Federal Policy Research

Final report

EXPERTISE CENTER FOR FORENSIC WOOD RESEARCH | ENFORCE

RT/22/ENFORCE

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ABSTRACT

The ENFORCE project has established a Belgian centre of expertise for forensic timber research to combat illegal timber trade and improve compliance with biodiversity legislations. Key objectives are to provide scientific expertise services, improve existing techniques and develop new methods. ENFORCE performs wood identification through anatomical examination and chemical profiling. The centre has provided numerous expertises to various applicants such as customs and the timber industry. ENFORCE exposed false claims of timber identity and origin, the latter in collaboration with World Forest ID for provenance determination. The project participated in international forensic initiatives such as congresses and timber check operations. Outreach is provided through the ENFORCE website, various news and magazine articles and the publication of an A1 scientific paper. Recommendations include the expansion of reference databases, the application of machine learning, the development of a more extensive network of laboratories, and ensuring trained staff and funding to safeguard Belgium's compliance to international timber regulation requirements such as the upcoming EUDR.

1. INTRODUCTION

Illegal logging is considered the most profitable breach of biodiversity regulations. A large portion - 15 to 30% - of the global timber trade is conducted illegally, and in some tropical countries this can be as high as 90% (Interpol, 2022). Thus, illegal timber trade constitutes one of the largest international crimes. At the same time, 27.5% of shipments of primary tropical timber into the European Union are imported through Belgium, mainly through the port of Antwerp. Belgium thus plays a key role in the international timber trade and has an important responsibility to (1) monitor trade in timber and timber products and (2) build research capacity for timber identification and apply it in an enforcement context.

Currently, important biodiversity regulations are in place to combat illegal logging such as the Convention on the International Trade in Endangered Species (CITES) and the European Timber Regulation (EUTR), currently transitioning to the European Deforestation Regulation (EUDR). Since 2013, the European Timber Regulation (EUTR) aims to combat the trade of illegal timber within the EU by requiring industry players to ensure that the timber and timber products they place on the market are legally harvested. It imposes due diligence obligations on operators to assess and mitigate the risk of illegal timber entering supply chains. Competent authorities are tasked with ensuring compliance through a "regular and proportionate" number of checks. The European Deforestation Regulation (EUDR) broadens the scope of the EUTR. This ambitious regulation aims to prevent deforestation and forest degradation driven by EU consumption by ensuring that specific products placed on the EU market are free from deforestation and comply with local laws. It targets commodities like cattle, palm oil, soy, coffee, cocoa, rubber, and wood, as well as derived products. Operators must still conduct due diligence and prove that the production of these goods did not occur on land that was deforested. Member states' competent authorities are responsible for enforcement through checks, risk assessments, and penalties for non-compliance, with specific thresholds for annual checks on low, standard and high-risk commodities.

2. MOTIVATION AND OBJECTIVES OF THE PROJECT

Given the enormity of the illegal timber trade and the challenges for competent authorities and other stakeholders to perform numerous checks on the species and possible origin of timber products, the Restart and Transition Plan initiated the installation of a Belgian forensic timber identification centre (ENFORCE) at the Royal Museum for Central Africa (RMCA). The RMCA's xylarium (reference wood collection) is among the largest in the world, comprising more than 81,000 wood samples, including more than 14,000 species. The Wood Biology Service of the RMCA not only curates this reference collection but also uses it continuously for wood research and identification.

The objectives of ENFORCE are divided in two major categories: scientific service and scientific research. The scientific service objectives entail (1) carrying out wood identification through routine analyses of wood anatomical characteristics and chemical profiling (namely through services to the Belgian inspection services and customs), (2) analyses of derived material potentially composed of different wood taxa, (3) acting as a reference address - including the possibility to call on the RMCA for wood analysis - for wood importers in Belgium and Europe, (4) providing training and (5) developing a sampling strategy with customs and DG Environment aimed at systematic controls of the wood trade.

The scientific research objectives must answer to the need to modernize, improve and automate routine techniques (especially in the area of applying machine learning, Direct Analysis in Real Time Mass Spectrometry and origin identification), as well as to improve the identification of wood species in wood panels (plywood, MDF, chipboard). These derived materials require an improvement of the available techniques, while several reports indicate that misidentification of wood species often occurs in these wood products.

3. METHODOLOGY

Methodology as described in CONTRACT NR RT/22/ENFORCE:

- Elaborating a formal procedure for handling incoming wood samples and for reporting on the results of analysis. This will be done through contacting forensic wood laboratories in Germany, UK and the USA. Also, analysis of web pages of similar forensic services will be explored.

- Organising research on reference material and completing relevant databases, including on wood anatomical species descriptors (Insidewood), end-grain images and wood anatomical annotations of xylarium specimens (IIIF) and metabolome spectra of xylarium specimens for DART-TOFMS (ForeST - Forensic Spectra of Trees Database, actually containing more than 13 000 spectra). The research will be performed with microscopic and mass spectrometric methodology.

- Developing visual wood identification keys on the XPER and LUCE platforms. Scans of end grain timber, microscopic images and text based descriptions of the wood structure will be used as input for these platforms. This will result in dichotomic identification keys that can be used by scientists and laymen.

- Automating wood identification through applying machine and deep learning techniques. The image databases (IIIF) will be used to apply techniques of artificial intelligence. Cropped images will be used to explore the wood variability potentially hampering the identification process.

- Developing a methodology for analysis of charcoal, panels and other wood derived products. Non-solid wood can still be characterized wood anatomically by the microscopic structure of the fragments used in the derived products. The features used to identify solid wood will not all be relevant and need to be completed with detailed observations of single isolated cells and cell walls, observed at high microscopic resolution and with the SEM (Scanning Electronic Methodology).

4. SCIENTIFIC RESULTS AND RECOMMENDATIONS

ENFORCE delivered different types of expertises (further also referenced under the term "scientific services") for a wide range of applicants. These include government agencies such as customs and FPS environment, industry players such as importers and retailers, museums and art galleries. Standard protocols were used for each scientific service, such as microscopic analysis of wood anatomy by microtomy for solid wood and macerations of wood products. In addition, DART (Direct Analysis in Real Time) -TOF (Time-of-Flight) mass spectrometry is used to obtain chemical fingerprints of metabolites in wood. The ENFORCE project has carried out more than 400 scientific services over three years (Figure 1).

The number of scientific services received increased strongly over the years, showing the impact as ENFORCE became better known amongst government instances, industry players, furniture retailers, research institutes, art galleries etc. The largest part of received requests originate from government instances and industry players (Figure 2), showing that ENFORCE reached its target audience in the context of international timber trade law. As expertise requests for furniture and materials such as plywood often include multiple species identifications, the number of wood identifications is a multitude of the number of scientific services.

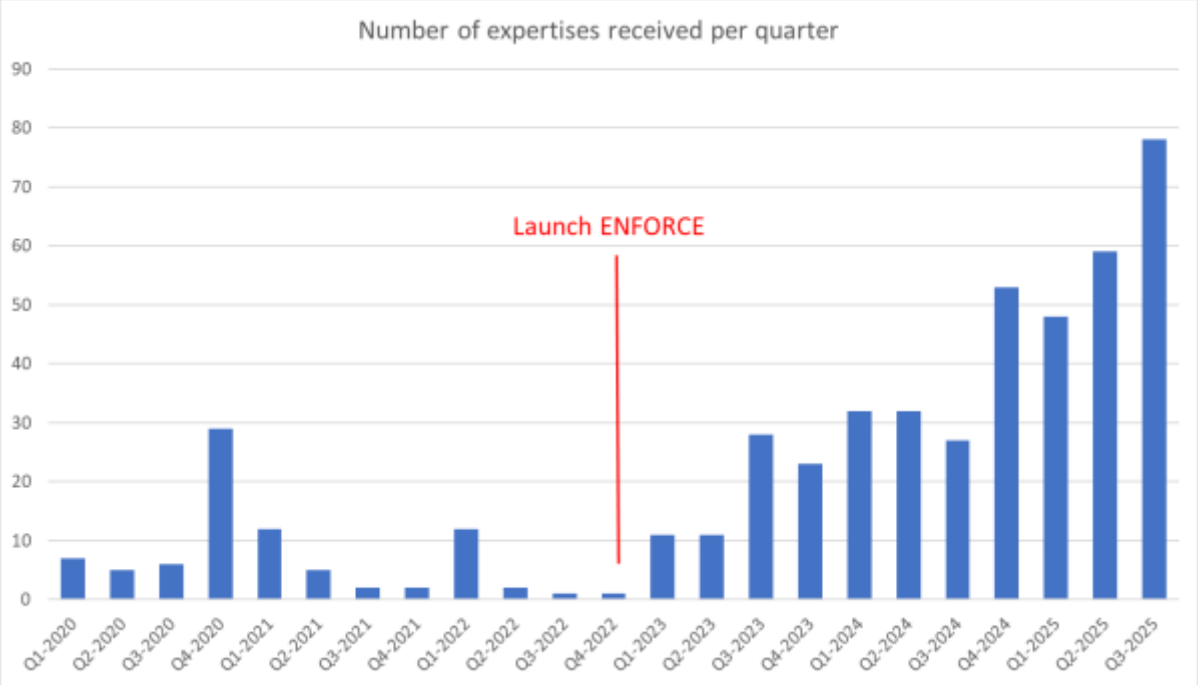

Figure 1: Number of expertise requests received per quarter by ENFORCE from 2020 to 2025. Previous to the launch of ENFORCE (November 2022), sporadic scientific services were already provided by the staff of the Service for Wood Biology (RMCA).

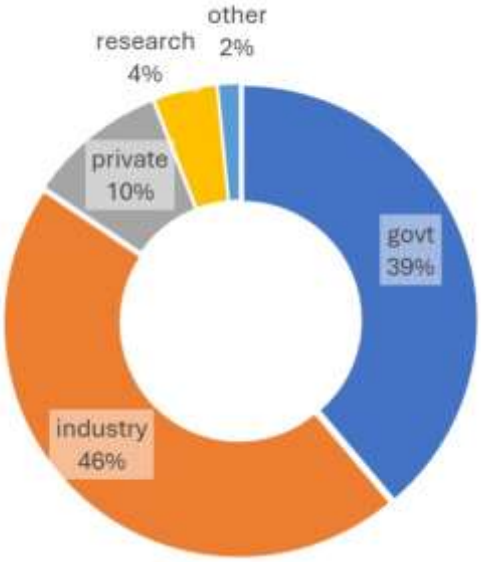

Figure 2: Source of the received expertise requests by ENFORCE (2022 – 2025)

A DART-TOF mass spectrometer was successfully installed in the lab of the Service for Wood Biology in the RMCA in January 2024. It aids greatly with the expertise results and is further being used to gather data for research topics (see below). A standardized protocol has been developed for routine use. The results show that DART-TOFMS is a valuable addition in the identification methodology, as in 61% of the scientific services where it was applicable (for instance the identification of solid wood and veneer samples) it either improved or confirmed the results from wood anatomy, giving the identifications significantly greater reliability.

The most important part of the scientific services is the determination and verification of wood species, for instance comparing declared information of species (composition) with the results of the identification. Scientific services included identification of CITES genera/species and their lookalikes, species listed on the European Council Regulation (EC) No 338/97, timber species verification in the context of EUTR/EUDR and dealt with both commercial and non-commercial species. The identifications were performed on a wide variety of wood-based materials, ranging from solid wood to particleboards and fibreboards (Figure 3). This variety increased significantly over the years, reflecting the importance of ENFORCE's capabilities of researching and analysing not just solid wood, but now also wood-based products. The project identified different types of errors, including different species, genera, families and incomplete claims.

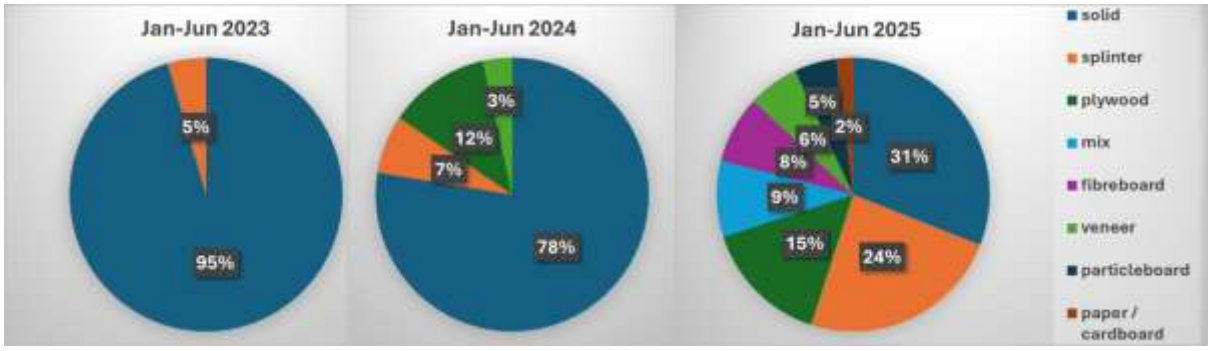

Figure 3: Type of expertise products analysed by ENFORCE over the first half of 2023, 2024 and 2025 for comparison.

A small number of scientific services concerned conflict timber from Eastern Europe. With the embargo on wood imports from the Russian Federation and Belarus, timber laboratories started receiving expertise requests to verify or determine the species and origin of either Eastern European or Russian timber imported in Belgium. These questions can be answered using the Stable Isotope Ratio Analysis (SIRA) methodology. A partnership between ENFORCE and World Forest ID was developed to successfully process these expertise requests. ENFORCE receives the samples for wood identification and sends subsamples to an external commercial lab for the SIRA measurements, while World Forest ID uses their extensive reference database to interpret the results. Completed and ongoing analysis of this type includes birch (*Betula* spp.) and pine (*Pinus* spp.) timber.

ENFORCE completed an additional specific expertise request from the Virginia Museum of Fine Arts for the identification of 500+ wooden art objects from Tanzanian origin curated by Marc Félix. Since a complete lab analysis of each of these objects was not feasible, a new methodology was developed to provide educated guesses and CITES verifications on the genus level for the objects.

The activities of ENFORCE were communicated to a larger public through its website, various conferences and news and magazine articles. An A1 scientific paper has been published in Annals of Forest Science (see dissemination and publications). A sample taking protocol was developed so that applicants can provide optimal samples for lab analysis at ENFORCE.

The activities of ENFORCE result in a number of recommendations to better tackle the illegal timber trade context described in the Introduction.

- The routine application of new methodologies (DART-TOFMS, SIRA, microscopic identification of macerations of wood-based products) is heavily reliant on the expansion of reference databases constructed from these techniques. Sampling campaigns, both in the Tervuren Xylarium and in the field are necessary to maximize the benefits of these methods to answer to expertise requests from for instance governmental agencies and industry players.
- The application of AI and machine learning in timber identification can accelerate the methodology of identification labs and make the monitoring of timber trade much more accessible to laymen, for instance for customs officers.
- A more developed network between timber identification laboratories facilitates more successful timber analysis, exemplified by the collaboration between ENFORCE and World Forest ID for wood identification and origin analysis.
- The management and daily operation of a timber identification lab depends completely on the continued presence of trained staff able to execute the developed methodologies and to innovate techniques for wood measurements and species identification through research. This requires budgets and recurrent funding to provide 1) species identification services, 2) new research project proposals, 3) dissemination via articles and scientific publications, 4) new and expanded databases for the identification techniques, 5) supervision of students and visiting research fellows, 6) literature and other information resources upon request, 7) the organisation of seminars, workshops and scientific meetings.

5. DISSEMINATION AND VALORISATION

The scientific services and scientific research performed under ENFORCE was valorised and transformed to public outreach with the following means.

- Website launch just after the kick-off of the forensic centre (https://enforce.africamuseum.be), with regular news updates.
- A follow-up committee was developed, with a very broad panel of stakeholders (from government up to NGO's, from the wood importer until the retailer so covering the whole supply chain). At the time of writing, this committee consisted of 70 members. By consulting them multiple times per year, ENFORCE kept track of evolutions, communicated new developments and was able to adapt research and scientific services to their needs. A total of 5 meetings (two online and three in-person) were held.
- ENFORCE participated in the Thunder Operation for 2024 by providing identification services for timber trade checks. Operation Thunder is an annual global initiative led by INTERPOL and the World Customs Organization to combat wildlife and timber trafficking. It brings together law enforcement agencies from numerous countries to coordinate efforts against illegal trade, including timber. The operation helps identify trafficking routes, expose document fraud, and disrupt criminal networks that blend illegal timber with legal shipments. By fostering international cooperation, Operation Thunder significantly enhances the detection and interception of illegal timber, contributing to the protection of threatened tree species and global forests.
- Policy support: ENFORCE provides policy support in terms of scientific advice and analysis of wood samples to the EUTR/EUDR- and CITES-teams at the FPS Environment. For this purpose, agreements are signed and the competent authorities can call upon the Service for Wood Biology at the RMCA for scientific and technical support.
- Thematic tours with a focus on timber were organized in the RMCA for various stakeholders.
- A tour and workshop for students was developed in collaboration with the educational service at the RMCA. This guided tour for TSO/BSO aims to educate future young professionals who will encounter the EU Deforestation Regulation (EUDR). It emphasizes that tropical wood is acceptable when used correctly and provides information about relevant regulations. The tour prepares future stakeholders for discussions and perceptions surrounding tropical wood and regulations, including the necessary paperwork and potential fraud they might encounter. It also highlights that ENFORCE can assist in uncovering the truth regarding compliance and legality. This educational initiative helps students understand the complexities of the timber industry, including sustainability practices, legal requirements, and the importance of due diligence in the global wood trade.
- List of participations to / hosting of congresses, visits, workshops and events:
    - 27/01/2023: First ENFORCE stakeholder / follow-up committee event (in-person)
    - 13/02/2023 - 17/02/2023: Workshop DART-TOFMS at Kew Gardens (London, UK). User training for DART-TOFMS analysis and visiting the Jodrell Laboratory.
    - 11/02/2023 – 25/02/2023: Workshop DART-TOFMS and visit to the U.S. Fish and Wildlife Forensic Lab in Ashland, Oregon (US).
    - 26/06/2023: Second ENFORCE stakeholder / follow-up committee event (online)
    - 13/09/2023: Presentation of the ENFORCE activities at an EUDR event in Brussel
    - 12/12/2023: Third ENFORCE stakeholder / follow-up committee event (online)

- 21/03/2024: Presentation of ENFORCE during an international meeting of WWF Europe in the Havenhuis with a joint visit to the customs and terminal.
- 04/2024 – 05/2024: Visit by the Director-General of the Federal Public Service for the Environment in preparation for the European summit held with the RMCA on the 22nd and 23rd of May 2024. The FPS Environment involved ENFORCE for the evening programme on 22 May (ENFORCE presentation, World Forest ID and a thematic tour of the museum).
- 23/04/2024: Guided tour within the Service for Wood Biology, presentation services ENFORCE and participation in panel discussion within BOS+'s Sustainable Wood Consumption project.
- 06/2024: Participation and presentation of the activities of ENFORCE through oral and poster presentations at IUFRO Stockholm (https://iufro2024.com/).
- 04/07/2024: Participation of ENFORCE to the Hout & Bast Club at SHR (Wageningen). This event is a gathering of Dutch-speaking wood researchers to share knowledge and learn about developments in the field.
- 11/09/2024 - 12/09/2024: Participation and presentation of ENFORCE at the first EU Wildlife Forensic Conference in Prague (https://forensics.natur.cuni.cz/en/eu-wildlife-forensic-conference-3/).
- 20/12/2024: Fourth ENFORCE stakeholder / follow-up committee event (in-person)
- 08/01/2025: Study visit of Liège University and Howest students in applied forensic sciences.
- 09/04/2025: Visit of the UNODC Brazil delegation for the LEAP (Law Enforcement Assistance Programme to Reduce Tropical Deforestation) project, in the context of illegal wood under CITES.
- 04/07/2025: Hout & Bastclub: meeting of wood researches (anatomists, technology researchers, archaeologists etc.) from the Netherlands and Belgium.
- 25/09/2025: Fifth ENFORCE stakeholder / follow-up committee event (in-person)
- 04/12/2025: Study visit of the UNODC Asia delegation in context of illegal wood under CITES.

6. PUBLICATIONS

List of publications:

- 12/2022: A first article on the kick-off of ENFORCE in popular press was published at the end of 2022 in Bosrevue (BOS+) (https://bosplus.be/bosrevue/bosactua-oprichting-forensisch-expertisecentrum-enforce/).
- Website launch just after the kick-off of the forensic centre (https://enforce.africamuseum.be). The website contains all useful information for expertise requests as well as regular news updates and contextual information.
- 09/2023: Communication in the ATIBT-newsletter, one of the biggest associations of companies working with tropical timber. (https://www.atibt.org/en/news/13373/enforce-a-new-belgian-center-of-knowledge-on-timber-identification).
- 03/2024: EOS Wetenschap article: “Illegaal hout onderscheppen: waarom is dat zo moeilijk?” (https://www.eoswetenschap.eu/natuur-milieu/illegaal-hout-onderscheppen-waarom-dat-zo-moeilijk).
- 05/2024: Article on the science news section of the RMCA website concerning 50 years of CITES-administration in Belgium and the role of ENFORCE and the RMCA in this context. (https://www.africamuseum.be/nl/research/news/woodresearch).
- 06/2024: Poster and oral presentations at the international IUFRO conference in Stockholm, one of the largest forest research conferences worldwide.
- HoutBedrijf Q4 2024 edition: presentation of ENFORCE in the quarterly magazine of the Belgian timber industry.
- 24/11/2025: A1-article published: “Combining wood anatomy and chemical fingerprinting maximizes tropical timber identification success”. The article 1) evaluates the performance of the individual and joint application of the two timber identification methods utilized by ENFORCE on a set of timber samples originating from the Central African tropical forests (DRC) and 2) conducts market research by verifying the correct identity of these timber samples sold on local DRC markets. Link: https://doi.org/10.1186/s13595-025-01317-3

7. ACKNOWLEDGEMENTS

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