

CONSERVATION

CITES Designation for Endangered Rosewood in Madagascar

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Logging in Madagascar, one of the world's most threatened biodiversity hot spots (1, 2), has rapidly increased amid political turmoil since a transitional government assumed power in March 2009 (1, 3). With as much as 90% of the country's primary forest already lost, continued logging will mean species extinctions across all biotic elements of Madagascar's ecosystems, where rates of endemism are unparalleled (2, 4, 5). We demonstrate immediate risk for rosewood (genus *Dalbergia*) species extinctions and thus the need for protection via international trade regulation under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Protection of Malagasy rosewood species, which suffer from targeted logging because of their high value in international markets, would not only avoid their extinction but also extend the benefits of protection to all biota within these threatened ecosystems.

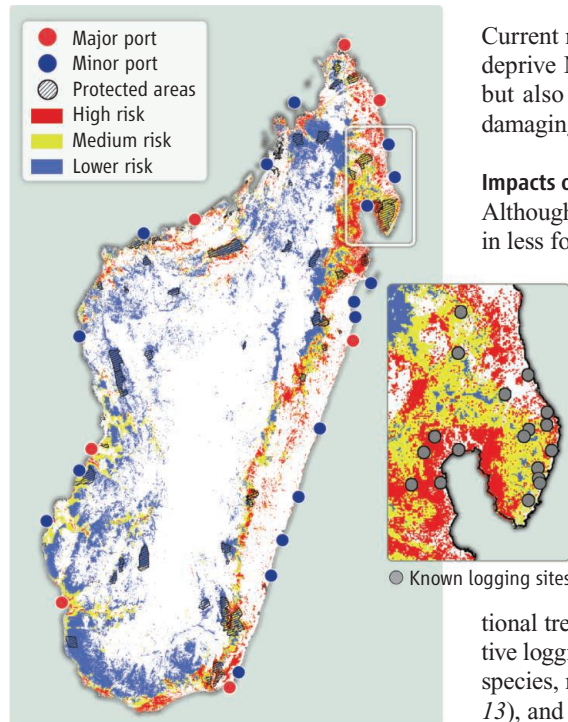
Despite public concern from international parties (6), the Malagasy rosewood issue was absent from the March 2010 CITES Conference of Parties (CoP). Yet one day before the meeting's conclusion, the Malagasy government issued a decree prohibiting rosewood logging and export, likely a response to international pressure (7). This unexpected, positive change, a window of opportunity in an unstable political climate, combined with the 3-year delay before the next CoP at which species can be voted on for full CITES protection, heightens the potential and urgency for listing of rosewood under CITES Appendix III by the Malagasy authorities (8).

Market-Driven Logging Pressure

A conservatively estimated 1137 containers, each carrying an average of 144 rosewood logs and valued at more than U.S. \$227.4 million, have been exported from Madagas-

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Areas at risk for future illegal rosewood logging in Madagascar. Much known current logging has occurred in the northeast (inset), especially in protected areas (fig. S3).

car since April 2009 (1, 9). Exporters have benefited from the transitional government's exceptions to a previous ban on exportation of unfinished hardwood products (1, 3). The administration legalized rosewood export on 31 December 2009, yet overturned this ruling on 24 March 2010, by banning logging and export of rosewood for the next 2 to 5 years (Decree no. 2010-141) (7). The enforceability of the ban is questionable, and the fate of 10 to 15 thousand metric tons of felled rosewood waiting in ports remains uncertain.

Rosewood is sought for its rich burgundy color and hard wood, qualities valued for high-end furniture and musical instruments (fig. S1). Most exports have been shipped to China, the world's largest consumer of tropical hardwoods, where an opaque regulatory process and high demand for rosewood furniture have driven the market (1, 10). A rosewood armoire can command \$20,000 in China, in stark contrast to the \$0.49 a Malagasy laborer earns for each rosewood log extracted (1, 11).

Predicted forest losses and a recent government ban on logging build support for trade protection of Malagasy rosewood.

Current rosewood market practices not only deprive Malagasy laborers of a living wage but also impair future rural livelihoods by damaging essential ecosystems.

Impacts of Rosewood Logging

Although selective rosewood logging results in less forest loss than clear-cutting, the consequences are still destructive (12). Because of the low density of rosewood trees per hectare, loggers must routinely encroach on new territories—up to 20,450 ha have been affected by selective logging in the northeast region thus far (9). In order to float dense rosewood logs downstream for export, four or five lighter trees are cut to raft each rosewood log, amounting to hundreds of additional trees daily (fig. S1) (1, 9). Such selective logging facilitates invasion of non-native species, reduces native species diversity (12, 13), and aridifies landscapes, which leads to an increased likelihood of fires (14). The loss of nitrogen-fixing by *Dalbergia* results in a reduction in soil fertility (15, 16).

Increased access to forests via logging trails and roads leads to further resource extraction and deforestation, as seen with settlement patterns around logging hot spots in northeastern Madagascar (7). Increased fragmentation of forests can amplify environmental stress, impair wildlife and ecosystem health, induce local species extinctions, shift community composition, and lead to significant loss in genetic diversity of isolated populations of endemic animals and plants (12, 17–19). Increased forest access has led to the emergence of a bushmeat market in Madagascar (20). Hunting and habitat loss will deteriorate conditions for already endangered animal species (12). Rosewood extraction undermines the legitimacy of Madagascar's National Parks management, impairing conservation efforts and destabilizing the once-thriving ecotourism industry.

Estimating the Extent of Decline

Using geospatial tools, we modeled eight species of rosewood (21) to address the following questions [supporting online material (SOM),

§ 1]: (i) Where are Madagascar's richest areas for rosewood species? (ii) How reduced is the distribution of rosewood versus estimated historic distributions? (iii) Which areas are most vulnerable to further logging? (iv) Is there sufficient evidence and urgency to call for CITES designation of Malagasy rosewood?

Historic distributions extended almost entirely throughout Madagascar (93% coverage), with the highest richness—seven co-occurring species—in northeastern rain forests. Depending on the species and deforestation scenario, distribution reduction ranged from 54 to 98% (fig. S2 and table S2), which demonstrates intense habitat loss. Based on a logging-risk model combining logging access and rosewood presence (SOM, § 1c), we confirmed high logging risk in northeastern protected areas, where lack of enforcement and higher quality, size, and density per hectare of rosewood attract increased logging (3). Our analyses forecast that logging could extend throughout the country (see the figure, p. 1109, and fig. S3); we identified 25 protected areas that are at high or medium risk for future logging (fig. S3).

CITES Designation, Government Action

Despite their threatened status (table S2) (22), no Malagasy *Dalbergia* species are protected under CITES (12). However, three non-Malagasy *Dalbergia* species are currently regulated under CITES (table S2). Brazilian rosewood, listed as vulnerable by the International Union for Conservation of Nature (IUCN), as are several Malagasy species, has benefited from CITES protection since 1992 (22). Some claim that much logging shifted from Brazil to Madagascar because of this listing (23).

Although CITES may not provide an immediate or comprehensive solution, owing to the lengthy process, difficult implementation, and need for political will (24), it nonetheless affords the best protection available (12, 25). The eight species analyzed here satisfy criteria for listing under CITES Appendix I (8), primarily because of severe range reductions (table S2). The two endangered rosewood species for which we lacked sufficient data would qualify for Appendix II because of their resemblance to these eight rosewood species (SOM, § 2c, and table S2). Despite participation by Malagasy authorities at the 2010 CoP, little discussion of Malagasy rosewood occurred (26). However, an international working group was formed to help Madagascar identify species to evaluate at the next CoP in 2013 (27). We urge the Malagasy government to immediately list these 10 rosewood species for limited protection under Appendix III to ensure their existence until

they can be listed in Appendix I or II, pending CoP approval in 2013 (SOM, § 2d).

CITES listing of rosewood would signify commitment by the Malagasy government and could provide a consistent legal framework for traders. Any export would require a permit that certifies the specimen was legally collected in a method nondetrimental to species survival. To ensure sustainability, forestry strategies including land-use planning, explicit management policies, chain-of-custody timber tracking, and log DNA bar-coding should be implemented (24). International agencies have called upon the government to seize all illegal timber and to use money from its sale within legal markets to start a trust fund for conservation and rural development; however, this may only enhance opportunities for continued corruption (1).

Government declaration of high-risk logging areas identified in these analyses (see the figure and fig. S3) will raise awareness about enforcement efforts. The government should consider expansion of the protected area network, but additional funds for park patrols and infrastructure will be essential (28).

Role of the International Community

Weak penalties and limited enforcement, as well as difficulties in identifying and tracking illegally sourced specimens, remain fundamental challenges. The international community should raise awareness of the consequences of rosewood logging, place pressure on the Malagasy government to implement improvements, and reduce market demand for illegal wood products. The recently amended U.S. Lacey Act (29) bans trade of illegally sourced plant and wood products and requires importers to declare origin and species of all plants. Even so, the United States continues to import \$3.5 billion in illegal wood products from China annually (10), and European companies have been implicated in recent rosewood export (1).

Malagasy forests could offer far greater, renewable economic value when evaluated through innovative markets. Potential revenue of \$72 to \$144 million per year for Madagascar from a Reducing Emissions from Deforestation and Forest Degradation (REDD) program far exceeds the estimated \$9 million in annual conservation funding received before the political unrest (30).

Environmental costs of political instability are high; no long-term conservation goals can be achieved in a governmental void. The urgency of illegal rosewood logging demands national and international action to conserve both rural livelihoods and remaining biodiversity habitats.

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- Ten of the 48 Malagasy *Dalbergia* species (SOM, § 2b) are economically and ecologically important and targeted for timber markets (31). We had sufficient expert-validated data to estimate historic distributions for 8 of these 10 species (table S1 and fig. S2).
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Supporting Online Material

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