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Protecting threatened species and music traditions

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Protecting threatened species and music traditions

Silke Lichtenberg[1,2*], Udo Nehren[1], Dieter Anhuf[2], Iris Brémaud[3], Tiago de Oliveira Pinto[4], Viviane S Fonseca-Kruel[5], Volker Haag[6], Elisabeth Huber-Sannwald[7], Stefan Jänicke[8], Gerald Koch[6], Jakob Kusnick[8], Haroldo C Lima[5], Eduardo Luiz Longui[9], Daniel Piotto[10], Juan Antonio Reyes-Agüero[11], and Patrícia Rosa[5,12]

Musical instruments are indispensable to music traditions worldwide and often made from natural materials derived from species that are increasingly endangered. International trade threatens the survival of some of these species, as addressed by their inclusion in the UN Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). However, CITES regulations can substantially impact music traditions and alone are insufficient to preserve trade-relevant species from extinction, such as the pau-brasil (*Paubrasilia echinata*), which is used for the bows of stringed instruments. Therefore, new CITES listings of species or species products used in the manufacture of musical instruments, or potential future shifts of CITES-listed species to the strictest category, will require anticipation, preparation, and precautionary actions. In international species trade negotiations, it is crucial to target the protection of species and music traditions beyond trade regulations. We propose novel social–ecological pathways to address these challenges and reconcile conflicting stakeholder interests between species conservation and cultural conservation.

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Music is essential to human culture; indeed, 70% of the intangible cultural heritage listed by the UN Educational, Scientific and Cultural Organization (UNESCO) is directly or indirectly related to music (de Oliveira Pinto 2018). Musical instruments are crucial to music cultures worldwide. Brémaud (2012) recorded more than 500 woody species used in musical instruments associated with different non-Western music traditions. For 29 European musical instrument families—including orchestral instruments, guitars, accordions, and recorders—material from 758 animal and plant species are or have been used in 153 musical instrument parts (Kusnick *et al.* 2024). Cultural and sound identity of musical instruments often relates to the material that originates from animal and plant species in their natural habitats. Thus, performances with musical instruments can be said to represent unique "music ecosystems", characterized by complex connections and feedbacks among natural ecosystems (from various biomes and continents), diverse actors, and cultural elements linked to music traditions (Kusnick *et al.* 2024). Music ecosystems can be described as particular social–ecological systems (SESs) consisting of interacting and interdependent abiotic, biotic, and social components, viewed from a "humans-in-nature" perspective (Chapin *et al.* 2009) but with a focus on music cultures.

Music and the traditional manufacture of musical instruments are at a crossroads because many species and ecosystems are increasingly threatened (IPBES 2019), which limits legal access to resources for instrument making. Global environmental changes, including habitat loss, ecosystem degradation, land-use change, resource extraction, and climate change, amplify these threats to species (Hogue and Breon 2022). This complex spectrum of threats requires novel, well-aligned cross-sectoral agreements and actions that integrate species-specific, ecosystem, biodiversity, sociocultural, and conservation policies.

The International Union for Conservation of Nature (IUCN) monitors the conservation status of species through

In a nutshell:

- Social–ecological systems with a cultural focus give a framework to analyze music–ecosystem connections in a metacoupled world
- The species used in the production of musical instruments are increasingly threatened with extinction; conservation measures must integrate the protection of species, ecosystems, and cultural traditions
- Trade regulations alone are insufficient for conserving endangered species used in musical instruments; targeted recovery actions are urgently required to avoid their extinction in the wild
- An innovative global vision for sustainable music ecosystems can orchestrate regulated trade, transparency, sustainable timber production, and (especially) in situ species conservation

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its Red List of Threatened Species. Examining the IUCN Red List status of species circa 2023 in relation to information from the database in Kusnick *et al.* (2024) allows quantification of the number of endangered species used in the manufacture of musical instruments. In 2023, almost one-quarter (180 of 758) of species that were or are used in the production of European musical instruments were listed as "Vulnerable", "Endangered", or "Critically Endangered" (hereafter collectively referred to as "threatened") with extinction as according to the IUCN Red List. By contrast, in 2003 only half (89 species) were categorized as threatened, with many (114 species) classified as Data Deficient. Bolam *et al.* (2023) highlighted that more than half of the threatened species assessed and red-listed by the IUCN can be protected from extinction in the wild only through targeted recovery actions. We envision an unexplored opportunity for various international conventions and intergovernmental bodies (Panel 1) to coordinate, interconnect, and align joint actions. Consequently, targeted recovery programs should consider the known interconnections between species, materials, musical instruments, craftsmanship, and music along with the contribution of cultural ecosystem services and provisioning services within these music ecosystems. The final aim should be to maintain such coupled human and natural systems or SES. The described global interconnections require a holistic approach, as proposed by Liu (2017)—a metacoupled SES framework. Combining a metacoupled SES (Liu 2017) with a targeted focus on culture, as proposed by Lichtenberg *et al.* (2022) for telecoupled systems using the example of pau-brasil (*Paubrasilia echinata*) and bow making, allows for comprehensive consideration of all key elements (music cultures, cultural heritage, natural heritage, species, and ecosystems) and their cross-scale interactions at a global scale (Figure 1).

Panel 1. Names and abbreviations of relevant international conventions, organizations, unions, and platforms

CBD:	Convention on Biological Diversity
CITES:	Convention on International Trade in Endangered Species of Wild Fauna and Flora
FAO:	Food and Agriculture Organization of the UN
IPBES:	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IUCN:	International Union for Conservation of Nature
UNCCD:	UN Convention to Combat Desertification
UNEP:	UN Environment Programme
UNESCO:	UN Educational, Scientific and Cultural Organization
UNFCCC:	UN Framework Convention on Climate Change

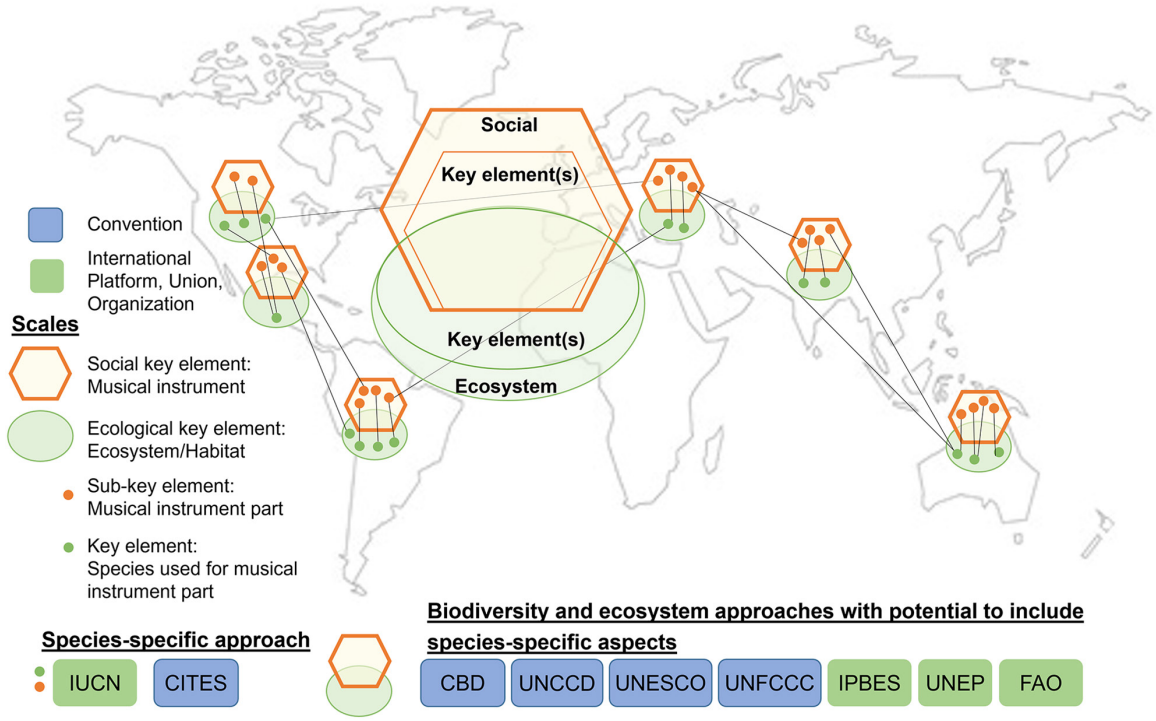


Figure 1. A metacoupled social–ecological system (SES) framework serves to explore the relationships between music cultures and their musical instruments, intangible cultural heritage, ecosystems, and threatened status of species. Global efforts must go beyond the CITES mandate and its trade regulations to comprehensively address the conservation of such systems. Species-specific conservation efforts must be linked to nature, culture, economy, and policy, considering polycentric governance including local, national, and international bodies such as United Nations conventions (CBD, UNCCD, UNESCO, UNFCCC) and intergovernmental bodies (IUCN, IPBES, UNEP, FAO). For a list of spelled-out acronyms, see Panel 1.

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CITES—addressing trade-related species threat in metacoupled SES

Metacoupled systems, such as music ecosystems, span the globe, leading to international trade and connectivity over long distances. Only international binding legal instruments can extend the necessary guidance effect to protect endangered species that are internationally traded and are part of a metacoupled SES. Although national binding legal instruments are important for regulating trade, effective solutions will only be possible through internationally coordinated efforts. One key tool for preventing the extinction of threatened species associated with international trade is through their listing by the UN Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). As the only legally binding convention relevant in this context, CITES aims to limit international trade in specimens of wild animals and plants to a non-detrimental level to ensure their survival. CITES Appendix I lists endangered species affected by international trade and prohibits the international trade thereof, with few exceptions. CITES Appendix II lists species not necessarily threatened with imminent extinction due to international trade but that nevertheless require special protection through strict trade controls. CITES Appendix III lists species that are protected in at least one country requesting trade control assistance. Of the species listed in CITES, 210 are or have been used in the manufacture of European musical instruments (Kusnick *et al.* 2024). Of these 210 species, 18 are included within Appendix I. For plants, one of the most renowned examples is Bahia rosewood (*Dalbergia nigra*), which is endemic to the Atlantic Forest biome in Brazil and is a preferred wood in the making of guitars. For animals, a prominent example is the African elephant (*Loxodonta* spp), the ivory of which is often used as an ornamental element in a variety of musical instruments. The remaining 192 species are listed in Appendix II, a large proportion of which belong to the rosewoods (*Dalbergia* spp) that are used in guitars, percussion instruments, woodwind instruments, and accessories of stringed instruments. Currently, no species listed in Appendix III are used in European musical instruments (Kusnick *et al.* 2024).

The intertwined challenges of alternative and CITES look-alike species

Species diversification for use in musical instruments is an important step toward reducing pressure on certain endangered species. However, switching to alternative woods, for example, can trigger unforeseen consequences and simply shift a problem from one species to another. Species with similar physical and acoustical characteristics could also have a similar visual appearance at both microscopic and macroscopic levels (Gasson 2011; Haag and Plath 2016). In such cases and as a precautionary measure, CITES applies the look-alike principle to avoid species misidentifications that could further imperil CITES-listed, endangered, and internationally traded species (CITES [1973] Article II 2.b). This principle implies that one or more species from one or several genera that look similar can be included in the same Appendix. For identifying species and detecting illegal timber trade, we consider DNA barcoding and isotope testing of wood samples as key methods for establishing transparent supply chains in the future. However, examination of finished cultural objects in particular requires non-invasive methods such as microscopic and macroscopic identification.

Cultural implications of CITES Appendix I listing

Musical instrument makers and musicians worldwide are strongly affected by each CITES Appendix I listing of species used in the making of musical instruments. CITES Appendix I listings require that owners of musical instruments that are composed of components from these species must register their instruments at the national CITES Management Authority or an equivalent competent authority. This is because future non-commercial (travel-related) and commercial (sale-related) movements are permitted only if it has been proven that the particular component of a musical instrument had been acquired prior to the species' listing in any CITES Appendix (CITES [1973] Article VII, paragraph 2; CITES 2019). It is therefore in the interest of any owner of CITES Appendix I-listed material to follow the prescribed procedure, regardless of the age, value, or condition of the instrument. For instance, for owners of stringed instruments containing material from upgraded or new Appendix I-listed species, this requirement entails important administrative implications.

There are at least 1698 orchestras and opera houses worldwide (www.musicalchairs.info). A symphony orchestra includes on average 60 musicians playing stringed instruments (16 first violins, 14 second violins, 12 violas, 10 celli, eight double basses). Assuming that each musician owns at least one musical instrument, professional orchestra musicians alone would have to register well over 100,000 musical instruments and subsequently apply for Musical Instrument Certificates (MICs) within 90 days of the amendment's entry into force (CITES [1973] Article XV, paragraph 1 [c]). This number does not include professional musicians active outside orchestras and opera houses (including traditional and diverse popular music), nor does it include music students, amateur musicians, conservatories, museums, foundations, bow makers, violin makers, and owners of collections of musical instruments. The burden of proof of prior purchase for CITES registration or certification lies with the owner of the listed wood or object. Costs for such certificates vary considerably from country to country, ranging from US$/€ 0 to 100 (FIM and PEARLE 2021). A major challenge after any Appendix I listing is to inform all instrument owners of the pending tightening of regulations and their implications to

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prepare owners to register their musical instruments within the deadline.

Pau-brasil as a case study

At the 19th Conference of the Parties to CITES (COP19) held in Panama in November 2022, one of the most controversial species discussed for re-listing from Appendix II to I was pau-brasil (*Paubrasilia echinata* [Gagnon *et al.* 2016], syn *Caesalpinia echinata*), whose high-quality wood is used in the making of bows for stringed instruments (Bueno 2002). Pau-brasil, also known as brazilwood and by bow makers as pernambuco, grows exclusively in coastal areas of the highly fragmented Atlantic Forest (Mata Atlântica) biome, one of 36 biodiversity hotspots worldwide (www.conservation.org/priorities/biodiversity-hotspots).

Before the middle of the 18th century CE, bow makers used various temperate and tropical hardwoods, including pau-brasil. Around 1800, François Xavier Tourte (1747–1835), the most famous French bow maker, gave the bow its modern shape and established its ideal length (Retford 1964). Pau-brasil wood was initially chosen for its extraordinary properties (Longui *et al.* 2014). The fine bow-making craftsmanship was derived from a profound understanding of how to work with this specific wood, the heartwood of which was renowned for its optical and vibrational qualities (Brémaud 2024). Since then, precious stringed instrument bows have commonly been made from pau-brasil wood, with the bow-making tradition slowly spreading first across the Global North and then around the globe—transforming a telecoupled music ecosystem into a metacoupled one. Pau-brasil is therefore of extraordinary importance to the traditional craftsmanship of bow-making (Lichtenberg *et al.* 2022) and the music traditions of stringed instruments.

The current precarious situation of pau-brasil's natural populations must be placed in the context of a centuries-long history of exploitation and livelihood dependency on this species in Brazil and globally (Bueno 2002). Various Indigenous peoples inhabiting the Atlantic Forest had a strong biocultural connection to pau-brasil, called *ibirapitanga* by the Tupinambá tribe (Rocha 2004). After the colonization of Brazil, Europeans exploited its resources, including pau-brasil for its red dye, disregarding Indigenous cultures and contributing to the disappearance of entire ethnic groups (Rocha 2004). Nevertheless, Brazil owes its very name to this tree species, which was declared as the national tree in 1978 (Government of Brazil 1978) due to its cultural and economic importance in Brazilian history (Dean 1996). Colonial history favored global interconnections and European access to foreign resources, ultimately enabling the use of pau-brasil for bow-making (Lichtenberg *et al.* 2022) and the integration of stringed instruments into non-European cultures.

In 1992, pau-brasil was included on Brazil's list of endangered species due to uncontrolled habitat loss and overexploitation; this listing was confirmed in 2012 (CNCFlora 2012) and again in 2022 (MMA 2022). In 1998, pau-brasil was classified as Endangered on the IUCN Red List. In 2007, increasing risk caused by continuous commercial exploitation led to pau-brasil's listing in CITES Appendix II, excluding finished bows (Annotation #10; CITES 2007), which was limited to the re-export of finished bows at COP19. CNCFlora (2012) indicated that the exploitation of pau-brasil continues, despite its CITES listing and Brazilian federal laws prohibiting its wild harvest. A recent study warrants that pau-brasil be considered as Critically Endangered, given the 84% contraction of its original range (de Lima *et al.* 2024).

Although stricter CITES trade regulations would curtail further declines of at-risk populations, including those of pau-brasil, international trade regulations alone would likely be insufficient to preserve threatened species from extinction in the wild. Addressing this issue requires a twofold commitment. First, the ecological situation must improve substantially in the medium term to a degree that allows species such as pau-brasil to be removed from the IUCN's threatened status and similar assessments. This is especially true for pau-brasil because many of its native populations are still drastically suppressed in the wild (Cardoso *et al.* 2005). Second, the intangible cultural heritage linked to species like pau-brasil must be secured in a sustainable way to preserve such unique music ecosystems for future generations.

Although most pau-brasil plantations have been established to contribute to the species' conservation, a lack of genetic diversity has been reported in these plantings (Rees *et al.* 2023). Existing pau-brasil plantations designed for sustainable timber production remain scarce but may become the primary, if not the sole, future source for markets, provided legal registration schemes are met and trees are grown to large enough sizes. Transparent documentation from the harvested plantation tree to the bow will be crucial, as combating illegal trade remains an important task, as it continues to jeopardize the extinction of pau-brasil in the wild. Studies suggest that plantations show promise for producing quality wood if rotation cycles are long enough for heartwood to form and align with surrounding conditions (Schimleck *et al.* 2013). Nevertheless, pau-brasil may be susceptible to a species of ambrosia beetle (*Megaplatypus mutatus*; de Souza Girardi *et al.* 2022), a destructive tree pest, which could affect the establishment of plantations.

Ultimately, the preservation of (1) pau-brasil in the wild, (2) the Brazilian biocultural heritage, and (3) pau-brasil's value for music will require involvement, cooperation, and coordination of all relevant stakeholders, including musicians, orchestras, bow makers, and bow traders worldwide; residents of local communities within the species range and near extant populations; and growers, breeders, and scientists.

Other CITES-listed species used in the production of musical instruments face similar circumstances. Consequently, instrument makers and musicians have established several initiatives that focus on: (1) *establishment of plantations* (the International Pernambuco Conservation Initiative [http://www.ipci-usa.org, https://www.ipci-deutschland.org] and the

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African Blackwood Conservation Project [www.blackwoodconservation.org], which center on pau-brasil and *Dalbergia melanoxylon*, respectively); (2) *implementation of sustainable forest management schemes* (the Mpingo Conservation & Development Initiative [www.mpingoconservation.org], which implements sustainable harvest of *D melanoxylon*); and (3) *ecological restoration of lost or degraded forest areas* (an Indigenous Pataxó cooperative [https://news.mongabay.com/2022/11/indigenous-cooperative-restores-forests-to-form-ecological-corridor-in-bahia], which plants pau-brasil and *Handroanthus* spp in the Brazilian state of Bahia, as well as Eben!Holz [www.eben-holz.org] and Orchestra of Change [www.orchester-des-wandels.de/#c276], which plant *Diospyros* and *Dalbergia* spp in Madagascar and native species in Brazil). Likewise, non-CITES-listed species used in the production of musical instruments are the focus of similar initiatives, which aim to support reforestation of target species through species conservation and maintenance of future timber supply (The Ebony Project [https://sustainability.taylorguitars.com/projects/ebony-in-cameroon-2] for *Diospyros crassiflora* in Cameroon and Siglo Tonewoods [https://siglotonewoods.com] for *Acacia koa* in Hawai'i).

Pathways toward sustainable music ecosystems

Concerted, far-reaching measures—ones that go beyond international trade restrictions and the mandate of CITES—are needed if endangered species used in the manufacture of musical instruments are to be protected. Public policies that specifically target endangered, culturally important species and that promote integrated, large-scale ecological restoration are needed to preserve these species and their genetic diversity. Therefore, we call for joint national and international policy efforts and the endeavors of civil actors connected to the affected species to address such social–ecological challenges. The conservation of endangered, culturally relevant species and music ecosystems must encompass (1) conservation, rehabilitation, and ecological restoration; (2) controlled species-specific sustainable forest management, plantations, and artificial propagation; (3) diversification of material choices; (4) transparency and authenticity in management along the entire value chain; (5) research and education; and (6) cultural preservation (Figure 2).

Baseline assessments are essential prior to defining actions toward promoting sustainable music ecosystems. For selected countries, direct financial assistance through CITES-funded programs, such as the CITES Tree Species Program (https://cites-tsp.org), could enable assessments that directly support conservation and species-specific management measures for sustainable, legal, and traceable trade in compliance with CITES provisions. Cross-sectoral cooperation among various CITES partners (Convention on Biological Diversity or CBD [Conference 16.5], Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services or IPBES [Conference 18.4], and UNESCO [Conference 18.5], including experts on intangible cultural heritage) could enable coordinated, multilayered efforts and facilitate transformative solutions (Figure 1). Strategic considerations of "CITES and Forests" (CITES 2023) point in this direction. However, linking the scales associated with habitats and species across various conventions should not affect the autonomy, strength, and importance of each convention.

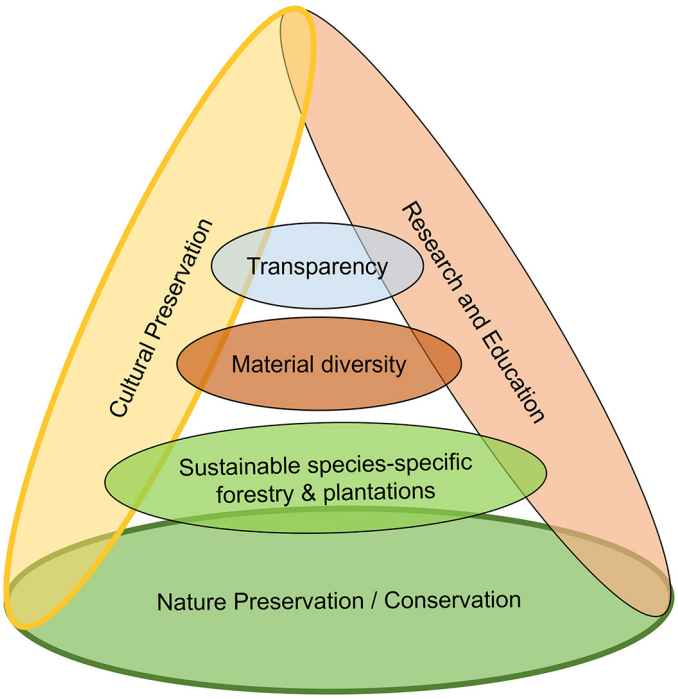


Figure 2. Sustainability vision for music ecosystems. From bottom to top: the foundation is (1) conservation and ecological restoration of endangered species used in the production of musical instruments within a given habitat, followed by (2) sustainable species-specific forest and plantation management of the focal species to meet demand, (3) diversification of available choices in materials of musical instruments and their parts to minimize pressure on focal species, and (4) transparency and authenticity regarding supply chains and material origin of each musical instrument part. Right side: (5) Research and education serve as a basis for improving knowledge and raising awareness. Left side: (6) Cultural preservation depends on factors 1 through 5 but also can positively affect the system through cultural events and adaptation of traditions.

The Kunming-Montreal Global Biodiversity Framework addresses the conservation activities needed for threatened species in Target 4 (Halt Species Extinction, Protect Genetic Diversity, and Manage Human–Wildlife Conflicts). After analyzing the eight targets of the post-2020 Global Biodiversity Framework that contribute to reducing threats for species extinction, Bolam *et al.* (2023) concluded that reducing the extinction risk for over half of the world's threatened species (eg species that have very small populations or ranges), a criterion often met by CITES-listed species, will require a broad suite of recovery actions, including ex situ conservation, reintroductions, and other species-specific interventions. The effectiveness of conservation actions for particular species in

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terms of slowing biodiversity decline was recently highlighted by Langhammer *et al.* (2024). Threatened species used in musical instruments should be classified as priorities in immediate cross-sectoral action plans that encompass species-specific recovery activities at different scales. Integrative conservation efforts for single species used for cultural purposes should reflect the complexity of both management and planning. We suggest that CITES-listed species should be prioritized in conservation actions and that commitments should be expanded, and strongly encourage intergovernmental bodies and UN environmental conventions to recognize and abide by these commitments. Finally, establishing multistakeholder partnerships, including local stakeholders and end-users of conservation efforts (eg through conservation programs, REDD+, or payments for ecosystem services supported by orchestras and opera houses worldwide), could foster new dialogue and agreements. In addition, tonewood traders, instrument makers, and musicians should collaborate to create a support system for all species used in musical instruments that (1) gathers species-specific information from harvesting areas and (2) helps to ensure that wood traded for musical instruments originates from strict species-specific sustainably managed forests. Furthermore, instrument makers, musicians, and audiences could co-create unprecedented learning environments to strengthen the collective commitment to nature and culture. A holistic approach will open opportunities for social innovation to tackle the complex challenges of preserving endangered species and intangible cultural heritage associated with musical instruments to achieve multilevel sustainability.

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Empirical data were not used for this research.

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