within a few days after surfacing.

2.4 *Connecting Diverse Diversities: Construction of a Dedicated Database*

All species listed in the different sources (two surveys by the author, three scientific surveys, three guitar-making surveys or lists) were gathered in a single database. I had previously developed a database on the diversity of woods in musical instruments of the world (Brémaud *et al.* 2007; Brémaud 2012), but present research required the creation of a specific database on guitar-makers' woods to better examine functionality and quantitative issues. For each "ethnospecies" (see below), the different components cited in each source were listed separately. Then, after checking taxonomy, all components — and the number of times they were cited — were gathered for each given species. This database includes groups of fields about nomenclature, uses, sources of citations, taxonomy, origins, conservation status, and available data on properties.

2.5 *Checking Nomenclature, Taxonomy, Biogeographical Origin, and Conservation Status*

The meta-analysis database compiled on woods used in guitar-making listed 448 "ethnospecies" (i.e. citations and names given to a wood by a community and for its uses). The main difficulty, as stated by Bennett (2016), was to identify valid nomenclature from woods often cited by common names. The identification of botanical names was already done in the three scientific references here compiled. Botanical names were also provided in the three professional

sources surveyed but were sometimes invalid (earlier synonyms or spelling typos). In the original surveys conducted, luthiers and suppliers indicated botanical names for a significant proportion of woods, but there were also issues of including some invalid names and citing many of the woods by common names only. For assigning “ethnospecies” to their most likely botanical names, comparison between the eight different sources compiled in my meta-analysis was helpful. The correspondences between common trade names and botanical names were checked with wide-scale books and databases (Gérard *et al.* 2016; TervurenXylarium 2024; TheWoodDatabase 2024). One main issue comes from the notions of “under-differentiation” (one common name covering several botanical species, e.g. “Madagascar rosewood” for several *Dalbergia* spp.) and “over-differentiation” (several common names given to a single species), which is clearly stated by Bennett (2016). Despite this, all cited woods could be reliably assigned at the level of the genus spp., and a majority (410) at the level of species.

Then, the nomenclature and taxonomy of all listed woods were verified and homogenised (to include only botanical names that are accepted as of 2024) using the databases of Kew, also Missouri, Botanic Gardens (POWO 2024; Tropicos.org 2024). Information on botanical families was completed — this was not presented in the compiled sources except in a single one — and, for Fabaceae, on sub-families using TervurenXylarium (2024).

The distribution of species was also checked with POWO (2024) and compiled in the database — distribution was cited only occasionally in the compiled sources. The species' origin was grouped by regions that roughly follow biogeographic realms (BGCI 2021), but with some subdivisions that have a meaning in the case of wood trade for guitar-making: North America, Mesoamerica and Caribbeans, Tropical South America, Temperate South America, Europe and Mediterranean, Northeast (NE) Asia, West and Central (W&C) Africa, South and Southeast (SE) Africa, Madagascan region, South and SE Asia (Indo-malayan realm), subdivided in “continental” and “islands” (Malaysia, Philippines, Indonesia), and the Australasian realm (grouped with Oceanian).

The conservation status/level of threat of all species was checked with the database of the International Union for the Conservation of Nature (IUCN 2024). A difficulty was with “ethnospecies” that could only be identified at the level of the genus, or that correspond to a group of several botanical species (notion of “under-differentiation”). For these, in some cases, it was possible to assign an “average” status, when the botanical species of that genus and origin shared the same status. Otherwise, these were listed under “not evaluated”. In this article, the acronyms used by IUCN will be used, i.e. CR (critically

endangered), EN (endangered), VU (vulnerable), NT (near threatened), LC (least concern), DD (data deficient), and NE (not evaluated). In the broad-scale analyses made by Botanic Gardens Conservation International (BGCI 2021; 2024), CR, EN, and VU are termed as “threatened”, NT as “possibly threatened”, and LC as “not threatened”.

3 Results and Discussion

3.1 *A Highly Diversified Craft*

3.1.1 Evaluation of Collected Data on Biological and Functional Diversity

In total, the meta-analysis database I compiled on woods uses in guitar-making listed 448 “ethnospecies” (410 identified by a binomial name of species, the rest as genus sp. or spp. with indication of origin). Such an amount of diversity could be regarded as rather impressive for a given woodcraft (especially considering that, in the present work, sources related to uses in Western cultures mainly were surveyed). It is certainly impressive compared to violin-making, in which the number of used wood species is very limited (Carlier *et al.* 2018).

However, this very high recorded diversity could also be “the tree that hides the forest”. Indeed, among the eight sources in my meta-analysis (two original surveys, three scientific surveys at broad scale, and three professional surveys at broad scale), species cited in all sources examining acoustic guitars (seven sources) or electric guitars (four sources) are only 19. A total of 230 species are cited in a single source, and a further 100 species in no more than two sources (Fig. 1A).

Beyond a global, unclassified, number of species used in guitar-making, it is important to consider the diversity inherent to each of the different “functions”, i.e. the different types and components of guitars (Fig. 1B). The total number of cited species ranked from “electric body and top (EBT)” (50 spp.), “acoustic top-plate (AT)” (79 spp.), “acoustic bridge (Br)” (97 spp.), “acoustic and/or electric fingerboard (Fb)” (127 spp.), and “acoustic and/or electric neck (Ne)” (156 spp.), to “acoustic back and sides (B&S)” (317 spp.). However, among the species cited in a single source, those cited only by Jahnel (2000) represented 86% of single citations for Ne, 82% for Br, 67% for Fb, and 42% for AT (but only 17% for B&S). It was not explicit in this source if all cited species were “actually used” or “could possibly be used”. Without the single citations from this given source, the total number of cited species would rank in this order: Ne (47 spp.), EBT (50 spp.), Br (50 spp.), AT (54 spp.), Fb (66 spp.), and B&S (289 spp.). In most of the subsequent analyses of this article, it was decided not

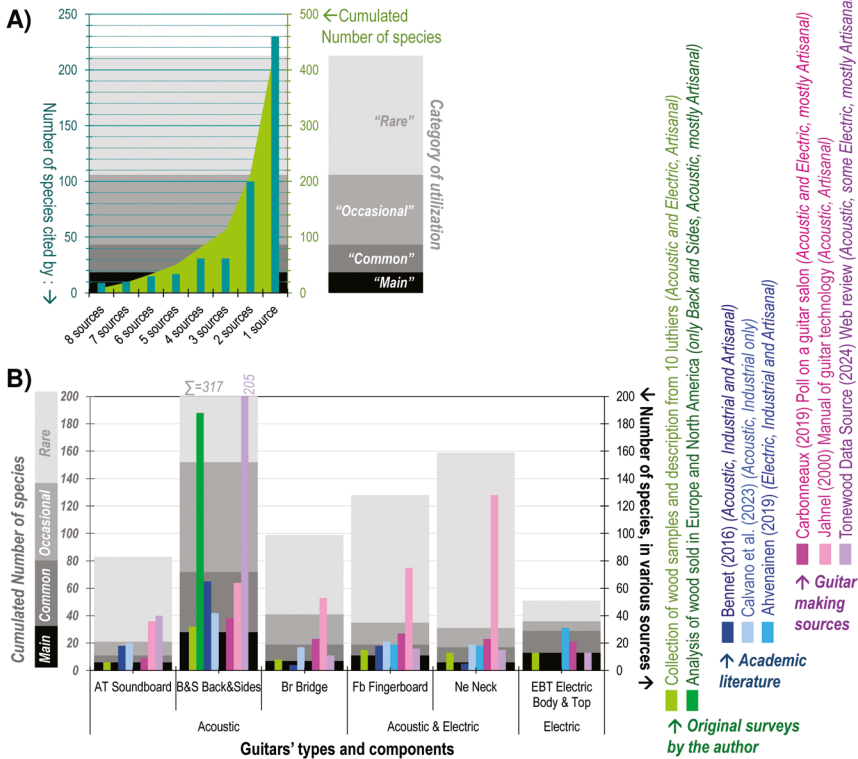


FIGURE 1 Number of guitar-making species and categorisation into “frequency of citations” or “reputation of use”. (A) Total number of wood species as a function of the number of compiled sources citing the guitar-making uses of the species. (B) Number of wood species cited for the different components and types of guitars by each source (right axis) and cumulated (left axis)

to filter out the original information compiled; yet, this probable discrepancy in single citations for the neck, bridge, and fingerboard should be kept in mind.

Comparing the amount of diversity found in several of the compiled sources was useful for assessing the representativity of the database I gathered. In acoustic guitars, the quantitative overview by Calvano *et al.* (2023) of the global/worldwide market of major industrial companies lists 55 species used as solid wood. Surveys from mostly Western guitar-making — but not only industrial — list 90 (Bennett 2016), 230 (ToneWoodDataSource 2005–2024), or 188 (our survey of tonewood vendors) species. Only at a local scale in France, our surveys with 16 artisan luthiers indicated ca. 55 species (48 implemented in the database), i.e. numbers close to that in the census of the global industrial market. Local-scale surveys of diversity in guitar-maker’s woods are unfortunately

sparse, but interesting examples from Mexico and Australia (Guridi Gómez & Garcia López 1997; Morrow 2007) (not implemented in the present database) will be discussed later. All the sources compiled in my meta-analysis examined biodiversity in guitar-making woods. Although they concerned different fields and scales and listed numbers of species that vary by more than four times, each source contributed at least some additional species not found in other sources. This tends to support the hypotheses that the guitar-makers' world is prone to exploring wood diversity, and that artisan/craft luthiers have a higher curiosity and flexibility towards wood diversity than industrial companies and markets do.

3.1.2 Definition of Species' (Global) and Functions' (Part-Specific) "Reputation of Use" and of "Uses' Citation Index"

Beyond a simple number of species (related to the ecological notion of species richness), it is important to consider the frequency of occurrence (related to the ecological notion of species abundance). Quantitative frequency of use was included in only part of the sources in the present meta-analysis, and when presented they had been calculated on a different basis, scope, or scale (i.e. some on acoustic guitars only, some electric only, or both; or some artisanal only and some industrial only). Thus, it was here not possible to compute an aggregated, synthetic "index of frequency of use" that would represent the actual proportion of guitars built using each species for each function.

Still, as the present meta-analysis compared eight different sources all addressing the diversity of guitar-making woods, it allowed me to define a notion of "reputation of use" and some "uses' citation index" (UCI, see below). Globally (i.e. all types and components of guitar together), species were ranked by the number of sources citing their use (Fig. 1A). Their "reputation of use" was categorised into "main" (34 species cited in six to eight sources), "common" (a further 48 species cited in four to five sources), "occasional" (a further 131 species cited in two to three sources), and "rare" (230 additional species that were cited in a single source). In the following analyses, to allow geographic comparisons that would be difficult on too small a number of species, species in "main" and "common" uses' categories will often be regrouped (i.e. 82 species cited by at least half of compiled sources).

A categorisation into "reputation of use" was then done for each of the individual components of guitars. This was based on the same principle as the global one, yet, as the number of sources addressing the different components varied, the criteria were slightly adapted. The only delicate case was EBT, addressed in only four of the compiled sources; yet, as some of these presented

some quantitative “use index”, this was used for the categorisation. Still, for EBT, fewer “occasional” or “rare” species could be surveyed, so they were here more represented by “main” and “common” uses than the other components. The number of species in “main and common uses” ranked in the order AT (11 species) < Ne (17 species) < Br (19 species) = Fb (19 species) < EBT (29 species) << B&S (72 species).

Finally, although a real index of frequency of use could not be compiled, a “uses’ citations index” (UCI) was computed, in order to represent both the component-specific and the global importance of the species in guitar-making. This UCI was defined by the ratio between the number of citations of a given species for a given component, over the total citations for that component, summed up between the different components/functions:

$$UCI = \left(\frac{N_{cit}^{\circ}(AT)sp.}{\sum cit^{\circ}(AT)} + \frac{N_{cit}^{\circ}(B\&S)sp.}{\sum cit^{\circ}(B\&S)} + \frac{N_{cit}^{\circ}(Br)sp.}{\sum cit^{\circ}(Br)} + \frac{N_{cit}^{\circ}(Fb)sp.}{\sum cit^{\circ}(Fb)} + \frac{N_{cit}^{\circ}(Ne)sp.}{\sum cit^{\circ}(Ne)} + \frac{N_{cit}^{\circ}(EBT)sp.}{\sum cit^{\circ}(EBT)} \right) / 6.$$

The advantage of this index is that it gives a total of 100% for all species and represents both the number of citations (“reputation”) and the functional uses of species (some species have specialised uses, and some are very multifunctional). For example, among the highest values are found *Swietenia macrophylla* (UCI = 1.7%, very widely cited and for all guitar components — even if occasionally for some), *Dalbergia latifolia* (UCI = 1.4%, very widely cited in several but not in all components), and *Picea abies* (UCI = 1.0%, cited in all six sources that address acoustic top-plates, and only once for necks). Its inconvenient is that, for woods used mostly or only in the back and sides, the UCI was proportionally reduced because the sum of all citations (665) for this component was disproportionally (three to eight times) higher than for other components. However, prominent woods used for B&S are most often rather multifunctional, and this UCI also allowed a better comparison on the biogeographical and floristic basis (as otherwise the very high diversity for “occasional or rare” uses in the back and sides would hide all other species and uses). Globally, the species in “main and common” uses sum up ca. 50% of this UCI, “main, common, and occasional” sum up ca. 75%, and “rare” uses represent the remaining ca. 25% of the sum of UCI. But observing separately a given cumulated % of UCI cannot tell directly the “reputation of use”.

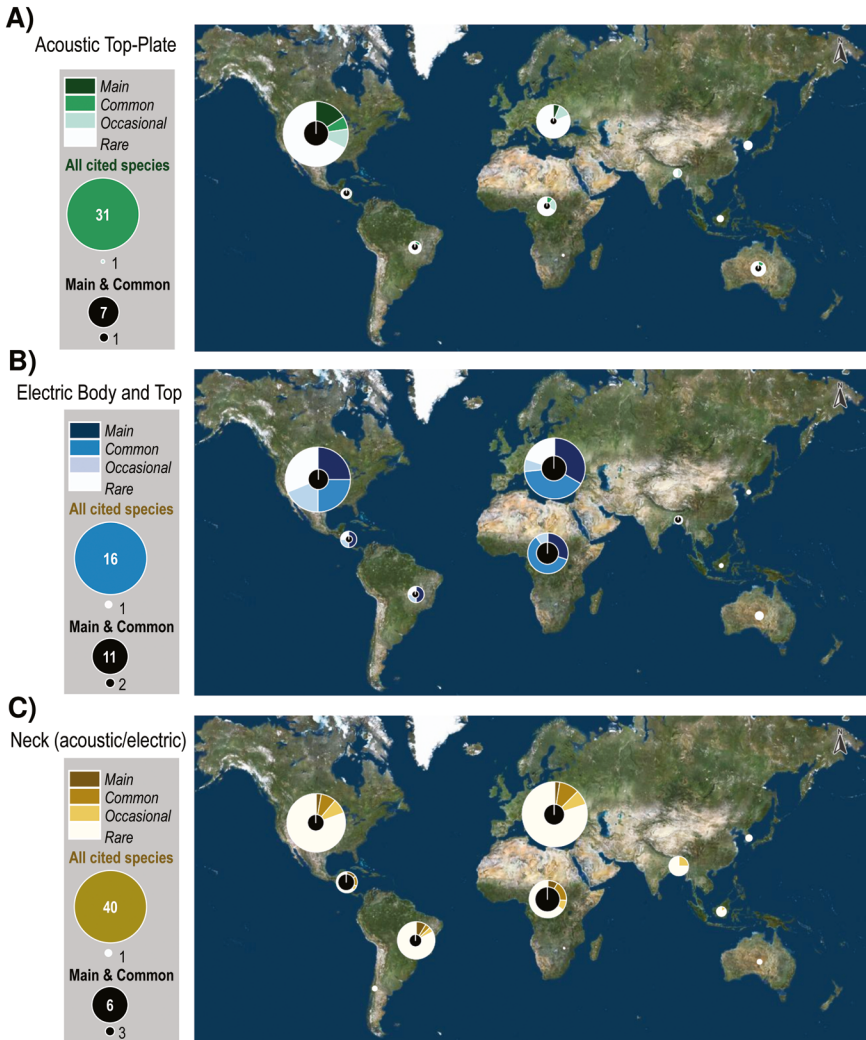


FIGURE 2 Biogeographical origins of tree species used for guitar components supposedly requiring light to relatively light woods: (A) top-plates (“soundboards”) of acoustic guitars; (B) body or top of solid-body electric guitars; (C) necks of acoustic and/or electric guitars (including heavier woods used for neck reinforcement)

3.1.3 Ubiquitous Wood Origins, Biological versus Functional Diversity

The regions of the origin of woods, categorised by their “reputation” of use for the different components and functions of guitars, are presented in Figs 2 and 3.

Woods in “main and common” uses for the top-plates (Fig. 2A) — or “soundboard”, the vibrating element — of acoustic guitars originate, as is well known,

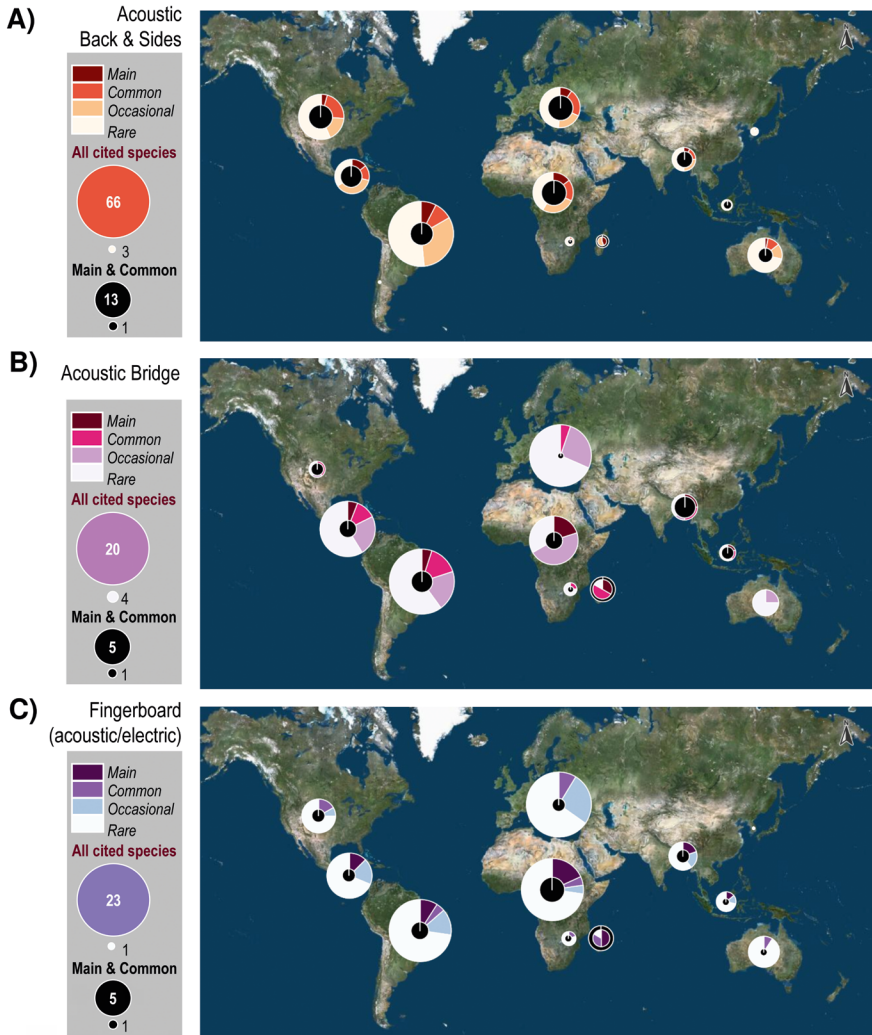


FIGURE 3 Biogeographical origins of tree species used for guitar components supposedly requiring relatively dense to very dense and hard woods: (A) back and sides (“soundboxes”) of acoustic guitars; (B) bridges of acoustic guitars; (C) fingerboards (fretboards) of acoustic and/or electric guitars

mostly from conifers of Europe (here with one main species (*Picea abies*) that is most frequently used and reputed); of North America (with a higher number of frequently used species); and occasionally of Australasia/Oceania. Yet, some main/common uses concern broad-leaved tropical species such as “mahoganies” (*Swietenia*, *Cedrela*, *Khaya*) from Central and South America and

W&C Africa. The degree of “experimentation” or “diversification” (i.e. the ratio between the total number of cited species and the number of species in “main or common” use) is highest among species from Europe and North America.

For the (solid) body and top of electric guitars (Fig. 2B), the “main and common” species originate from Europe, W&C Africa, North America, and a smaller number of species from Central and South America. The degree of experimentation/diversification is more difficult to assess (due to the smaller number of compiled sources), but it seems highest among temperate woods from Europe and mostly North America.

For necks (Fig. 2C), the species mainly or commonly used originate from Central and South America — including the woods most reputed for necks of classical guitars (*Cedrela*, *Swietenia*), but, considering all types of guitars, as many or more “main/common” species originate from W&C Africa, Europe, and North America. The degree of experimentation/diversification is highest among species from Europe and North America, followed by South America. Besides the already mentioned “suggestions of use” in Jahnel (2000), electric guitars contribute significantly to the diversity of species used in necks, as there is a strong interest of the profession in trying many combinations of “neck reinforcements” with stiffer — and usually denser — woods.

These three functions in guitars (acoustic top-plates, electric body, and necks) supposedly require light to medium-light woods, and (at least for top-plates and necks) a rather high stiffness-to-density ratio. However, there is only a small degree of overlapping of species between the three functions (main overlappings are between necks and electric bodies). For these three functions, the uses of species from the SE African and Madagascan, Asian, and Australasian biogeographical regions remain anecdotal, even when woods with close botanical and/or physical characteristics are present in some of these regions (Brémaud 2012).

As indicated earlier, the back and sides (Fig. 3A) — or “soundbox” — of acoustic guitars are, by far, the function that uses the highest biodiversity: the present meta-analysis recorded ca. 315 species in total, and high numbers in “main” (28, about three times more than other components/functions) or “main and common” uses (71, three to seven times more than in other components). The back and sides are the only guitar function for which species originating from all biogeographical regions are recorded. Apart from some biogeographic origins that are very occasional/anecdotal (temperate South America or North-East Asia), all other regions bear some species that are in “main or common uses” for the back and sides. The degree of experimentation or diversification is highest from South America, followed by North America and Australasia, then Europe, West & Central Africa, and Central America.

On the contrary, the proportion of Madagascan species is higher in “main and common uses” than it is in experimental uses. Also, despite a non-negligible number of “newly proposed” species from South-East Asia (continental or islands), these regions have a higher share in the “main and common uses” than in the “occasional or rare” ones.

Woods used for bridges and for fingerboards are usually found among the species that are used for the back and sides, but they focus on more restricted ranges of woods, usually those with higher densities or hardness. Since these components have rather small dimensions, they could be obtained from species of trees (or even shrubs) having small trunk diameters, contrary to backs and sides that require rather important trunk diameters.

For bridges (Fig. 3B), the “main” wood selection is among the most restrictive ones (only six species), but reaches 19 species for “main and common” uses. Yet these woods have rather ubiquitous tropical origins: SE Asia (continental and islands), Africa (W&C, SE and Madagascar), S and C America. Temperate species from Europe and N America are more anecdotal but some are in “common use”. The degree of experimentation appears extremely high (this will be discussed below), mostly from Europe, S and C America, lesser so W&C Africa and Australasia. On the contrary, woods from Madagascar and from SE Asia have a high share in well-established uses, but less so in experimental uses.

Wood selection for fingerboards (Fig. 3C) is less exclusive in “main” uses (11 species), but it is equivalent for “main and common” (19 species). The patterns of biogeographical origins are comparable to those for bridges, but with a higher representation of woods from Europe and Australasia. The degree of experimentation or diversification for fingerboards is important and concerns nearly all “main and common” biogeographical regions — here again to the notable exception of those from Madagascar, whose share proportion is higher in “established” than “experimental” uses.

3.1.4 Biogeography and “Reputation of Uses” — Specialisation and/or Multifunctionality

The repartition of the different functions that are actually (“main and common” uses), or could potentially be (“occasional and rare” uses), fulfilled from each biogeographical origin is presented in Fig. 4. It should also be kept in mind that some species are very specialized (concern a single or a limited number of functions), while some others are very multifunctional (i.e. are used for many, or even all, of the considered functions/components). The species that are “main and common” in guitar-making are cited, on average, for 3.1 different components of guitars, those “occasionally used” for 1.8 components, and “rarely” cited species for 1.5 components. However, this differs

between regions of origin. Among “main and common” woods, the proportion of multipurpose species is higher in SE Asia (e.g. *Dalbergia latifolia*), in W&C Africa (e.g. *Entandrophragma*, *Guibourtia*, *Millettia*), and in Central America (e.g. *Swietenia*, *Cedrela*, *Cordia*). Also, besides multipurpose species (*Swietenia*, *Cedrela*) common to Central America, South America is the origin of many species with more focused uses. On the contrary, the “main and common” woods from Europe and North America tend to have more specialised uses, especially those used in acoustic top-plates (*Picea*, conifers); these temperate regions, however, also provide some very multipurpose species (e.g. *Acer*, *Juglans*). Interestingly, this multipurpose aspect is rather reversed when considering species of “occasional” uses, where temperate woods tend to be used/experimented for more different guitar components, than tropical woods from most origins. A hundred species are multipurpose (used in three to six different components of guitars). Among these, 98% are used in B&S. A total of 345 species have more specialised citations of uses (one or two components); among these, “only” 64% are cited for B&S.

Regarding biogeographical specialisation or multifunctionality, the major regions of origin of guitar-making woods (Europe; North, Central, and South America; W&C Africa) all provide “main and common” woods (Fig. 4A) for guitar-making for all components. Yet, among these regions, tropical ones have a higher share of species for bridges and fingerboards. Other regions (SE Africa, Madagascan, SE Asia, and Australasian) mostly provide reputed woods for bridges and fingerboards, obviously so for back and sides — but proportionally less in terms of the number of species.

Species in “occasional uses” (Fig. 4B) could be considered as “alternative” woods that are actually tried on a significant basis, or as “specialty/exclusive” woods. Despite a non-negligible number of species for bridges and fingerboards (Europe, Central and South America, W&C Africa), this category of use is dominated, in all regions, by species for back and sides. The number of species “experimented on a significant basis” for the back and sides is particularly high from South America and Central America. Species with “rare” uses (cited by a single source, Fig. 4C) are obviously more difficult to analyse. They appear to concern more of all the different components. But, for the neck, fingerboard, and bridge, and to a smaller extent for top-plates, this comes mostly from what might only be “suggestions of uses” in Jahnel (2000). Nevertheless, all biogeographical regions are now represented for several components. Woods from Australasia are clearly represented for all components here. Uses of Australasian species appear “rare” in the present meta-analysis from sources mainly based on European and North American guitar-makers, but locally the

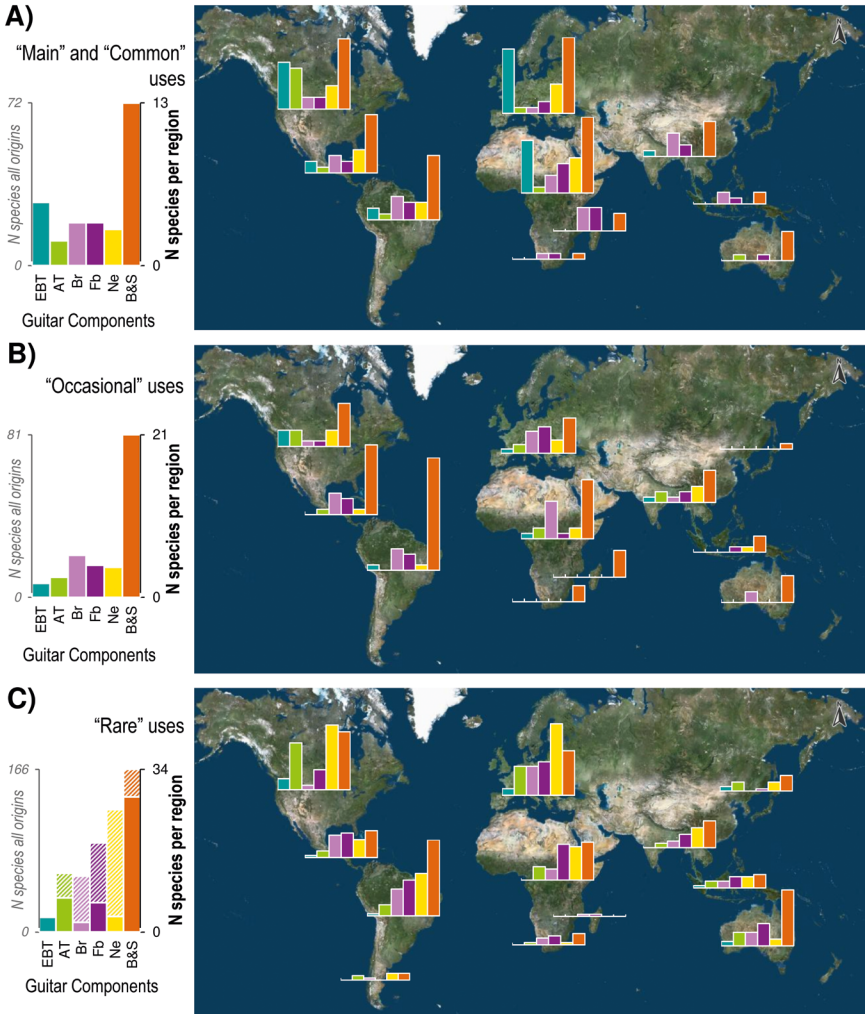


FIGURE 4 Number of species used for the various components and types of guitars at global scale (bar-chart on the left) and originating from the different regions for (A) “main and common”, (B) “occasional”, and (C) “rare” categories of uses. In the “rare” uses, the global histogram on the left differentiates (dashed bars) the single citations coming from Jahnel (2000), following the comment in Section 3.1.1.

use of a significant diversity of local species for all components is rather firmly established in Australian guitar-making (Morrow 2007).

Obviously, the widely different number of species for the different guitar components, the range in “reputation” (from main uses to rare ones), and the multifunctionality of many species call for analyses that are not simply based

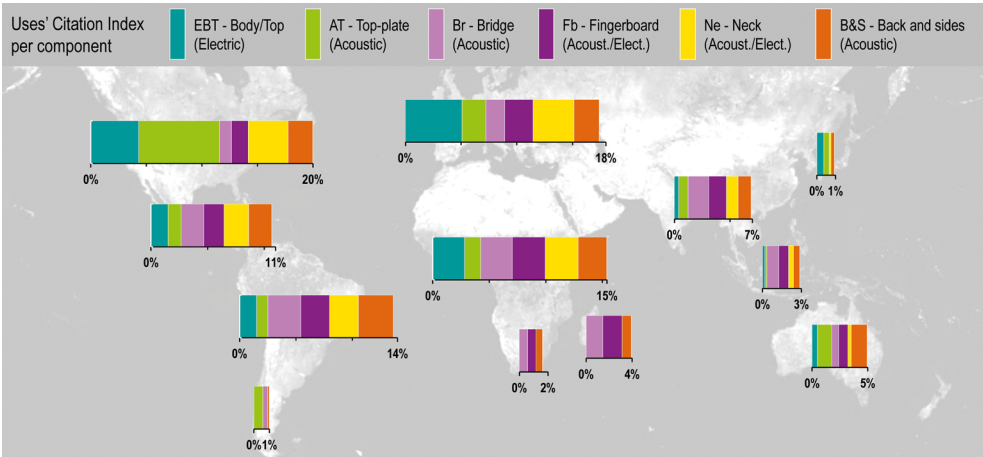


FIGURE 5 “Uses’ citation index” (UCI), for individual components and types of guitars, summed up by biogeographical regions of origin of woods. (Nb. In this figure the single citations coming from Jahnel (2000) have been filtered.)

on the number of species. In Fig. 5, the individual UCIs, computed separately for the different guitar components, are summed up for the different biogeographical regions. This allows more effective observation of how different regions of origin of trees actually contribute to the biological and functional diversity of woods used by guitar-makers of the Western world.

3.2 Natural Heritage — Threats and Diversification

The issue of threatened species is often addressed in the literature about “iconic” tonewoods. However, what is the situation when observing a wide census of species cited in guitar-making, and how does it compare with the global situation for all trees? These questions are explored in Fig. 6, on (IUCN 2024) conservation status for woods with different “reputations of use” and regions of origin, and compared, in Table 1, to global data for world tree species (BGCI 2021; Hills *et al.* 2022; Mark *et al.* 2014).

For the woods reputed in guitar-making (82 species in “main and common” uses, Fig. 6A), globally (Table 1), 47% are non-threatened (LC) and 11% have unclear status (DD and NE), while 30% are threatened (CR, EN, VU) and a further 12% are possibly threatened (NT). The percentage of threatened (+ possibly) species decreases from Madagascar ≥ SE Asia continental > islands ≥ W&C Africa = Central America ≥ SE Africa > South America > North America > Australasia > Europe. In terms of the number of threatened (+ possibly) species “main/common” in guitar woods, the different regions of origin rank in the decreasing order of W&C Africa >> South

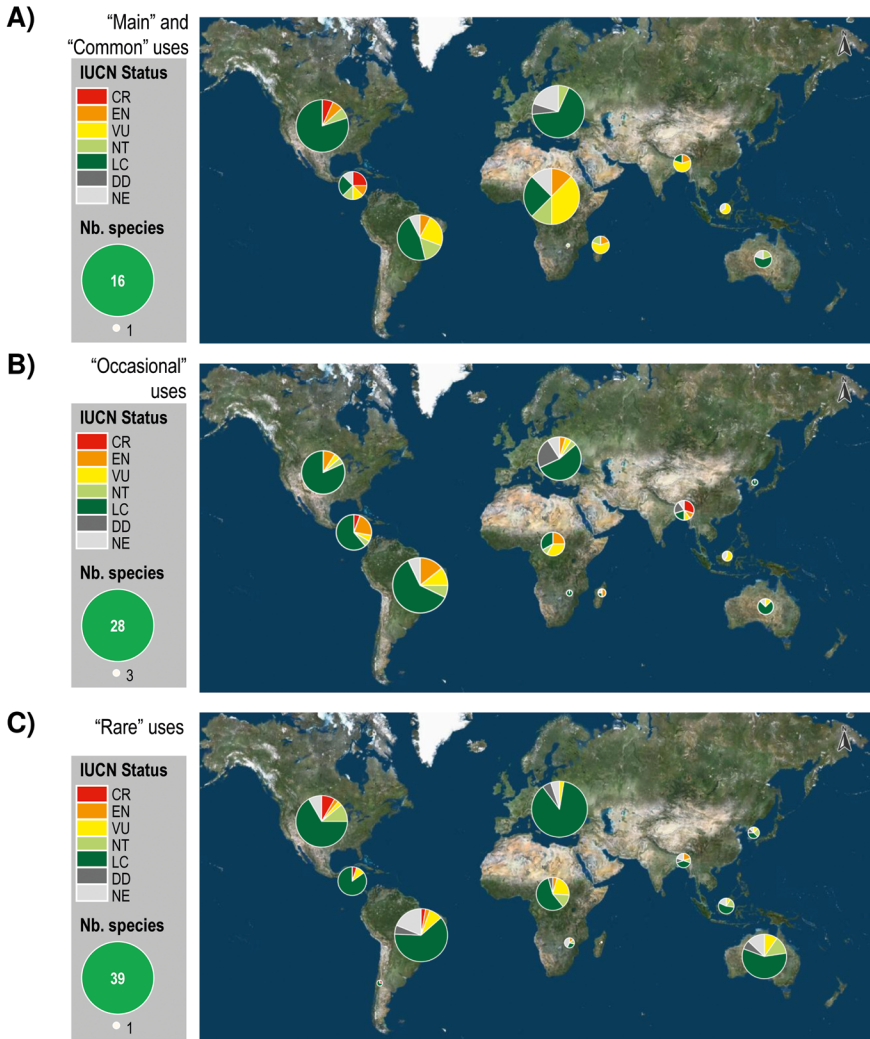


FIGURE 6 Number of species and their IUCN conservation status originating from the different regions for (A) "main and common", (B) "occasional", and (C) "rare" categories of uses

America > Madagascar = Central America > SE Asia continental > North America > SE Asia islands >> SE Africa = Australasia = Europe. Nevertheless, when considering the levels of threats, the reputed guitar-making species that have the most worrying status (CR) originate from North (1 sp.) and Central (2 spp.) America. Those with the second most worrying status (EN) originate from W&C Africa, followed by Madagascar; North, Central, and South America; and SE Asia.

TABLE 1 Wood species used in guitar making compared to world tree diversity: number of species and conservation status for (a) the different biogeographic realms (BGCI 2021) and all world trees (BGCI 2021), (b) all timber trees (Hills *et al.* 2022), or (c) commercial timber in international trade (Mark *et al.* 2014)

Ensembles	Categories	No. of species	Threatened	Possibly	Not threatened	DD/NE
Palearctic	All trees ^(a)	5994	21.8%	7.9%	57.4%	12.6%
	Guitar woods (all)	87	4.6%	5.7%	71.3%	18.4%
	Guitar (M/C/O)	40	5.0%	7.5%	62.5%	25.0%
Nearctic	All trees ^(a)	1432	24.1%	10.8%	58.7%	5.0%
	Guitar woods (all)	73	13.7%	8.2%	74.0%	4.1%
	Guitar (M/C/O)	38	13.2%	5.3%	78.9%	0.0%
Neotropics	All trees ^(a)	23 631	29.8%	6.1%	46.6%	17.4%
	Guitar woods (all)	128	22.7%	4.7%	62.5%	10.2%
	Guitar (M/C/O)	64	28.1%	9.4%	56.3%	6.3%
Afrotropics	All trees ^(a)	9237	39.5%	5.6%	45.9%	9.5%
	Guitar woods (all)	72	38.9%	12.5%	37.5%	11.1%
	Guitar (M/C/O)	37	51.4%	10.8%	32.4%	5.4%
Indo-Malaya	All trees ^(a)	13739	27.8%	7.8%	30.2%	33.9%
	Guitar woods (all)	44	38.6%	6.8%	29.5%	25.0%
	Guitar (M/C/O)	20	60.0%	0.0%	15.0%	20.0%
Australasia (+Oceania)	All trees ^(a)	7442	20.0%	8.4%	48.1%	23.4%
	Guitar woods (all)	44	9.1%	11.4%	61.4%	18.2%
	Guitar (M/C/O)	14	7.1%	7.1%	71.4%	21.4%
All world	All trees ^(a)	58 497	29.9%	7.0%	41.5%	21.4%
	All timbers ^(b)	4945	33.7%	9.3%	53.8%	3.1%
	Int. timber trade ^(c)	1713	17.6%	6.7%	62.9%	12.8%
Guitar woods	Main	34	47.1%	14.7%	32.4%	5.9%
	Main and Common	82	29.6%	12.3%	46.9%	11.1%
	Main, Common and Occasional (M/C/O)	213	27.2%	7.5%	54.0%	11.3%
	All cited woods	448	20.1%	7.6%	59.2%	13.2%

Guitar-making woods are categorised by number of citing sources (Main, Common, Occasional, all including Rare; M/C/O are cited by at least 2/8 sources) in the present work's database. Comparisons with world tree species come from: (a) data from BGCI (2021), (b) data from Hills *et al.* (2022), (c) data from Mark *et al.* (2014).

For the species in “occasional uses” in Fig. 6B (i.e. that could be considered either “actually tested alternatives” or “specialty/exclusive” woods), the proportion of non-threatened species is 59% globally, indeed higher than woods with the highest reputation of uses. Yet, some regions with the highest proportion of threatened species in “main and common uses” are clearly much less prospected in “occasional” uses (W&C Africa, Madagascar) but still have equally worrying proportions of threatened species. For SE Asia, the share in terms of number of species is equivalent or slightly increased but with a much more worrying distribution of high levels of threats. On the contrary, Central and South America provide a higher share of species used “occasionally” than they do for “main and common” uses, and here these “alternative” species are clearly less often threatened than most reputed species from these same regions. While “occasionally used” species from Europe have a more uncertain conservation status than the “main and common” ones, with a smaller proportion of non-threatened species, and higher proportions of “threatened or possibly” and of DD or NE.

Regarding species that are “rare” (Fig. 6C) in guitar-making uses, the global landscape suggests a higher proportion (65%) of non-threatened (LC) wood species. However, these “rare uses” also include some of the highest level of threat (CR): six species from temperate (North and South) and tropical (Central and South) America. The biogeographical regions that suffer from the highest proportion of threatened species among more reputed uses become either much less represented or nearly absent from “rare” guitar-making uses.

Over all guitar-making woods, Fig. 7 compares the conservation status between regions of origin, not only in terms of numbers/proportions of species but also on repercussions on guitar-making uses as expressed by the UCI to represent both the different reputations and multifunctionality of uses.

For woods originating from temperate regions, the non-threatened woods represent a higher share of uses than of the number of species, while for woods from tropical regions the threatened (and possibly threatened) represent a higher proportion of uses than of species, and this especially so for Afrotropics and Indo-Malayan realms.

All guitar-making woods (and all those with “confirmed uses”, i.e. cited by at least two sources) were compared to the global situation of tree biodiversity, by grouping into biogeographical realms as in (BGCI 2021) in Table 1. The proportion of species with unclear status (DD or NE) is usually smaller in woods selected for guitar-making, or occasionally higher (Palearctic), which does not make the comparisons straightforward. For Afrotropics and Indo-Malaya, the ratio between threatened (+ possibly) and non-threatened species is higher among woods used in guitar-making than among all trees in these regions. In

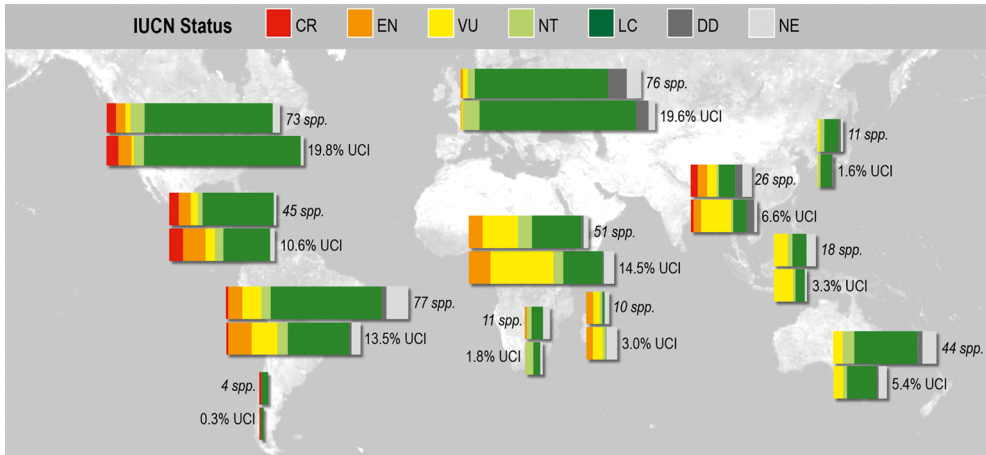


FIGURE 7 Biogeographic regions of origin compared on both basis of their share in total number of species, and in total “Uses’ Citation Index” (UCI), according to the IUCN conservation status of species

the four other biogeographic realms, this ratio of threatened species tends to be lower among woods used in guitar-making than on all trees of these regions. This might sound counterintuitive considering the very high concern about the issue of threatened species in guitar-making. It needs to be discussed in regards to other elements of comparison.

The proportion of threatened (+ possibly) species used in guitar-making is higher than in all trees (Table 1) from the Afrotropics and Indo-Malayan realms, and, furthermore, these species of worrying status have a higher share in the UCI of these regions (Fig. 7). Although in the Neotropics the species with worrying status have, also, a higher share in uses, overall for this realm the woods used in guitar-making tend to include a smaller percent of threatened/possibly than all tree species in the region. And, in temperate regions, the share of non-threatened species is higher in guitar-making woods than in all local trees; furthermore, they represent a higher share in uses.

Finally, at the global scale, guitar-making woods of different reputations of use could be compared to the situation of world trees and of timber species (Table 1). The proportion of threatened species among 82 woods “main or common” in guitar-making is 29.6%. This is very comparable to the situation over all ca. 60,000 tree species of the world (29.9%) (BGC1 2021) and slightly less than for ca. 5,000 all-timber trees (33.7%) used at local or international scales (Hills *et al.* 2022). But among the only 34 wood species most generally cited (“main”) in guitar-making, the proportion of threatened species rises to nearly half (47.1%). While across all woods cited for guitar-making “only” 20.1%

are threatened, lower than all world tree species, and comparable to a list of ca. 1700 commercial timbers in international trade (Mark *et al.* 2014) — the latter being slightly counterintuitive.

This means that the conservation status of the few most iconic guitar-making woods is indeed particularly alarming. But, also, that the slightly wider panel of woods commonly used by guitar-makers mostly tends to mirror the global situation of all world tree species. The cultural value and image of guitar-making might be considered as a means to raise awareness on the global issue of the erosion of tree biodiversity. From the complete overview of biodiversity of woods cited in guitars, it seems conceivable to lower the proportion of threatened species in guitar-making (although the volumes used in this trade are likely much smaller than in other end-uses such as furniture and building (Carbonneaux & APLG 2019–2021; Gibson & Warren 2021; Lake Zhu 2020)). Yet, trials of diversification should examine in advance the situation in each biogeographic region (or at more local scales of species distribution, as seen in the fine visualization tool by Kusnick *et al.* (2024)), should avoid simply targeting “lesser-known” species as some might be at risk, and should consider the artisanal values and preferences for wood characteristics associated with certain taxa.

3.3 *Bio-Cultural Diversity: Floristic Composition vs. Reputation of Use*

In order to better understand the biodiversity of woods that is used in guitar-making, the repartition between botanical families is analysed in Fig. 8. The 448 “ethnospecies” (assigned to a binomial name or at least to a *Genus* sp. + origin) come from 234 genera in 64 families.

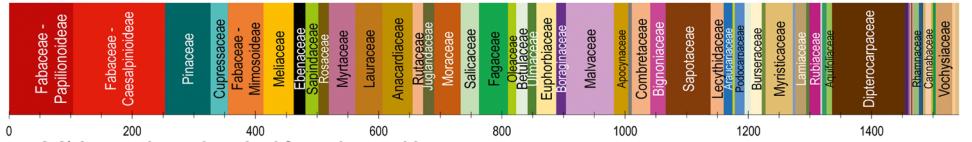
Apart from two families (represented by only one species each with single citations), 62 families (Fig. 8A.1) cited in guitar-making also include at least one species considered as internationally traded commercial timber species (Mark *et al.* 2014) (in this analysis I did not compare with the wider list of timber trees with both international and local uses (Hills *et al.* 2022)). Among the families providing international commercial timbers, 48 are not cited in guitars. In all parts of Fig. 8, families are ranked by the number of species cited in guitar-making (Fig. 8A.2). Some families with a high number of species considered as commercial timbers are very anecdotal in guitar-making (e.g. Dipterocarpaceae, Sapotaceae, or Myristicaceae). Conversely, some families (e.g. Ebenaceae, Sapindaceae, Fabaceae-Papilioinoideae, Cupressaceae, but also Meliaceae, Rosaceae, Juglandaceae, or Oleaceae) include a disproportionately higher proportion of their species cited in guitar-making (Fig. 8A.2) than in general commercial timbers (Fig. 8A.1). The discrepancy in distribution of the families is further increased when observing not only the number

A) Number of species per family

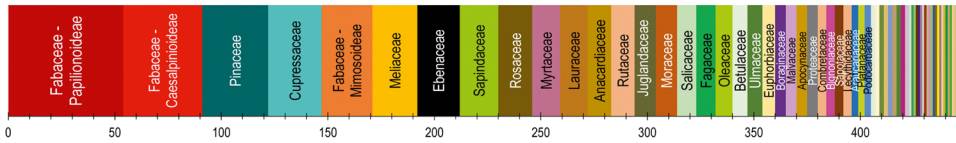
A.1) In “internationally traded commercial timber species”

48 families not cited in guitars →

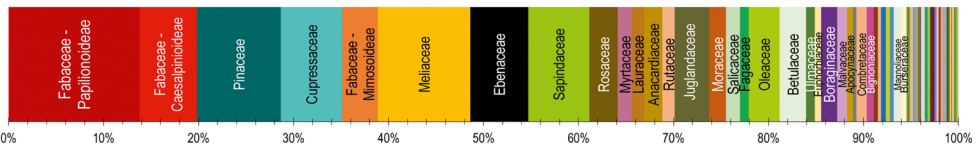
↓ 62 families of which at least one species is cited in guitars



A.2) In wood species cited for guitar-making



B) Index of “Citation of Uses” in guitar-making, per family



C) Distribution per regions of origin

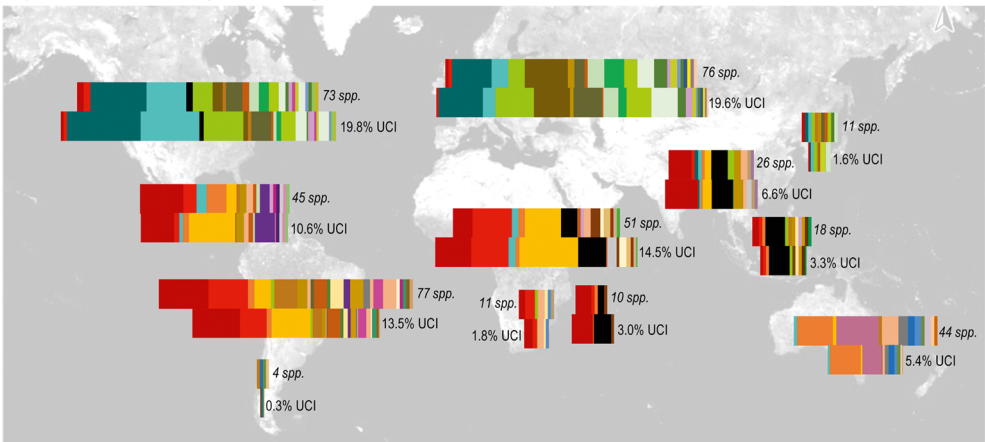


FIGURE 8 Floristic composition represented by botanical families. (A) Number of species per families, among (A.1) world species considered international commercial timbers (c.1700, data from Mark *et al.* (2014)) and among (A.2) species cited in guitar-making (c.450). (B) Cumulated “Uses’ Cttation Index” UCI in guitar-making, grouped by families. (C) Biogeographical distribution of number of species, and of cumulated UCIs, per families of woods cited in guitar-making. In all parts of this figure, families are ranked in the same order, i.e. by decreasing number of species per families cited for guitar-making as in (A.2).

of species but also their UCIs (Fig. 8B). Half of the total UCI (but including all reputations of uses, including “rare” ones) is contributed by only six families (Fabaceae-Papilionoideae, Meliaceae, Pinaceae, Cupressaceae, Sapindaceae, Ebenaceae). These families correspond of course to the most “iconic” guitar-making woods (“rosewoods”, “mahoganies”, “spruces”, “cypress”, “maples”, and “ebonies”), but most of these families are represented by more numerous genera than those of the iconic species. Three-quarters of the total UCIs are contributed by 13 families, i.e. by seven additional families (Fabaceae-Caesalpinioideae, F.-Mimosoideae, Juglandaceae, Oleaceae, Rosaceae, Betulaceae, Anacardiaceae — although Boraginaceae and Moraceae have a nearly equal share with the latter). From another indicator, the “Main and Common” woods come from 23 families (and 43 genera). Regarding the very wide family of Fabaceae, its three sub-families show contrasting trends. The proportion of Papilionoideae increases notably, from their share in commercial timber species, to their share in the number of guitar-making species, and to their share in guitar-making uses. Caesalpinioideae follow an inverse trend, while Mimosoideae remain in all cases behind the other two sub-families. The high share of Papilionoideae both in species and in UCI in guitar-making obviously includes the contribution of the true rosewoods (genus *Dalbergia*) that are particularly iconic in guitars. However, Papilionoideae are highly represented beyond this, as *Dalbergia* (23 species here recorded, and probably more due to the issue of under-differentiation) accounts for “only” about half (55%) of the UCI of Papilionoideae, the other half (45%) being contributed by 32 species from 19 other genera.

Beyond the global figures, the degree of biodiversity in guitar-making compared to floristic composition varies widely between regions of origin (Fig. 8C). For example, the three regions (tropical South America, Europe, North America) from which the highest diversity of species cited in guitar-making originates, provide similar number of species (77, 76, 73) from a similar number of families (23, 22, 23), but from a much higher number of genera (57, 44, 44) from South America. This seems logical considering the highest tree biodiversity occurring in the Neotropics. Yet, the total biodiversity of guitar-making woods originating from Europe seems proportionally high for a region where the number of tree species is estimated to about 454 (Rivers *et al.* 2019), compared to the estimated 23,631 from the Neotropics realm (BGCI 2021). (The number of species is shown by individual regions in Fig. 8C and grouped into realms in Table 1.) For the three other regions providing rather high diversity in guitar-making woods, i.e. W&C Africa, Central America, and Australasia/Oceania, with comparable number of species (51, 45, 44), the respective numbers of families (15, 17, 13), but mostly of genera (35, 34, 22), seem linked to the global patterns of

biodiversity between their biogeographical realms. However, for regions providing a small number of guitar-making woods, the floristic composition is very contrasted: 11 species from 11 genera from 11 families from NE Asia; 11 species from 10 genera from seven families from SE Africa; and 10 “species” (probably more, problem of under-differentiation) from five genera from five families from the Madagascan region, but represented, in terms of uses, mostly by two genera (*Dalbergia* and *Diospyros*) from two families. Indo-Malaya is the home of higher numbers of species cited in guitar-making, but it is clearly dominated by *Diospyros*/Ebenaceae (“islands”) and *Dalbergia*/Fab.-Papilionoideae (“continental”).

The various main botanical families employed in guitar-making are distributed very differently between regions. This is obviously related to the floristic composition of the different biogeographic realms, yet the different families also contribute to the UCI in a way that is disproportionate to their number of species and in a very region-specific way. For example, Fab.-Caesalpinoideae have a smaller share in UCI than in the number of species for South America but a high share in UCI in W&C Africa. Or, Myrtaceae, among the most numerous species cited from Australasia, show a reduced share in the UCI of this region. Or, Boraginaceae, nearly anecdotal at the global scale, have a significant share in UCI for Central America. Fabaceae (Papilionoideae and/or Caesalpinoideae) have a high share in most tropical regions, both in number of species and in UCI, and Ebenaceae have a high share in species and even more so in UCI for Afrotropics and Indo-Malaya. Some species of these emblematic families are occasionally found/cited in Europe (Fabaceae) and North America (Fabaceae, Ebenaceae), but their share in UCI from these temperate regions is even more anecdotal than their small number of species.

3.4 *Reputation of Use, Trade Value ... and a Rainbow of Woods*

In order to better understand how the reputation of use can be related to wood characteristics, but also to trade value, a visual mapping of wood samples collected during this research is presented below (Figs 9–12). This analysis was focused on woods retailed for acoustic guitars’ backs and sides specifically. The reason was that, as seen above, this is the function with the highest biodiversity, while including many multifunctional woods, on the one hand. On the other hand, woods for the back and sides are particularly present in guitar-making discourses and debates (Taggart 1989; Olsen & Burton 1998; TonewoodDataSource 2005–2024; Gore 2011; LGRP 2012–2017; Bennett 2016; Carcagno *et al.* 2018; Applegate 2021; Zhou *et al.* 2022).

The visual mapping is based on the quantitative information that we gathered in the part of this research about the analysis of suppliers specializing

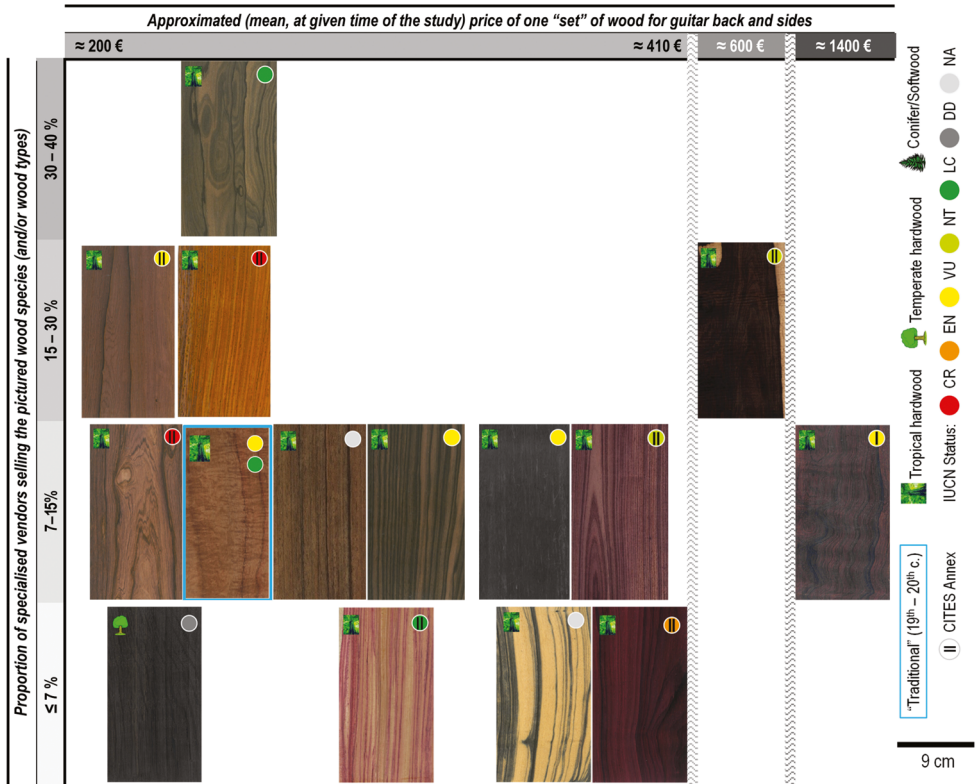


FIGURE 9 Visual mapping by the approximate mean price and by the proportion of specialised tonewood vendors proposing the woods (at the given time of the survey) for some of the "semi-precious (more than twice the median price) to extremely precious" woods in the guitar back and sides, as pictured from samples gathered for tests in the present study. Pictorial codes on sample are in the legend (right); common and botanical names are listed in the Appendix.

in guitar-making tonewoods. In Figs. 9–12, pictures of wood sample plates are organized according to the approximate average price of one "set" of wood for the guitar back and sides (horizontal direction) and to the proportion of suppliers proposing the considered wood (vertical direction). Woods were grouped into four categories according to their trade value. "Very cheap to relatively cheap" woods (Fig. 12) are in the first quartile of prices, i.e. $\leq \text{€}70$ per set. "Relatively cheap to medium-expensive" woods (Fig. 11) in the second quartile, i.e. $\text{€}70\text{--}100$ per set. "Medium expensive to expensive" woods (Fig. 10) range from median price to twice the median price, i.e. $\text{€}100\text{--}200$ per set. And "precious" woods (Fig. 9) are above twice the median price, i.e. mostly $200\text{--}400\text{€}$ per set but with some outliers. It is very important to note that indicated prices are as were actually recorded, averaged between different vendors



FIGURE 10 Visual mapping by the approximate mean price and by the proportion of specialised tonewood vendors proposing the woods (at the given time of the survey) for some of the “medium-expensive (median price) to expensive (twice the median price)” woods in the guitar back and sides, as pictured from samples gathered for tests in the present study. Pictorial codes on sample are in the legend (right); common and botanical names are listed in the Appendix.

from different countries, at the given time of the survey — some might have increased significantly even over a short period of time. Of course, this visual mapping is not complete, as samples from 71 woods are here pictured among the 188 species listed in my full analysis of wood traded for the backs and sides, yet it represents the majority of the most reputed woods, as well as a significant number of “occasionally” or “rarely” used woods.

Among the 15 “precious” woods pictured in Fig. 9, three originate from Central America, three from South America, three from SE Asia (continental or islands), two from Madagascar, one from SE Africa, one from Oceania, and one from Europe. The vast majority are true rosewoods (eight *Dalbergia*) or ebonies (four *Diospyros*). Two species here are considered as most traditional by Bennett (2016), Brazilian rosewood and koa, yet they are retailed by only a

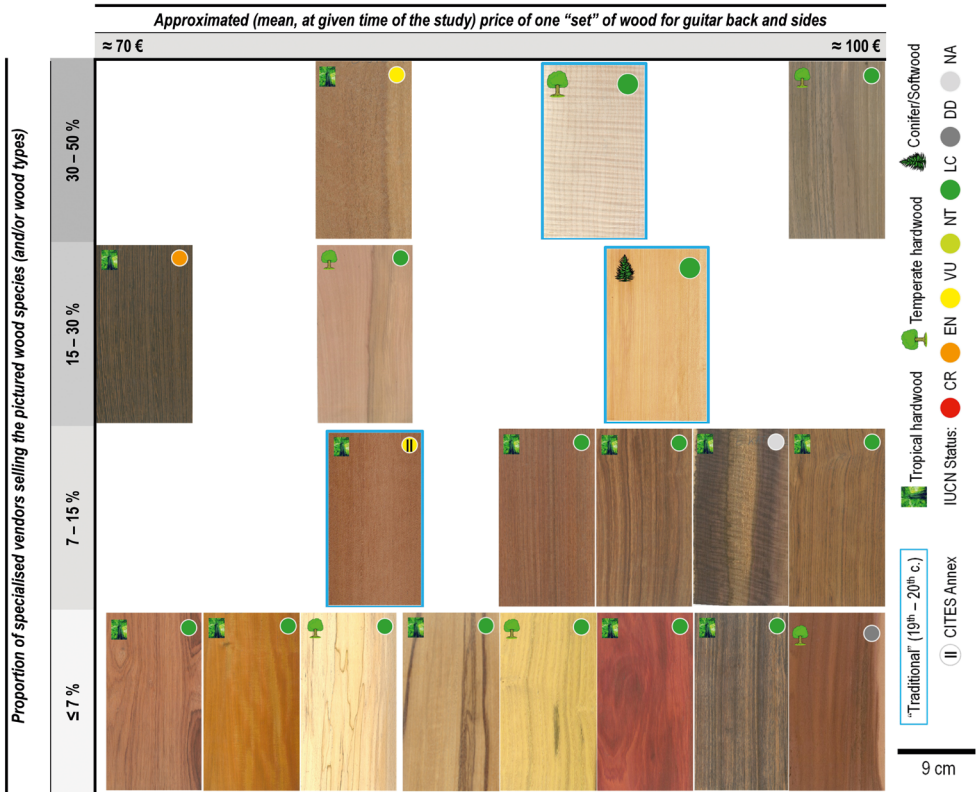


FIGURE 11 Visual mapping by the approximate mean price and by the proportion of specialised tonewood vendors proposing the woods (at the given time of the survey) for some of the “relatively cheap (beginning of second quartile) to medium-expensive (median of prices)” woods in the guitar back and sides, as pictured from samples gathered for tests in the present study. Pictorial codes on sample are in the legend (right); common and botanical names are listed in the Appendix.

moderate proportion of suppliers. In the case of Brazilian rosewood (*Dalbergia nigra*), this seems logical as it is listed in Annex I of CITES; however, some retailers occasionally propose some pre-convention supplies (some even dated back to 200 years). Beyond the simple proportion of vendors, among all these precious woods, only a few appear to be retailed in relatively high amounts (as far as could be estimated), mostly Madagascar rosewood, cocobolo, and ziricote, and to a lesser extent Macassar ebony or koa. Some of the less frequent woods might be proposed in reality in a very small number of sets. As far as could be estimated from data collected in this study, the total of this group would represent a trade volume between two and three times lower than woods in the three other price categories. The vast majority of these precious

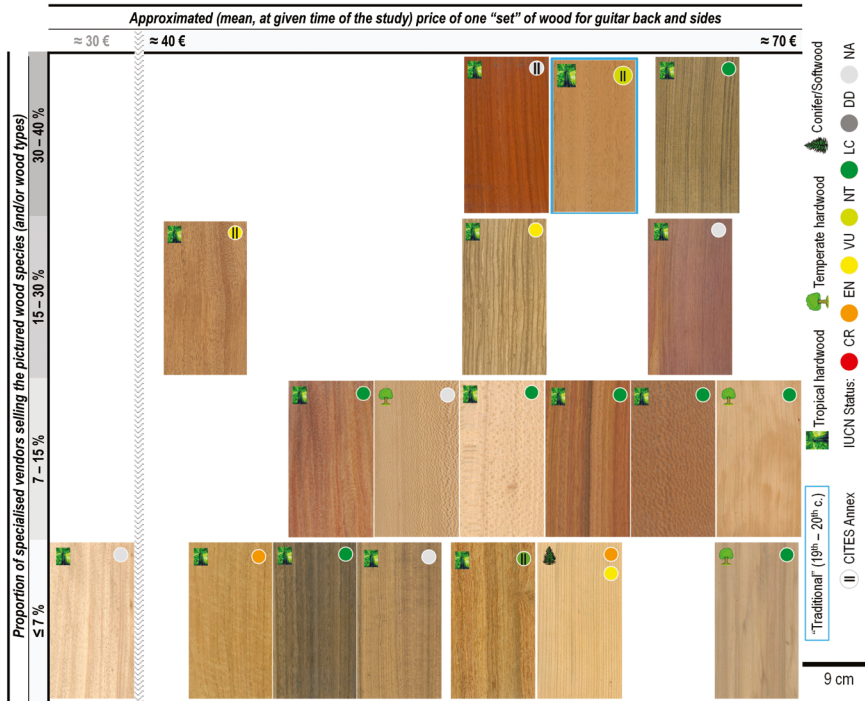


FIGURE 12 Visual mapping by the approximate mean price and by the proportion of specialised tonewood vendors proposing the woods (at the given time of the survey) for some of the “very cheap (minimum values) to relatively cheap (end of first quartile)” woods in the guitar back and sides, as pictured from samples gathered for tests in the present study. Pictural codes on sample are in the legend (right); common and botanical names are listed in the Appendix.

woods (to the exception of ziricote) have either a worrying (or at least unclear) IUCN conservation status or are CITES listed. However, some may be CITES listed but have a least concern (or NT) status, whereas some may be vulnerable but not CITES listed. When looking not at the data but at the wood specimens, all these precious woods share some striking aesthetic features. They are obviously (for most of them) rather dark (here, the sole temperate wood, from Europe, is not the natural colour of the species, as it is “bog oak”, i.e. wood that has been buried underground for “thousands” of years). They also include a high proportion of dark-reddish hues, a characteristic that is not found in temperate woods, and, among tropical hardwoods, *Dalbergia* are among the few genera that can have the reddest hues (Brémaud *et al.* 2021). This characteristic of rosewoods is unfortunately the cause of the recent explosion of their consumption in Chinese furniture industry (Lake Zhu 2020), which is a major

part of the threats on *Dalbergia* genus (Basik Treanor 2015). A most distinctive characteristic of these precious woods lies in their colour veins, usually fine and clearly contrasted, featuring either evenly stripped patterns or, on the contrary, bold colour figures such as “spiderwebs”. This means that these precious woods are above all characterized by exceptional heartwood formation. The latter can also have repercussions on physical and vibrational properties, depending on botanical families (Brémaud *et al.* 2010; 2009; Minato *et al.* 2010).

Among the 18 “medium to expensive” woods pictured in Fig. 10; five originate from South America; four from Europe; two each from Indo-Malaya (continental or islands), W&C Africa, Central America, and North America; and one from Australasia. They belong to 12 different genera, with three species of *Acer*, and two species each for *Swietenia*, *Acacia*, *Dalbergia*, and *Diospyros* — i.e. true rosewoods and ebonies are much less frequent than in “precious” woods. These “medium to expensive” woods include five species that are considered as most traditional by Bennett (2016), and most of these are retailed by an important proportion of suppliers, especially Indian rosewood (*Dalbergia latifolia*), which is the single species to be proposed by the highest proportion of vendors (58%, while for all other species, in all price groups, the maximum is 44%). A few of these “medium to expensive” woods are Vulnerable, Near Threatened, and/or CITES listed, yet globally a majority of woods pictured here have a Least Concern conservation status. Regarding wood characteristics, only half of these “medium to expensive” woods clearly exhibit heartwood colour veins and stripes that are so typical of the most precious woods. Yet some show striking figures coming from wood structural organisation (wavy, pommel , birdseye, very fine knots). Or, interestingly, some show figures coming from what could be considered as “accidents”, such as spalting (by fungi creating colour lines and zones, e.g. (Vega Guti rrez & Robinson 2021)), or incomplete heartwood formation. These latter two characteristics are not the most frequently proposed, yet it seems that they have been gaining more attention in guitar-making supplies in recent years. Altogether, these “medium to expensive” woods share much fewer characteristics in common between them, than do the “precious” woods which share several common features between them. Furthermore, in these “medium to expensive” woods, there are fewer dark woods and much fewer red hues.

Among the 19 “relatively cheap to medium-expensive” woods pictured in Fig. 11, seven originate from Europe, six from Central America, four from South America, and two from W&C Africa. They belong to 18 different genera, with the only genus with two species pictured here being *Platymiscium*. In this category of prices, as in the next cheaper one, there are no true rosewoods nor ebonies (*Dalbergia* or *Diospyros*), yet these terms are sometimes

used in vernacular names for some species of other genera (e.g. “Caribbean/Mexican rosewood” sometimes used instead of “granadillo” for *Platymiscium* spp., or “Mexican ebony” instead of “katalox” for *Swartzia cubensis*). This category of prices includes three woods considered most traditional by Bennett (2016), including two from Europe (*Cupressus sempervirens* and *Acer pseudo-platanus*), and which are proposed by a majority of suppliers. Apart from three species threatened (including one endangered), the vast majority of woods in this category have a least concern conservation status. Regarding wood characteristics, woods in this price category are very different between them. There are several rather dark woods, but “very dark” woods are even fewer than in the above price category. On the contrary, there are here several very brightly coloured woods, with more species with red hues than in the “medium to expensive” category, and also bright yellow hues. Woods with well-defined, contrasted, and tightly spaced heartwood-formation-driven colour veins are now only slightly more than one-quarter of this group.

Among the 19 “very cheap to relatively cheap” woods pictured in Fig. 12, seven originate from W&C Africa, five from South America, three from Europe, three from Australasia/Oceania, and one from North America. They belong to 17 different genera, with the only genus with more than one species pictured here being *Pterocarpus*. This category includes only one species (*Swietenia macrophylla*) considered most traditional by Bennett (2016), but that was already included in higher-priced categories. Indeed, *Swietenia macrophylla*, here pictured for a sample of “plain” appearance, ranges for the same species from “relatively cheap” to “medium to expensive” woods when at least slightly figured, while exceptionally figured specimens reach the absolute highest prices recorded in this study (but obviously were not sampled here). This particular case also illustrates that, beyond the “average” reputation and trade value of a species, within-species variability and/or sought-after singularities play a very important role (Carlier *et al.* 2018; Brémaud 2024). Although it concerns the least traditional, and the least expensive/valued, woods, this category is not the one with the least worrying conservation status. On the contrary, it includes much fewer least concern species than “relatively cheap to medium priced”, and fewer even when compared to “medium to expensive”. It includes more uncertain status (DD or NE) and more threatened species than the two upper categories of prices. It has nearly as many CITES-listed species as the “medium to expensive” category. Regarding wood characteristics, there are very few dark woods in this “cheap” category of prices, the main one being a thermo-treated (called “aged”) wood — a trend that is gaining increased attention in guitar-making wood research and/or uses recently (Krüger *et al.* 2018). “Cheap to relatively cheap” woods include some with bright and very red hues,

but they remain a small proportion of woods in this group. The figures due to wood structural organisation are here mainly represented by interlocked grain or by wide medullary rays. Slightly more than one-quarter of these pictured “cheap to relatively cheap” woods show some heartwood-formation driven colour veins, but they are either brown-grey, or the veins are of low contrast or very irregular.

3.5 *Artisanal Values and Relation with Wood in Guitar-Making Cultures*

Understanding the biological and functional diversity of guitar-making woods, their reputation, and trade values together with their characteristics requires consideration of the multiple aspects of artisanal values and relation to wood anchored in guitar-making cultures.

Dawe (2016) stated that “[Spanish] guitar makers are absolutely obsessive about the woods they use’ and that ‘the characteristics of the wood used in guitar-making features in an elaborate poetics that is at once an ecopoetics’. Dudley (2014) provided a fine analysis of the relationship between North American luthiers and the craft object, techniques, and material — wood — in the sense of relations between humans and non-humans. This relational aspect with wood is often mentioned among the motivations for becoming a luthier.

Among the few luthiers we met in this research, some had been driven to the profession through music, as is often thought in the general public; however, many rather insisted on their will to work in an independent way, with woods, through meticulous techniques, in their vocation. When talking about their woods, guitar-makers often highlighted many different characteristics — on “sound”, “aesthetics”, and more generally sensorial (such as the “smell of chocolate when working with rosewood”); some physical-mechanical aspects; and the workability — here the makers often described woods that are “easy” or “pleasant” to work with. Beyond individual wood characteristics, the notion of “pleasurable work” is important in craftsmanship (Marchand 2022). Luthiers’ visual description of their woods, beyond “beauty” and “colour” (often “dark” or “red”), often mentioned “contrast”, “veins”, “patterns”, and “figures” (but also “sober”), i.e. related to wood characteristics that clearly appeared from the visual mapping constructed in the present work. Of course, physically, the different components of guitars play different functions (e.g. Gore 2011). Our characterisations of wood properties were not presented in this article but will be in future ones. Yet, in some cases, there are endless debates on the “role” played by wood characteristics or properties into the “function” of the produced object/instrument. For example, regarding the back and sides, many luthiers’ discourses concerned the different “tone colorations” or “tonal qualities”

imparted by each given wood species (e.g. *TonewoodDataSource* 2005–2024), but where “blind” acoustical tests would not identify a significant influence (LGRP 2012–2017; Carcagno *et al.* 2018). Nevertheless, the most reputed woods indeed have exceptional (in the sense of non-standard) vibro-mechanical properties linked to wood structure or “grain figure” (Alkadri *et al.* 2018), to chemistry or “colour” (Brémaud *et al.* 2010), and to botanical classification (Brémaud *et al.* 2009, 2012). Vibrational properties of wood are sharply perceivable by luthiers (Fouilhé *et al.* 2012; Carlier *et al.* 2018;). But that is without considering the often-stated idea of ‘hearing with our eyes’ (e.g. *TonewoodDataSource* 2005–2024) or that ‘given the time necessary to build a guitar, it would seem mad for a luthier not to choose the most beautiful wood available’, cited in Olsen and Burton (1998). Of course, the essence of craftwork lies in the synthesis of functionality and aesthetics (Risatti 2009). Johnson (2007) argued that “aesthetics of wood” should not be restricted to the visual — but more broadly sensorial — and should further reveal a “second-life” of trees into handmade things and the gathering of communities sensitive to wood.

The different cultures of guitar-makers probably also play a strong role in the degree of the wood diversity employed. Dudley (2014) mentioned the emulation in the sharing of knowledge and exploration of information among “neo-artisans”. These issued many texts on a diversity of woods (Taggart 1989; Curtis 1993; Olsen & Burton 1998). The situation might be different in cultures with more traditional transmission (Dawe & Dawe 2001). Another socio-cultural divergence, here between craft and mass-industry productions, might also be drawn when comparing the worldwide analysis by Calvano *et al.* (2023) of woods in industrial acoustic guitars, bearing 55 species, with two “instant picture” surveys in a single country (France) with artisan luthiers (present work, compared with Carbonneaux (2019)), together bearing 85 species, i.e. 1.5 times more biodiversity than in worldwide-recorded industrial uses. The culture of electric guitar-makers has also received less attention, at least from wood-related research, while it seems that electric-guitars’ luthiers focus highly on woods used and their repercussions, including experimentations, debates, and results on some components not often discussed elsewhere (Paté *et al.* 2015; Ahvenainen 2019).

In the results of the present article, there is a striking discrepancy between the immense diversity (nearly 450 species) cited overall in guitar-making and the restrained number (20–34) of species considered as most traditional and/or in main uses. Today, about half of these rather few traditional woods have alarming conservation status, and guitar-maker communities have been concerned and aware of this issue for at least four decades now (Curtis 1993; Dudley 2011; Gibson 2019). So, one might wonder why, despite this awareness

and the curiosity of guitar-makers to explore diversity, traditional woods are still among the most valued in trade. Obviously 'traditional woods are traditional for good reasons' (Taggart 1989). But also, 'it's a customer driven market, and by customer I mean the player, not the luthier', as Taggart (1989) indicated. The fact is that wood reputation plays a strong role in the trade value of produced instruments (Kies 2013; Dudley 2014; Bennett 2016; Gibson & Warren 2021). Specifically, the wood attributes of "aesthetic" (there "dark wood"), "traditionality", "decay resistance", and "scarcity" have been found to be important for consumers of industrial acoustic guitars (Zhou *et al.* 2022). "Traditional" or "precious" woods can also have symbolic values, including of social status (Dawe 2016; Lake Zhu 2020; Applegate 2021).

On the other hand, artisan guitar-makers often express a rather high degree of environmental consciousness. Yet, several luthiers mentioned that the volume of wood used by artisanal guitar-making is so small that it would have only a limited impact on trees and forests. They rather expressed concerns about mass-produced industrial instruments that turn into "disposable" commodities. Regarding tropical woods, many makers expressed an attachment to woods that have singular characteristics, from which they could anticipate what results they could obtain. Some expressed the wish that the supply could be on a "fair-trade" basis. While a few other luthiers criticised the very use of "exotic" timbers, independently of their conservation status, but from the points of view of colonial history and/or of long-distance transportation. Confidential a few decades ago, today several luthiers' movements and initiatives focus on using locally sourced woods, e.g. LGRP (2012–2017).

The meaning of this term "local woods" could also be discussed. The analyses presented in this article are based on sources from mainly European and North American guitar-making. Examples of "local" woods uses in guitar-making can be cited from Australia, where a rather high diversity of Australian woods was reported as significantly entering the local guitar-making trade nearly two decades ago (Morrow 2007); yet, most of these species appear rather confidential in the current uses among European and North American guitar-makers. By comparison, in a survey conducted three decades ago (Guridi Gómez & García López 1997) on the wood used by the most famous community of luthiers in Paracho, Mexico, concert classical guitars were then almost entirely built from "imported" timbers (from Europe, North America, Indo-Malaya, and even Australia). Local Mexican species were then used in the student grades, or in the types of guitars used in popular/traditional music. Still in Paracho, but a few years later, Kies (2013) stated that guitars built from imported Indian rosewood (*Dalbergia latifolia*) were more highly valued than those made from the local *Dalbergia palo-escrito*, but also reported that this local wood started

to gain reputation in the trade, locally, and gradually internationally. Although this species started to benefit from research efforts on conservation through agro-forestry plantation (Suarez-Islas *et al.* 2020), it is now threatened (EN), and recent research has tried to find local alternative species to this local species for local guitar-making (Quintanar-Isaías *et al.* 2025). The volumes of wood used for local and artisanal guitar-making may be too small to be a significant cause of threat on species, but this example highlights the complexity of issues in craft lutherie, from “normative” wood preferences from the global market and culture, to artisanal valuations of species that could be local and/or lesser-known from global trade, but are eventually impacted by global changes.

4 Conclusion

This research aimed at reassessing, on a wide-scale scope and with both quantitative and qualitative approaches, the diversity of wood uses in the craft culture(s) of guitar-makers. This topic has recently received increasing attention and concern from both craft and academic research, but often through a single perspective, or limited number of perspectives. By combining surveys from artisan guitar-makers and their wood suppliers, collections of wood samples, and meta-analyses of broad-scale professional and academic sources, some of the main outcomes of this work are summarised as follows:

- Nearly 450 species are cited for guitar-making, from sources mainly focused on wood uses by luthiers from the Western (European and North American) cultures. This probably situates guitar-making as one of the woodcrafts that employs the highest biodiversity.
- This wide global diversity should not be “the forest that hides the tree”: only 34 species are here identified as in “main” uses (cited by all sources), and 20 are described as iconic or most traditional species. Even these “main” uses are, however, much more diversified than in other musical-instrument making crafts such as violin-making. The number of species that are “main and common”, and cover 50% of citations of uses in guitar-making, is 82.
- The global diversity of woods in guitar-making could be categorised into functional, biogeographical, and botanical diversity. For functional diversity, the number of “commonly” employed species for the different components and types of guitars could be ranked as acoustic top-plates < necks < bridges and fingerboards < electric bodies << acoustic back and sides. The number and “functionality” of provided woods, as well as the degree of “experimentation”, vary widely between regions of origin of wood/trees. For botanical diversity, all wood uses cover 234 genera from

64 families, “main and common” uses cover 23 families; however, when considering even “rare” uses, six families concentrate 50% of uses’ citation index, and 13 families 75% of this.

- The issue of threatened species is of high and topical concern in guitar-making communities and literature. The present results, however, indicate more complex patterns. The situation is indeed alarming for the few most “iconic” guitar tonewoods: nearly half are threatened. But the woods “commonly” used in guitar-making tend to mirror the global erosion of biodiversity on all the world’s tree species. It varies a lot between regions of origin and between reputations of use.
- Our results allow new insights comparing trade value and wood characteristics. They confirm that threatened species are more frequent in “precious” wood (traded in smaller quantities), but they also indicate that they are followed by the cheapest and least traditional woods. Medium-priced woods include many least concern species. The different categories of prices originate from different regions of the world, and from different botanical families and genera. They mostly exhibit different wood characteristics (heartwood-related colour and — mostly — colour veins, and grain-related figures) that resonate with the terms that luthiers use in the description of their woods.

The overview of wood diversity obtained in this work could be useful for further explorations of guitar-makers’ woods, that should also include quantitative material properties, and deepen the qualitative approaches. Taking into account the artisanal values and relation with wood in guitar-making cultures is indispensable for understanding the intertwining between the biological and cultural diversity of wood uses, between functionality and aesthetics, and, ultimately, between craftsmanship as intangible cultural heritage and tree biodiversity as natural heritage.

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Appendix

This appendix presents the vernacular and botanical names of wood samples pictured in Figs. 9–12. Names are listed below in the order in which samples are organised from the top left to the bottom right of each figure.

Wood samples in Fig. 9: ziricote (*Cordia dodecandra*), Madagascar rosewood (*Dalbergia baronii* and/or spp.), cocobolo (*Dalbergia retusa*), African blackwood (*Dalbergia melanoxylon*), Honduran rosewood (*Dalbergia stevensonii*), koa (*Acacia koa* syn. *koaia*), Malaysian blackwood (*Diospyros* sp., designation “*D. ebonasea*”), Makassar ebony (*Diospyros celebica*), African/Gaboon ebony (*Diospyros crassiflora*), kingwood (*Dalbergia cearensis*), Brazilian/Rio rosewood (*Dalbergia nigra*), bog oak (*Quercus* spp., buried in peat-bogs over so-stated “thousands of years”), Brazilian tulipwood (*Dalbergia decipularis* and/or *frutescens*), royal/black and white ebony (*Diospyros malabarica*), Madagascar bois de rose (*Dalbergia maritima* and/or spp.).

Wood samples in Fig. 10: Indian rosewood (*Dalbergia latifolia*), Santos rosewood/pau ferro (*Machaerium scleroxylum*), bubinga (*Guibourtia demeusei* and/or spp.), birdseye maple (*Acer saccharum* and/or spp.), bocote (*Cordia elaeagnoides* and/or *gerascanthus*), Australian blackwood (*Acacia melanoxylon*), quilted maple (*Acer macrophyllum* and/or spp.), figured — here flamed — Honduran mahogany (*Swietenia macrophylla*), spalted/ambrosia maple (*Acer* spp., stained/attacked by fungi), Amazon rosewood (*Dalbergia spruceana*), olive (*Olea europaea*), Swiss pear/wild service tree (*Torminalis glaberrima* syn. *Sorbus torminalis*), Cuban mahogany (*Swietenia mahagoni*), tigerwood (*Astronium graveolens* and/or spp.), “exotic” African ebony (*Diospyros crassiflora* and/or spp.), European yew (*Taxus baccata*), African koa/tamarin des hauts (*Acacia heterophylla*), “green ebony” (*Diospyros blancoi* syn. *durionoides*).

Wood samples in Fig. 11: sapele (*Entandrophragma cylindricum*), wavy/fiddleback maple (mostly *Acer pseudoplatanus*, occasionally *Acer* spp.), European walnut (*Juglans regia*), wenge (*Millettia laurentii* and/or spp.), pear (*Pyrus communis*), Spanish/Mediterranean cypress (*Cupressus sempervirens*), cedro/“Spanish cedar” (*Cedrela odorata*), machiche (*Lonchocarpus castilloi*), Mexican granadillo (*Platymiscium dimorphandrum* and/or spp.), katalox (*Swartzia cubensis*), chechen (*Metopium brownei*), macacauba (*Platymiscium pinnatum* var. *ulei* and/or spp.), paela/chakte viga (*Coulteria platyloba*), spalted beech (*Fagus sylvatica*, stained/attacked by fungi), “brown ebony” (designation as *Sapium glandulosum*), mulberry (*Morus alba*), redheart/chakte kok (*Simira salvadorensis*), curupay (*Anadenanthera colubrina*), European plumwood (*Prunus domestica*).

Wood samples in Fig. 12: African padauk (*Pterocarpus soyauxii*), plain Honduran mahogany (*Swietenia macrophylla*), ovangkol (*Guibourtia ehie*), African mahogany (*Khaya ivorensis*, *anthotheca* or spp.), zebrano (*Microberlinia brazzavillensis*),

purpleheart (*Peltogyne venosa* and/or spp.), pau rosa (*Bobgunnia fistuloides*), European plane (*Platanus* × *hispanica*, syn. × *acerifolia*), Australian lacewood (*Grevillea robusta*), bloodwood/satiné (*Brosimum rubescens*), Brazilian lacewood (*Roupala montana*), European cherry (*Prunus avium*), acacia (*Acacia* sp.), Pacific rosewood (*Pterocarpus indicus*), « aged » eucalyptus (*Eucalyptus* sp., thermal treated), Brazilian laurel (*Cordia goeldiana*), muninga/kiaat (*Pterocarpus angolensis*), true/Mediterranean cedar (*Cedrus atlantica* and/or *libani*), red gum (*Liquidambar styraciflua*).