

## **Appendix 7.** Detailed descriptive historical trajectory

### *Pre-colonial ecocultural system in the Mata Atlântica and SES within Europe (before 1500)*

Pre-colonial land use within the Mata Atlântica, a social-ecological system was, according to Nehren (2011), characterized by ecologically sustainable land use of the pre-colonial Tupi and Guarani tribes living in the Mata Atlântica. They only carried out small-scale slash-and-burn agriculture that allowed the regeneration of vegetation and soil, and were otherwise specialized in hunting and gathering. In contrast, the social-ecological system in Europe was close to reaching an ecological threshold; according to Moore (2002) European Feudalism was characterized by a degraded environment and soil exhausting agricultural practices. Hence, a spatial solution, through internal and external colonization, was the response to this imminent ecological shift driven by pressures of the social system.

### *Pau-brasil exploitation for dyes (1500 to ~1800)*

Colonization in 1500 marks the beginning of telecoupling between the Mata Atlântica and Europe, as well as the economic period of pau-brasil (Rocha (2004), characterized by excessive exploitation (1500-1875) with far-reaching socio-economic and environmental consequences. The Portuguese soon recognized pau-brasil for its valuable red dye. According to Buono (2016), the indigenous people had been using *pau-brasil* as a colorant and must have introduced the French to pulping techniques; thus, pau-brasil quickly became the most important resource for the Europeans. The special political and economic importance of pau-brasil is represented by the monopoly of the Portuguese Crown (1549-1859) (Dean 1996) and by the Franco-Brazilian trade with the Tupi tribe from the Mata Atlantica in the 16<sup>th</sup> century (Dickason 1984, Buono 2016). For the use as red dye, the red-colored pau-brasil heartwood was pulverized and then added to water and/or other chemical solutions. The colorant brazilein evolves from the oxidized chemical wood component brazilin; as soon as the wood is exposed to the air the colorant was dissolved and finally dyed the fabric (Dapson and Bain 2015). Pau-brasil replaced the qualitatively inferior (due to lower brazilin content) Asian *Caesalpinia Sappan* L.

As far as the environmental dimension is concerned, the Mata Atlântica passed through three phases of exploitation, or emerging economies, which reduced the forest areas during this period: the exploitation of pau-brasil (1500-1550), sugar cane production (1550-1720), and gold rush (1720-1790). In the same period, the classical music in Europe went through the epochs of Renaissance (1400-1600), Baroque (1600-1750) and Classics (1750-1830) and was closely linked to the dimension of traditional violin and bow making with the era of Baroque bows, which were still made by violin makers themselves. The tradition of violin making originated in Europe and evolved from the craft of constructing lutes, a common instrument in the 15<sup>th</sup> century. The famous traditional violin craftsmanship in Cremona, Italy, goes back to Andrea Amati (1505-1577) with its most important representatives, the Amati, Guarneri and Stradivari family (Halbscheffel 2010). In the Renaissance and Baroque periods, concerts were intended primarily for small audiences and were reserved for the royal court. The first violin solo concerts and virtuous compositions for string instruments appeared in the classical epoch and the technical demands on the musicians increased. These changes in classical music led to more public music-making and general public audiences at the end of the 18<sup>th</sup> century (Skeaping 1955). According to Brémaud and Poidevin (2013), most probably baroque and later bows and western classical music would not have been able to develop as they did without the woods from Latin America, which are characterized by their very high density and rigidity. With the introduction of classical music to the Mata Atlântica region and to Brazil in general, at the beginning mainly Jesuit missionaries were favored; this contributed to an even stronger and

reciprocal telecoupled connection at a cultural level beyond economic exploitation. At the end of the 18th century, a series of new trends emerged as a consequence of complex changes associated with the cross-continental pau-brasil system (not yet CES): (1) increasing availability of pau-brasil in Central Europe as an important raw material for red dye production, (2) continuous evolution and demand of improved instruments in western classical music. This paved the way for experimenting with pau-brasil and for its later sole use for string bow making.

*The invention of the 'modern violin bow' gives rise to the telecoupled PB-CES (~1800 to ~1900)*

This period, like the romantic epoch in music (1820-1910), is described in the literature as a stormy and stressful period. Brazil, and with it the Mata Atlântica, was undergoing a transformation to the post-colonial period (1822-1889) and then to capitalism (1889-present day). Economically, the period was dominated by coffee production (1790-1860). During the classical period (1750-1830), musical compositions began to change and became more virtuosic, which required more demanding playing techniques from the musicians. In the romantic period, compositions for larger orchestras with more musicians were written, so that larger concert halls were needed for a bigger audience; also, because the general public access to classical music increased. In order to withstand these changes and to accommodate the larger concert halls, baroque violins had to be modernized to generate a louder sound. Around 1800, experiments were made with all kinds of bows made of different materials and in different shapes to meet technical and tonal expectations (Skeaping 1955). Niccolò Paganini (1782-1840) was one of the most famous violinists of this time, he developed and improved the technique of violin playing to an unprecedented perfection (Kommission für Musikforschung 2013); he tried all kinds of bows in order to best meet the increasing technical demands. With bows for stringed instruments, three things happened simultaneously: 1) a change in the construction method and the shape of the bows, 2) the construction of bows became more standardized in material and size, and 3) bow making became an own professional specialization, implying that most violin makers no longer produced bows. According to Brémaud and Poidevin (2013), bow makers were pushed by violinists who wanted to endow their violin play with a full and sustained sound with equal force from one end of the bow stick to the other. The weakness at the tip of the baroque bows got solved by increasing the height of the bow head and by stabilizing them with a lengthened and arched bow stick (Brémaud and Poidevin 2013). The bow makers experimented with different tropical woods at the beginning and finally adopted pau-brasil as the ideal wood by being lighter and just as dynamic and by solving the problem of balance with the mentioned structural changes. A good bow considers all these aspects and is precisely constructed by hand and is aesthetically pleasing. At the end of the 18<sup>th</sup> century, the Italian violinist Giovanni Batista Viotti (1755-1824) met the bow maker F.X. Tourte (1747-1835) in Paris and their mutual inspiration plus the experimentation with pau-brasil led to the new model of violin bows, i.e. the modern violin bow. During this time, musicians began to realize the importance of the bow for better sound quality (Mnatzaganain 2002). At the end of the 19<sup>th</sup> century, G.B. Viotti summed this up with the words: “Le violon, c’est l’archet” - the violin, it is the bow. Baroque bows were never fully replaced by modern violin bows, as there are still musicians who play early baroque music with baroque bows. Some bow makers still construct baroque bows for this purpose using the original, traditionally used wood types.

In the late 18<sup>th</sup> century, bow making was still in its initial phase, but the French bow makers, especially in Paris, had relatively easy access to pau-brasil due to the still existing and important dye industry in France. From the beginning, they had a considerable economic advantage in comparison to their competitors in Germany and Britain (Bunn and Seiber 1997). A recent anatomical analysis of historical French bows originating from the time of F.X. Tourte (1747-1835) and shortly after, indicates that the pau-brasil, which was used for these precious bows, most probably had its origin in the northeast of Brazil (Macedo 2015, Macedo et al. 2020)). By the end of this period (1875-1972) pau-brasil was considered extinct. There is no evidence whether this was due to the collapsed pau-brasil demand and the consequential missing attention to the species or due to the continuous wood demand for bow making in a drastically decreased biome.

#### *The deceptive calm and flourishing bow making (~1900 to 1998)*

From the 19<sup>th</sup> century onwards, bow making spread throughout Europe but mainly in Germany, France and England; in Germany mainly in Markneukirchen in Saxony, in England in London, and in France in Mirecourt and Paris (Bunn and Seiber 1997). During this period bow and violin makers in Europe used pau-brasil without restrictions. Supply shortages occurred only during the First and the Second World War; however, they were not attributed to a decline in pau-brasil populations. The musical epoch of modernism (1908-present day) encompasses a variety of music styles such as the twelve-tone technique, serial music, jazz, blues, electronic music and experimental music, among others (Brockhaus 1993). In musical instrument making, innovation and change was sought, but this was not induced by the scarcity of pau-brasil. Experiments with alternative materials for bows led to the first patent for bows made of carbon fiber by Claudio Righetti in 1989. However, bow makers and musicians perceive carbon fiber bows as inferior to pau-brasil bows with regard to playability, acoustic properties, haptics, and aesthetics. Nevertheless, the quality has improved significantly over the last 30 years (Femke 2014) and the market share of carbon fibre bows is continuously increasing. In the same period, triggered by the economic opening of China in 1978 (Lockett and Littler 1983), cheap, inferior musical instruments and bows, including pau-brasil bows, entered the international market (Hume 2008). Land use intensification and urbanization processes in large parts of the Mata Atlântica also explain substantial declines of pau-brasil populations during this period. However, there are no reliable data in this regard. Although according to Rocha (2004), pau-brasil has been in a period of regeneration since 1972, the species was listed as endangered by the Brazilian Institute of the Environment and Renewable Natural Resources (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis, IBAMA) in 1992. This measure was reinforced in 1998, when pau-brasil was included in the International Union for Conservation of Nature's (IUCN) Red List (Varty 1998) as an endangered species (EN A1 acd) due to overexploitation and decline of the species' population; this marked a regime shift for the PB-CES.

#### *Control of the PB-CES by intergovernmental protection and trade regulations (1998 to present day)*

The dominated intergovernmental control on pau-brasil protection was introduced by the listing of pau-brasil on the IUCN red list. In 1999, the Discovery Coast Atlantic Forest Reserves were listed as a UNESCO World Natural Heritage Site of Humanity, recognizing their value and the importance of their preservation. These reserves comprise the areas with the highest numbers of remaining natural pau-brasil populations and thus contribute to the recovery of the species by protecting them. UNESCO's international protection interest in these reserves of the Mata

Atlântica strengthens the perception of their ecological importance and underlines the importance of maintaining their protection status. Also in 1999, Marco Ciambelli, the son of a tortoiseshell worker family in France, learned that the ecological situation of pau-brasil was very critical and that the species could possibly be listed in one of the CITES Appendices (Rymer 2007). He had witnessed the collapse of the family business after the listing of tortoiseshell in CITES and therefore passed this information on to bow makers in a meeting in Paris (Rymer 2004). This information and the alarming threat that pau-brasil could reach the status of trade restriction were responsible for bow makers to become active and to found the International Pernambuco Conservation Initiative (IPCI) in 2000 with 50 founding members from 18 nations and implementing reforestation and conservation projects for pau-brasil in the Mata Atlântica (Gerbeth 2002). However, pau-brasil was finally listed in Appendix II of CITES in 2007. Bow makers, mainly from IPCI (Rymer 2004) and internationally renowned musicians such as Yo-Yo Ma, achieved at the last minute that the final product of pau-brasil, the bow, was to be excluded from Annex II (Sadler 2007). Hence, the species pau-brasil is listed in Appendix II of CITES, but the final products made from its wood such as bows, have no restrictions on their marketing.

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