ANEXO A

PROJECT PROPOSAL TO THE
Convention on International Trade in Endangered Species (CITES):
"Supporting sustainable management of endangered tree species"[1]

Submitted by: Brazilian Institute of Environmental and Natural Renewable Resources (**IBAMA)**
Management Authority CITES

TITLE of Proposed Activity: ***Rapid-Field Identification of Dalbergia Woods and Rosewood Oil by NIRS Technology***

SUMMARY The main objective of this project is the expansion of the use of NIRS Technology to between two forest products: *Dalbergia* wood species and rosewood oil in field conditions. Therefore, this project, which will directly contribute to the expected output of the CITES Tree Species Programme, is part of a long-term research project for the development of a user-friendly, rapid, powerful, non-destructive, cost-effective, reliable prediction methodology for wood identification which could be used by environmental enforcement agents at checkpoints. Near-infrared spectroscopy (NIRS) has already proven to be an effective, field-portable wood identification tool for some woods but has not yet been tested for *Dalbergia* wood species and rosewood oil (*Aniba roseodora*). Expanding the project funded by the ITTO-CITES Program for other timber-producing species, this project has the goal of 1) examining the feasibility of discrimination between *Dalbergia* spp. (CITES Appendix II); and 2) conducting an exploratory analysis of Brazilian rosewood oil (CITES Appendix II) using NIRS technology, at the request of the Brazilian CITES Authority, the Brazilian Institute of Environmental and Renewable Natural Resources (IBAMA). Outputs and specific Activities will include: gathering sample spectra in international and national xyloria, building and validating the discrimination models for at least 20 *Dalbergia species* (CITES Appendix II), including three native *Dalbergia* species collected in Brasília's Savanna; training of 10 Brazilian environmental agents and a Guatemalan student in NIRS technology and verifying the feasibility of discrimination of rosewood oil using NIRS Technology. The use of NIRS identification models is feasible to export to multiply its application, for its reasonable cost equipment, field mobility and easiness of training forest agents.

EXECUTING / IMPLEMENTING AGENCY(IES): Forest Products Laboratory (LPF/SFB)

COLLABORATING AGENCY: University of Brasília – UnB/Instituto de Química – IQ; Campus Universitário Darcy Ribeiro**,** CEP 70910-900 Brasília, DF

DURATION (months): 24 months
PROPOSED START DATE: March 1st, 2019

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PART I: CONTEXT

Origin/Background

This project is part of a long-term research project for the development of a user-friendly portable device for wood identification to be used in the field conditions by environmental enforcement agents. It was started at the Forest Products Laboratory (LPF/SFB) by Dr. Tereza C. M. Pastore and Dr. Vera T. R. Coradin. Posteriorly, Dr Jez W. B. Braga from the University of Brasília joined the team. Since 2006, LPF/SFB has been researching the technique of near infrared spectroscopy (NIRS) associated with multivariate analysis, named NIRS Technology.

A broad spectrum of public (CNPq, CAPES, FAP/D, INCTBio) and private (IAWA/WRI/GNTT) sources has supported this research program. Since 2014, principal funding has been provided by the ITTO-CITES Program. Infrastructural support in Acre state has been provided by the timber export company Agrocortex (Rui P. Ribeiro, Luiz Rogério de Oliveira) and, in Madison by the USDA/Forest Products Laboratory (Dr. Alex Widenhoeft). During the mission in Guatemala, our team received support from CONAP (Eng. César Beltetón), USAC (Prof. Myrna Herrera), and the FNPV (Mr. Abimael Renoso). In Bolivia, we are very thankful to CFB (Eng. Jorge Avila) and the IBIF (Dr. Nataly Ascarrunz). Dr. Fabrice Davrieux of CIRAD/Montpellier kindly offered training in NIRS and chemometrics, in 2011.

The pioneering work was to classify native look-alike wood species: *Swietenia macrophylla* King. (mahogany) - a CITES Appendix II species - from *Carapa guianensis* Aubl. (crabwood or andiroba), *Cedrela odorata* L. (cedar) – a CITES Appendix III species - and *Micropholis melinoniana* Pierre (curupixá). At first, all tests were made using benchtop equipment and grounded wood (Pastore *et al.*, 2011) and in the next step boards were used (Braga *et al.* 2011). Later on, it was verified that the wood collected from the trunk and branches of a single mahogany tree were chemically different. Other articles from our team refer to assessment of total phenols and extractives of mahogany wood (Silva *et al.* 2013), the robustness of the NIRS identification of mahogany from 27 countries (Bergo *et al.* 2016), and the evaluation of a NIRS handheld device for big-leaf mahogany and similar wood discrimination (Soares *et al.* 2017). Please, see References forward.

The main goal of the first project funded by ITTO-CITES Program was to lead a successful timber identification method from laboratory conditions to field conditions, evaluating the viability factors, time, and adverse eventualities. The performance of two portable devices was tested in the five field missions realized. Both devices generated two main sets of models. The first set of models discriminates mahogany dry wood from three anatomically similar Brazilian wood species. With the second set of models it was possible to identify the mahogany producer country: Bolivia, Brazil, Guatemala, Mexico, and Peru. After completion of the project, the following principal results were reached: *NIRS Technology is recognized as a promising tool for wood identification* as NIRS Technology was included in the "Best practice guide on forensic

timber identification" book, published by the United Nations Office on Drugs and Crime – UNODC/UNO. Another highlight is the recognition that NIRS Technology is a tool for identification of native timber's geographical origin. The mahogany wood collected in five Latin America countries were well classified according the geographical origin presenting a highly correct classification rate ranging from 89.1 to 100% (Silva et al. 2018).

This study intends to expand the efficacy of hand-held NIRS Technology in order to discriminate the spectra of some high-value *Dalbergia* wood species, all of which are listed on CITES Appendix II. *CITES lists 58 protected Dalbergia species, of which 51 are endemic to Madagascar, one is from Indochina and the remaining six are from Central and South America.* Brazil is home of the rare *Dalbergia nigra* (Vell.) Benth. and other *Dalbergia* species. *D. nigra*, also known as Brazilian rosewood, jacarandá-da-Bahia, caviúna, palisandre and jaracandá-preto, was widely used for furniture and musical instruments, but it has been overexploited, leading to listing on Appendix I of the CITES, the first tree species ever included in this Appendix (CITES 1992). In an effort to improve global protection for the genus, and recognition of the difficulty in identifying *Dalbergia* woods at the species level, all species of *Dalbergia* were included in CITES Appendix II except *D. nigra*, which remained in Appendix I (CITES 2017).

The most demanding problem in Brazil is a definitive identification of *Dalbergia* genus since *D. spruceana*, a look-alike species of *D. nigra*, occurs in the Amazonian Forest. Currently in Brazil, enforcement agents use the conventional method of describing and comparing anatomical characters to identify woods. Sometimes electronic keys are used to help solving cases that are more difficult. This method requires a skilled wood anatomist (due to the great diversity of species), and there are not professionals to meet the demand. Additionally, this analysis is subjective and depends on the knowledge and experience of the professional. Alternative physicochemical methods such as fluorescence and basic density were developed to differentiate *D. nigra* and *D. spruceana*. However, both are non-conclusive. Fluorescence may or may not occur in a particular species and the proximity of the basic densities values of these two woods, associated to the 10% variation error for tropical species, makes this method difficult to apply.

NIRS technology is defined as the association of near-infrared spectroscopy associated with statistical analysis. Experimentally we obtain spectra of 20 wood samples identified by a botanist, which are analyzed using multivariate analysis. The discrimination models are built with two complementary steps: the training and the validation activities. To discriminate five similar species, it is necessary to construct five different models, one for each species studied.

NIRS technology demands a large number of wood samples (minimum of 20), taken from the core of different tree trunks and with no apparent defects in order to construct a reliable discrimination model. The strategy of visiting the Madison xylarium and obtaining sample spectra, during the execution of the first project, brought significantly faster results reducing costs. This was possible because two steps of the whole process of constructing the

discrimination model were eliminated: 1) species identification by botanist and 2) gathering enough samples species. Thus, the geographic coverage of this project and the number of species studied are extremely dependent on variables that are not known precisely yet.

NIRS's excellence in wood identification technology from our team can also be extended to identify any type of organic material including essential oils. At the request of the Brazilian Cites Authority hosted by the Brazilian Institute of Environment and Natural Renewable Resources (IBAMA), the LPF/SFB have accepted the task of carrying out exploratory studies on the identification of *Aniba rosaeodora* Ducke or rosewood (pau-rosa) oil (CITES- Appendix II) since our country is considered to be the only producer in the world and the LPF also has some experience in this subject. (Moreira, 2017).

PART II: THE PROJECT

1. Project Goal and Objectives

The general objective of this project is to verify the feasibility of the use of NIRS technology for field identification of 20 *Dalbergia* wood species and rosewood oil to ensure that the international trade meets CITES' requirements for their sustainable management and conservation of the species.

The specific objectives are:

Objective 1 Build NIRS models using portable devices for identification/classification of *20 Dalbergia species* - CITES Appendix II and test them in field conditions;

Objective 2 Perform an exploratory NIRS identification model for rosewood oil (*Aniba rosaeodora*) - CITES Appendix II and test it in field conditions.

To our knowledge, there is no research project for any of these goals. See Annex 4 for a list of technical publications published in internationally recognized scientific magazines from the research conducted so far.

2. Justification

In order to comply with the law, enforcement agents around the world face a hard task: arresting illegal timber products and prosecuting illegal logging offenses, without having the means to identify timber with acceptable certainty. There is a necessity to develop tools to deal with different situations: screening suspect material and identifying final timber. The current identification method employed requires an expert wood anatomist and there are not enough professionals to meet the present demand. Several methodologies are being studied in an attempt

to find the most suitable tool capable of identifying specimens in species level quickly and in situ. NIRS technology is proving to be a suitable tool to be used in the field because it meets essential requirements such as: speed, precision, accuracy, robustness, reliability, and results in real time in the process of identifying wood. Our team has already presented to the public, a model for the identification of Swietenia macrophylla and five similar woods, in dry condition, using portable equipment (Soares et al, 2017). The spectrometer weighs 1.2 kg and is simple to manipulate.

NIRS technology relies on a large number of wood samples taken from different trees for a minimum of twenty samples to build a reliable discrimination model. In addition, it is necessary that the samples have been taken from the core, are dry (moisture between 10-15%) and in good condition (not attacked by xylophagous organisms). Therefore, the geographic coverage of this project and the number of species studied are extremely dependent on all these variables.

This project intends to make the at least 20 identification models of *Dalbergia* species originated in different regions of the world and covering a larger number of specimens, including the Brazilian *D. nigra* and *D. spruceana*. Considering that some species of *Dalbergia* are almost extinct and have very controlled international trade, visits to registered wood collections (xylaria) have proved to be an excellent strategy for obtaining wood spectra, saving time and resources. As the most time-consuming phase of NIRS technology has been to obtain a large number of required samples (at least 20 different trees) to construct robust identification models, the fact of bringing only the spectra to be processed and not wood samples to Brazil will enable to achieve the main objective of this project.

Visits to major international and national xyloria were included in the project for setting up a spectrum bank of the largest number of Dalbergia species as possible. The visit to xyloriyum in China is justified, since it concentrates a great diversity of species of Dalbergia produced in Asia (IAWA Index Xylarium 2016). At present, the number of Dalbergia identification models that will be constructed is not possible to accurately predict, since it depends on the number of suitable samples to obtain the spectra found for each of these species. A model will be build for each species that presents a minimum set of 20 different samples from which spectra can be obtained.

The development of a quick methodology to be used in the field for rosewood oil (Aniba roseodora) identification is a direct demand from the Brazilian Institute for the Environment and the Natural Resources - IBAMA to the LPF. Brazil is an almost exclusive producer of oil extracted from Aniba roseodora Ducke, called rosewood oil. It is one of the most valuable essential oil in international trade. In spite of this, the available methods of chemical analysis of the essential oil of rosewood remain time consuming, expensive and restricted to very specialized laboratories. NIRS spectroscopy has been successfully demonstrated to be effective in the identification of various plant essential oils, including oils from basil, chamomile, oregano, and copaiba. Therefore, the second specific aim of this project is to verify the viability of NIRS Technology to be used to identify rosewood oil at checkpoints.

2.1 Problems to be addressed

a. In order to comply with the law, enforcement agents around the world face a hard task: arresting illegal timber products and prosecuting illegal logging offenses without having the means to identify timber with acceptable certainty. There is a necessity to develop tools to deal with different situations: screening suspect material and identifying final timber. The current identification method employed requires an expert wood anatomist and there are not enough professionals to meet the present demand. Some methodologies are being studied in an attempt to find the most suitable tool capable of identifying specimens in species level quickly and *in situ*. For solving that cases, NIRS Technology is proving to be a suitable tool to be used in the field because it meets essential requirements such as: speed, precision, accuracy, robustness, reliability, and results in real time in the process of identifying wood.
b. Brazil is home to *D. nigra* and 39 other species from the *Dalbergia* genus, including trees, shrubs, and vines. *D. nigra* was the first tree species ever included in the Cites - Appendix I, though other *Dalbergia* species were listed in CITES Appendix II. The most demanding problem in Brazil is a definitive identification of species at checkpoints since *D. spruceana,* a look-alike species, also occurs in this country. This project intends to make the identification models of *Dalbergia nigra* and *Dalbergia* spp woods (Appendix I and II of CITES) more robust, covering a larger number of specimens and species from Brazil and other countries.
c. The development of a quick methodology to be used in the field for rosewood oil *(Aniba roseodora*) identification is a direct demand from the Brazilian Institute for the Environment and the Natural Resources - IBAMA to the Forest Products Laboratory. Brazil is an almost exclusive producer of the oil extracted from *Aniba roseodora* Ducke, called rosewood oil. It is one of the most valuable essential oils in international trade and was commercialized at the most as early as the 1980s. In spite of this, the available methods of chemical analysis of the essential oil of rosewood remain time consuming, expensive and restricted to very specialized laboratories. On the other hand, NIRS spectroscopy has also been successfully demonstrated to be effective in the identification of various plant essential oils, including oils from basil, chamomile, oregano, and copaíba. The latter was also developed by the LPF and UnB cooperation. (Moreira, 2017). Therefore, this project aims to verify the viability of NIRS Technology to be used to identify pure rosewood oil and adulterations at checkpoints.

2.2 Intended situation after Project completion

The products that will be developed in this project, will primarily favor the sustainability and legal character of trade in CITES-related products of species. In addition, they will also help countries achieve sustainable development goals by improving the technological capacity of the entire wood production chain, strengthening permanent forest maintenance, and promoting sustainable forest management.

After the completion of the project, we will put into the public domain, through scientific and

technical publications, as well as training of environmental agents, the complete methodology for identifying a high value tropical timber species still available in nature: at least 20 Dalbergia species and rosewood oil using a portable device that will allow the analysis to be carried out in field conditions, at the checkpoints, ports, etc. At present, the other methodologies available to assist conventional wood anatomy such as mass spectroscopy, stable isotopes, radiation, and DNA analysis need to be done under laboratory conditions, what prevent them to be of practical value. To our knowledge, only NIRS technology can be used at inspection sites, providing the result in real time. It is therefore an ideal tool to do screening analysis.

In Brazil, the NIRS technology for discrimination of mahogany in dry conditions needs to be tested in real field operations, right after the harvesting of the tree until the shipment of the wood in the port, as proposed in a project submitted to CITES. After these tests, it will be possible to propose an expansion. The Brazilian Government has recently acquired two NIRS portable devices to further implement mahogany identification under practical field conditions.

The cost of any technological analyses can be considered high in its development stage is normal for any field. However, after its development and its implementation in field, the cost of each analysis could drop to about 50% of the cost of conventional chemical analysis. Since NIRS Technology can be expanded to other CITES timbers, which are difficult to identify visually, the final price of the entire analysis would be dropped.

If the exploratory analysis of rosewood oil identification is successful, we will have some other benefits involving native communities.

In addition, all information will be disseminated through training courses and extension work for enforcement agents. Ten technicians of enforcement agency using the NIRS tool for forest products identification will be trained.

Additionally, opportunities will be created for students to develop MSc dissertations with endangered species as a central subject.

2.3 Target beneficiaries

The principal beneficiaries of the implementation of NIRS technology for wood and rosewood oil identification will be:

2.3.1 Member countries of CITES - having designed *Dalbergia* wood species and rosewood oil as Appendix II, the CITES apparatus must establish and disseminate basic technical parameters for the wood identification to the Scientific Authorities. Additionally, this project can provide technical support to the Management and Scientific Authorities as Dr. Tereza Pastore had already contributed to Working Group on the Mahogany and Plants of IBAMA, in 2015.

2.3.2 Forest managers and the forest products industry involved in the extraction, transport, and commercialization of wood species listed by CITES.

2.3.3 Federal and states government institutions which are responsible for the regulation and the conservation of natural reserves especially CITES Management and Scientific Authorities;

2.3.4 Federal Police and Highway Patrol engaged in combatting illegal logging;

2.3.5 Timber certification organizations;

2.3.6 Researchers interested in the technique identification of other wood species;

2.3.7 Manufacturers of NIRS equipment;

2.3.8 Students can benefit by engaging themselves on working with project experiments leading to academic works.

2.3.9 Small communities may cultivate plantations of rosewood and extract the oil from the branches and leaves of trees in a sustainable manner, with low environmental impact and excellent profitability.

2.4 Risks

2.4.1 The Regional Coordination Program does not get permission from some xyloria curators, so that the team cannot develop the mission of obtaining the NIR spectra of woods. To minimize this risk, xylorium from different countries should be contacted in advance. In addition, some spare wood collections should be included in the list of institutions to be visited.

2.4.2 The number of samples necessary to develop a robust model for determined wood species or for the rosewood oil discrimination could be not sufficient. Additionally, obtaining reference samples in great variability and in good physical conditions is crucial for this project and it is the most time-consuming step. Some actions should be taken to minimize this risk: rosewood oil's producer industries and small Amazon producing communities should be contacted in advance. For the case of wood, specifically, to check the number of species available in the database that the large xyloria usually maintains is a preventive action.

2.4.3 There is also the risk of the portable NIRS device breaking down during a mission. To mitigate this risk, two portable instruments are being purchased by the Forest Products Laboratory to perform the experimental procedures during the field missions.

2.4.4 Liberation of funds according to the schedule is also important in order to avoid delays in the activities.

3 Materials and Methods

3.1 Samples and surface preparation: the samples that will be used in this project are part of the collection of some international or national IAWA registered xylaria: Royal Botanic Garden Kew (K-Jw) (London/England); Smithsonian (USw) (Washington/USA); Montpellier (CTFw) or

Hamburg RBHw); and People's Republic of China, Botanic Garden (R-BW) (Rio de Janeiro); IPT (BCTw) (São Paulo); INPA (INPAw) (Manaus), and Belém (RBHw). Samples taken from the heart of *Dalbergia*, in the tangential or radial directions, without any visual defect, will have one surface sanded with sandpaper n.80 and the powder removed with a brush.

3.2 Near- infrared spectra (NIR): The diffuse reflectance spectra will be collected using handheld device Microphazir RX Analyzer (Thermo Scientific, Boston, MA, USA) with 8.7 nm resolution and spectral range of 1,595-2,396 nm. The background of instrument will be obtained based on the polytetrafluoroethylene standards provided by the instrument manufacturers. Three spectra will be obtained per sample, taken in different points.

3.3 Spectral processing and data analysis: Data analysis and spectral processing will be carried out using MATLAB 7.14 (R2012a) software with PLS toolbox 7.03. The baseline shifts and other instrumental variations will be corrected by choosing the most appropriated preprocessing set up. The dataset will be divided into training and validation sets, containing two-third and one- third of the total samples, respectively. All replicates of sample will be included in the specific set in the course of the assignment process.

3.4 Two classification statistical–models will be applied on spectra databank to build the Dalbergia woods discrimination models: Soft independent modeling of class analogy (SIMCA) and PLS-discriminant analysis (PLS-DA).

3.5. Figures of merit: the performance of both SIMCA and PLS-DA models will be evaluated via the determination of the figures of merit.

4 Outputs

4.1 ***Objective 1*** Build NIRS models using portable devices for identification/classification of *20 Dalbergia* species - CITES Appendix II and test them in field conditions.

Output 1.1 NIR spectra of *Dalbergia* species obtained in international xyloria.

Output 1.2 NIR spectra of *Dalbergia* species obtained in national xyloria.

Output 1.3 Three *Dalbergia* species collected in Brasília's Savanna and NIR spectra of their wood obtained.

Output 1.4 *Dalbergia* models of discrimination constructed, tested and validated, and tested in field situation.

Output 1.5 Four university students trained and one Junior researcher trained.

Output 1.6 Project results, guideline for NIRS analysis for *Dalbergia* discrimination published and a demonstration video produced.

Output 1.7 Ten executive agency technicians trained in identifying wood with NIRS Technology.

4.2 ***Objective 2*** Perform an exploratory NIRS identification model for rosewood oil (*Aniba rosaeodora*) - CITES Appendix II and test it in field conditions.

Output 2.1 About 40 rosewood oil samples or more collected in the Amazon state's communities and at industries for the construction of the databank.

Output 2.2 Rosewood oil discrimination model built, tested, validated, and checked in field situation.

Output 2.3 Two university students trained.

Output 2.4 Project results published.

5 Activities

Main objectives - The objective of this research project is to establish a reliable and rapid tool for timber and oil identifications based on NIRS Technology. Under this objective, two outcomes are expected, both using the same chemical analytical methodology:

5.1

Output 1.1 NIR spectra of *Dalbergia* species obtained in international xyloria.

- ***Activity 1.1.1.*** Collect *Dalbergia* spectra in Royal Botanic Gardens Kew (K-Jw) (London/England); Smithsonian (USw) (Washington/USA); Montpellier (CTFw) or Hamburg (RBHw) xylorium, and People's Republic of China xyloria. In addition to the *Dalbergia* species, spectra from woods that exhibit visual similarities and are often confused with that genus could be collected as well.

Output 1.2 NIR spectra of *Dalbergia* species obtained in national xyloria.

- ***Activity 1.2.1.*** Collect *Dalbergia* sample spectra in Botanic Garden (R-Bw) (Rio de Janeiro); IPT (BCTw) (São Paulo); INPA (INPAw) (Manaus), and Belém (RBHw) (Pará) xyloria. In addition, spectra from woods that exhibit visual similarities and are often confused with that genus could be collected.

Output 1.3 Three *Dalbergia* species collected in Brasília's Savanna and NIR spectra of their wood obtained.

- ***Activity 1.3.1*** Promote the collecting of botanical material and wood of the three *Dalbergia* genera, occurring in Brasília's Savanna with the objective of the samples becoming reference material in the Laboratory of Forest Products (Brasília), Royal Botanic Gardens (England) and the University of Brasília (Brasília) xylaria.

Output 1.4 *Dalbergia* models of discrimination constructed, tested and validated, and tested in field situation.

- ***Activity 1.4.1*** 20 individual models for each studied *Dalbergia* species will be built, tested, validated, and tested in field situation.

- ***Activity 1.4.2*** Five individual models of *Dalbergia* species will be tested in field situation.

Output 1.5 Four university students and one Junior researcher trained.

Activity 1.5.1 Training of three Brazilian university students**.**

Activity 1.5.2 Training of one Guatemalan university student.

Activity 1.5.3 Training of one local Junior researcher.

Output 1.6 Project results, guideline for NIRS analysis for *Dalbergia* discrimination published and a demonstration video produced

- ***Activity 1.6.1*** At least 1 paper will be published in international magazines within the project's activities.
- ***Activity 1.6.2*** Production of a video demonstrating how to use NIRS Technology for wood identification.

Output 1.7 *Ten executive agency technicians trained in identifying wood with NIRS technology*

- ***Activity 1.7.1*** Carry out a training course for 10 technicians on how to use the NIRS device, obtain the spectra and identify the wood in both laboratory and field conditions.

5.2

Output 2.1 About 40 rosewood oil samples or more collected in the Amazon state's communities and at industries for the construction of the databank.

- ***Activity 2.1.1***. Selection of production sites of rosewood oil to be visited to collect samples. Industrial and artisanal producers (small forest communities) will be included. French Guiana can be included in the list of visited places.
- ***Activity 2.1.2***. Promote a meeting between the producers of rosewood oil (extractive and industrial) and the coordination of the project with the support of the Brazilian CITES in Maués, state of Amazonas in order to disseminate the project and verify the possibilities of collecting the samples of rosewood oil.
- ***Activity 2.1.3*** Sampling about 40 samples from different sources or batches of rosewood oil at the selected places.

Output 2.2 Rosewood oil discrimination model built, tested, validated, and checked in field situation.

- ***Activity 2.2.1*** Obtaining sample spectra of the rosewood oil.
- ***Activity 2.2.2*** Building the database and the discrimination model for rosewood oil**.** A model for discrimination of pure rosewood oil and adulterated oil will be built, validated, and tested.

- ***Activity 2.2.3*** Perform at least one field test at the producer industries using the developed models for rosewood oil.

Output 2.3 Two university students trained.

- ***Activity 2.3.1*** One final course work is expected to be produced**.**

Output 2.4 Research findings published in scientific and technical journals covering basic and applied topics.

- ***Activity 2.4.1*** At least 1 paper will be published in international magazines within the project's activities.

6. Work Plan

The Work Plan is presented in **Annex 1**.

7. Budget

7.1 Total Budget by Activity is presented in **Annex 2**.
7.2 Project Budge by Source is presented in **Annex 3**.

8 Sustainability of Outputs after Project Completion

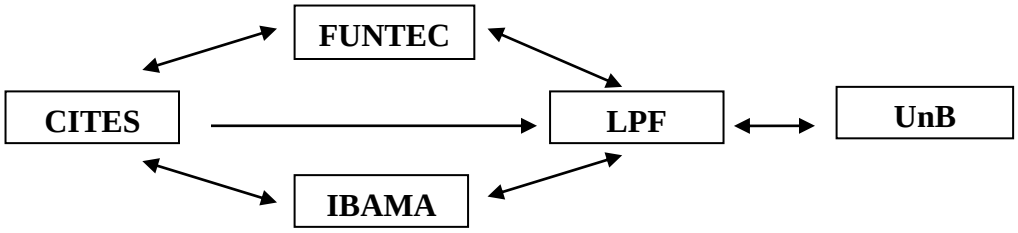
This project follows a research line of about twelve years, and its sustainability after completion can be considered high due to its applicability in field conditions. This applicable perspective is being constructed based on reliable scientific developments, reflected by the various papers published in international specialized magazines by the team.

The project impact on the forestry sector in the near future can be better understood considering the training of 75 environmental government agents planned with an assured budget, to happen in the next three semesters. These activities intend to spread the NIRS technology developed by the former projects focusing on mahogany and similar wood species. Two new portable devices were recently acquired by the Forest Products Laboratory/BFS to support these and other extension actions.

The organization of the well-known International IUFRO Conference, to be hosted in Brazil in 2019, suggested to the project coordination to hold a specialized roundtable on the NIRS forestry utilization, what is now under consideration, but this possibility is already another aspect of the project continuity.

PART III: OPERATIONAL ARRANGEMENTS

1. Management Structure



CITES – CITES Tree species Programme - Coordinator

IBAMA - Brazilian Institute of Environment and Renewable Natural Resources - as CITES Management Authority is responsible for inducing the demand and submitting the project, to bring and carry out the requests of the CITES Regional Coordination and to assist it in the supervision of the execution of the Project.

FUNTEC-DF – Foundation for supporting teaching, research and extension in Forest Technology and Geoprocessing, which will be in charge of managing project funds and providing logistic support for research activities regarding the project.

LPF - Forest Products Laboratory of the Brazilian Forest Service will provide project coordinator and researchers for implementing and monitoring research work. It will also provide premises, laboratories and support for analyzing data to producing project reports.

UnB – The University of Brasília will provide researchers in the areas of Chemometrics and Wood Anatomy, students, laboratories and all support for data analysis and construction of models of discrimination of wood.

2. Monitoring, Reporting, and Evaluation

(a) **Project Progress Reports** – short monthly project reports will be prepared as indicate in the project format.

(b) **Project Completion Report –** a final report will be submitted within two months of Project completion according to the project format

RESEARCH TEAM:

1. Dr. Tereza C. M. Pastore - Researcher and Project Coordinator.
2. Prof. Dr. Jez W. B. Braga - Researcher and Chemometrician - Institute of Chemistry (University of Brasília)
3. Dr. Vera T. R. Coradin - consultant of wood anatomy and morphology.
4. Dr. Paulo J. P. de Fontes - SFB/LPF, Researcher
5. Dr. Peter Gasson – Royal Botanic Garden, Researcher
6. Prof. Dr. Julia S. Oliveira - Wood anatomist, Botanic Institute (University of Brasília)

7. Prof. Dr. Floriano Pastore Jr - Researcher, non-timber products and Amazonian's communities specialist - Institute of Chemistry (University of Brasília)
8. Dr. Fernanda P. Pieruzzi - SFB/LPF, Researcher
9. MSc. Alexandre Bahia Gontijo - SFB/LPF, Researcher
10. MSc. Alessandro C. de O. Moreira - SFB/LPF, Researcher
11. MSc. Lúcia F. A. Garcia - SFB/LPF, Researcher
12. Liz F. Soares - MSc student
13. Diego C. da Silva - MSc student
14. Filipe Snel - MSc student

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Annex 1

WORK PLAN

OUTPUTS/ ACTIVITIES	Responsible party	SCHEDULE (months)																							
		Year I												Year II											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Output 1.1: NIR spectra of *Dalbergia* species obtained in international xyloria.																									
Activity 1.1.1: Collect *Dalbergia* spectra in Royal Botanic Gardens Kew (K-Jw) (London/England); Smithsonian (USw) (Washington/USA); Montpellier (CTFw) or Hamburg (RBHw) xylorium, and People's Republic of China xyloria.	coordinator																								
Output 1.2: NIR spectra of *Dalbergia* species obtained in national xyloria																									
Activity 1.2.1*:* Collect Dalbergia sample spectra in Botanic Garden (R-Bw) (Rio de Janeiro); IPT (BCTw) (São Paulo); INPA (INPAw) (Manaus), and Belém (RBHw) (Pará) xyloria.	coordinator																								
Output 1.3: Three *Dalbergia* species collected in Brasília's Savanna and NIR spectra of their wood obtained.																									
Activity 1.3.1: Promote the collecting of botanical material and wood of the three Dalbergia genera, occurring in Brasília's cerrado with the objective of the samples becoming reference material in the Laboratory of Forest Products (Brasília), Royal Botanic Gardens (England) and the University of Brasília (Brasilia) xylaria.	coordinator																								
Output 1.4: Dalbergia models of discrimination constructed, tested and validated, and tested in field situation.																									
Activity 1.4.1 20 individual models for each studied Dalbergia species will be built tested and validated.	coordinator																								
Activity 1.4.2 Five individual models of Dalbergia species will be tested in field situation.	coordinator																								
Output 1.5 Four university students and one Junior researcher trained.																									
Activity 1.5.1 Training of three Brazilian university students.	coordinator																								

OUTPUTS/ ACTIVITIES	Responsible party	SCHEDULE (months)																							
		Year I												Year II											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Activity 1.5.2. Training of Guatemalan graduate student	coordinator																								
Activity 1.5.3. Training of one local Junior researcher	coordinator																								
Output 1.6 Project results, guideline for NIRS analysis for Dalbergia discrimination published and a demonstration video produced.																									
Activity 1.6.1 At least 1 paper will be published in international magazines within the project's activities.	coordinator																								
Activity 1.6.2 Production of a video demonstrating how to use NIRS Technology for wood identification																									
Output 1.7 Ten executive agency technicians trained in identifying wood with NIRS technology.																									
Activity 1.7.1 Carry out a training course for 10 technicians on how to use the NIRS device, obtain the spectra and identify the wood in both laboratory and field.	coordinator																								
Output 2.1 About 40 rosewood oil samples or more collected in the Amazon state's communities and at industries for the construction of the databank.																									
Activity 2.1.1 Selection of production sites of rosewood oil to be visited to collect samples. Industrial and artisanal producers will be included.	coordinator																								
Activity 2.1.2 Promote a meeting between the producers of rosewood oil and the coordination of the project with the support of the Brazilian CITES in Maués, state of Amazonas.	coordinator																								
Activity 2.1.3 Sampling about 40 samples from different sources or batches of rosewood oil at the selected places.	coordinator																								
Output 2.2 Rosewood oil discrimination model built, testes, validated and checked in field situation.																									

OUTPUTS/ ACTIVITIES	Responsible party	SCHEDULE (months)																							
		Year I												Year II											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Activity 2.2.1 Obtaining sample spectra of the rosewood oil.	coordinator																								
Activity 2.2.2 Building the database and the discrimination model for rosewood oil. A model for discrimination of pure rosewood oil and adulterated oil will be built, validated, and tested.	coordinator																								
Activity 2.2.3 Perform at least 1 field tests at the producer industries using the developed models for rosewood oil.	coordinator																								
Output 2.3 Two university students trained.																									
Activity 2.3.1 One final-course work is expected to be produced.	coordinator																								
Output 2.4 Research findings published in scientific and technical journals covering basic and applied topics.																									
Activity 2.4.1 At least 1 paper will be published in international magazines within the project's activities.	coordinator																								