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COMPLETION REPORT

SFB + CITES + ITTO PROJECT

"Program for implementing CITES listings of tropical tree species"

HostCountry
Government of Brazil

Executing Agency
FUNTEC Foundation for Forest Technology and Geoprocessing

"USING THE NEAR INFRARED SPECTROSCOPY (NIRS) TECHNIQUE ON A PILOT SCALE, AS A POTENTIAL TOOL FOR THE MONITORING OF THE MAHOGANY TRADE"

CITES ITTO European Commission LPF SERVIÇO FLORESTAL BRASILEIRO MINISTÉRIO DO MEIO AMBIENTE BRASIL GOVERNO FEDERAL

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Executive Summary

The conventional method for the identification of wood lacking in botanical material is through the description of structural and anatomical features. Some species are very similar and require more sophisticated methods for reliable identification. The NIRS technology has found a wide field of application; it allows discrimination of similar woods by the association of spectroscopy with statistical multivariate analysis. In the specific case of *Swietenia macrophylla,* a CITES-Annex II protected species, more than 15 Brazilian wood species can be confused using the conventional anatomical analysis. Since 2006, the Laboratório de Produtos Florestais has been developing a methodology to classify Brazilian native wood species that look very similar to *Swietenia macrophylla* (mahogany): *Carapa guianensis* (crabwood), *Cedrela odorata* (cedar) and *Micropholis melinoniana* (curupixá). This project's main objective was to lead a successful timber identification method from laboratory conditions to field conditions, evaluating the viability factors, time, and adverse eventualities. The expansion of the spectra databank; training three undergraduates and two graduated students, and the dissemination of the technique to other groups complemented this goals. The strategy was to acquire a commercially avaiable portable device, transfer the discriminatory model developed in laboratory conditions to this instrument and perform missions in localities that produces mahogany wood, including two Brazilian regions and two mahogany-producing countries in Latin America. The use of the handheld NIRS device yielded results in agreement with the bench equipment. Some loss in the results' accuracy was expected and verified, but it did not affect the species discrimination models. Statistical models (PLS-DA) maintained their reliability and robustness. All four field missions were a success and it was possible to gather almost 11,000 spectra mainly of *S. macrophylla* species. Mahogany samples collected in Bolivia, Brazil, Guatemala, México, and Peru were able to be separated according the provenance and presented classification rate ranging from 89.1 to 100%. The general balance of the project is highly positive as the majority of the activities were carried out on scheduled. The highlight of the project was NIRS ID being recognized as a potential method for wood identification and included in "BEST PRACTICE GUIDE ON FORENSIC TIMBER IDENTIFICATION" to be published by United Nations Office on Drugs and Crime - UNODC. The mahogany spectra databank was expanded to include woods

from four *S. macrophylla* producer countries. Additionally, spectra of new 16 endangered forest species or similars (CITES and MMA) were inserted in the list of NIRS studied species. Another important outcome is the evidence that the NIRS technology can be reliably used for the identification of the timber's geographical origin. Four undergraduate students (instead of three) were trained with ITTO-CITES funds and a total of six extra scholarships (undergraduate and graduate) were funded by the Brazilian government. All results of this project were widely disseminated at national and international meetings and in scientific and popular magazines, ensuring the continuity of this investigation in future.

(Key words): tropical wood, identification, near infrared spectroscopy, chimiometry.

Project Identification

1.1 Context

An international effort to combat the illegal logging crimes and the associated trade in illegal wood products is hampered by a lack of available timber identification tools. There is a need to develop auxiliary tools to deal with two different situations: screening suspect material and identifying final timber. On the other hand, reputable wood dealers are increasingly being pressured to supervise their own supply chains and comply with the requirements with respect to the legality of the wood's origin.

The conventional identification method currently employed for this purpose is a combination of macroscopic and microscopic identification, in which many wood characters such as density, color, smell, brightness, texture, growth rings, vessels, fibers and porosity of an unknown sample are compared with candidate species. When an expert wood anatomist is available to perform the identification this method can provide highly reliable forensic results. Furthermore, there are identification keys that gather anatomical information about the most relevant species, which represent important databases to support the wood anatomist. Even with access to such tools, identification of wood using wood anatomical information requires an expert wood anatomist. Unfortunately, there are not enough experts to meet the demand. Therefore, the development of technological methods for wood identification that does not require specialist knowledge can help to improve field-level inspections and identification as well as forensic wood identification.

A range of scientific methods have been developed independently with the potential to provide the required identification information such as DNA barcoding, stable isotopes, dendrochronology, etc. Near Infrared Spectroscopy (NIRS) measures the quantity of radiation absorbed or reflected by material when exposed to near infrared energy. NIRS can be applied to solid timber, and returns information derived from both chemical components and the physical structure of the wood. Therefore, it can be considered a "fingerprint" of each species.

Near infrared spectroscopy (NIRS) is a powerful technique for wood assessment since it enables rapid and non-destructive analysis, can be applied to solid samples, requires minimal or no sample preparation, most of the times it

does not generate chemical waste, portable devices are already commercially available, and theoperation of the device does not require years of training. Hence, NIRS has been widely applied to study many wood chemical and physical properties and has also been increasingly used for wood identification. The raw spectroscopic outputs must always be used in association with multivariate analyses in order to obtain meaningful results. Spectra are analysed to determine the likely taxon when compared with reference datasets.

1.2 Project origin

Since 2006, LPF/SFB has been developing a methodology for wood species identification or classification applying the Near Infrared Spectroscopy (NIRS) technology, that is NIRS associated with multivariate analysis. The pioneering work of LPF/SFB was to classify native wood species that look like very similar: *Swietenia macrophylla* King. (mahogany), *Carapa guianensis* Aubl. (crabwood or andiroba), *Cedrela odorata* L. (cedar) and *Micropholis melinoniana* Pierre (curupixá). A database was built with a total of 132 milled samples taken from different trees, to ensure that the variability of each species was well represented in the developed model. It is worthwhile to observe that mahogany and cedar woods appear in Annexes 2 and 3 of CITES, respectively. The next step of this investigation was to study the possibility of using non-grounded samples, simulating the situation found in real procedures of wood control and inspection. The successful results of this study could be found in Braga et al. (2011) published in a special edition entitled "Wood Science for Promoting Legal Timber Harvest". In 2010, the LPF/BFS was integrated into the Research Program "NEXTREE - Excellence Center of Genomics Applied Forestry", to study *Eucalyptus* wood from different species, clones, ages and provenance using NIRS technology. It was possible to build models discriminating all 16 different woods varying from pure species as *E. grandis*, and *E. urophylla* to controlled hybrids of different clones as *E. urograndis*.

In March 2014, the activities of the project SFB-CITES-ITTO named "USING THE NEAR INFRARED SPECTROSCOPY (NIRS) TECHNIQUE ON A PILOT SCALE, AS A POTENTIAL TOOL FOR THE MONITORING OF THE MAHOGANY TRADE"officially began. Project results can bring great environmental benefits and prove a great contribution to the sustainable management and conservation of mahogany, cedar and similar species. This same methodology can be replicated, after building the

necessary spectra databank for each individual species, to monitor other wood with high commercial value. The fact that NIRS technology provides the wood identification results in real time and in any workplace, avoiding sending the sample to a specialized laboratory, brings tremendous advantages that very few methodologies have.

2 Objectives and implementation strategy

The main objective was to lead a successful timber identification research from laboratory to field conditions, evaluating the viability factors, time, and adverse eventualities. Therefore, the project was an attempt to use and operate the NIRS technology in the field, adapting and optimizing its performance for the wood identification of *Swietenia macrophylla* and similar species. A

The strategy was to acquire a commercially available portable device, transfer the discriminatory model developed in laboratory conditions for this instrument and perform missions in locals that produce mahogany wood, facing real conditions found in the field.

Additionally, a specific objective of these missions was to expand the spectra data bank of the studied species, including two regions of Brazil and two mahogany-producing countries in Latin America.

The training of three undergraduate and two graduate students closed the cycle of the project, ensuring the continuity of investigations in the future. Dissemination of the research work was also a part of the project's strategy.

3 Project Performance (Project elements planned and implemented)

Overall the project activities were carried out as scheduled. As a result of the project, several documents that describe the timber identification system of woods similar to *Swietenia macrophylla* were generated and presented in congress, seminars, etc. The Forest Products Laboratory has a wide collection of mahogany samples collected in Brazil, and some collected samples from Bolivia, Guatemala, and Peru. The NIRS database has 11,000 spectra for the 18 species analyzed at this stage, and altogether 537 solid wood samples are incorporated to the LPF

wood collection, mainly *Swietenia macrophylla* species. All samples were identified by a wood anatomist.

Only one planned field activity referring to cultivated mahogany had to be delayed due mainly to the weather conditions in the Amazon in the very beginning of this current year. This was overcome by the coordination of the ITTO-CITES program's authorization of the extension of the project period until March, 2017. Therefore, this Activity will be completed in this year, probably next October or November. Alternatively, arrangements were made to study the wood of some *Swietenia macrophylla* trees that will be harvest next September from a plantation nearby Brasilia (DF). At the end of this project, the number of samples needed for building the discriminatory model will be totalized and then, it will be verified if it is possible to recognize between native and cultivated *S. macrophylla* timbers.

Two activities not previously planned were inserted in the project, which refer to obtaining spectra of *Dalbergia* and *Cedrela* species (available in Madison xylorium - FPL/USA) and the analysis of *Swietennia humilis* from Guatemala.

Table 1 presents the Products of the project by Activities, Table 2 refers to the Annual Activity Program.

Table 3 presents the final and original approved budget of the project, which has undergone two structural changes during the execution.

Table 1 | Products of the Project

Outputs/Activity Planned	Means of monitoring	Product
Output 1.1 *Mahogany spectra databank and the statistical model transferred from laboratory instrument to the portable equipment;*		
Activity 1.1.1 Acquisition of the portable equipment	The purchase invoice of the equipment	The acquired device received the registration number 001FUNTEC.
Activity 1.1.2 Transfer methodology from lab to portable equipment	Report with discriminatory analysis made in portable equipment available	MSc Dissertation written by M. Cecília J. Bergo
Output 1.2 *Field tests with NIRS portable equipment carried on a pilot scale*		
Activity 1.2.1 Establishing two testing sites	Receipt of payment signed (the consultant did not charge for the indication)	Manuel Urbano (AC) and Brasilia (DF) cities. were defined as pilot sites
Activity 1.2.2 Pilot test	Travels tickets and reports on fieldwork	Reports with photos related missions in Manuel Urbano (AC) and in Brasilia (DF)
Activity 1.2.3 Evaluating the portable equipment	List of performance (advantages and disadvantages) of portable equipment done.	The comparation list is described in the MSc Dissertation written by M. Cecília J. Bergo
Output 1.3 *A databank of Mahogany spectra is prepared based on samples from two regions of occurrence in Brazil and two other Latin American countries,*		
Activity 1.3.1 Collecting of native samples and taking spectra	Authorization for wood transportation (no samples were colletected, it was taken only the wood spectra)	Paper published in IAWA Journal
Activity 1.3.2 Collecting of plantation samples and taking spectra	Authorization for wood transportation or Authorization for collected wood	This activity was postponed to November 2016.
Activity 1.3.3 Collecting samples from other countries and taking spectra	Document for transportation of wood samples (no samples were collected, it was taken only the wood spectra)	Poster presented in Workshop.
Output 1.4 *Three academic works and a demonstrative video will be prepared for dissemination*		
Activity 1.4.1 Training students	Receipt of payment signed	10 students were trained (see Table 2) and 3 academic works were published
Activity 1.4.2 Producing a demonstrative video	Receipt of payment signed	A video

Note: Activities that will finish in February 2017 are written in green.

Table 2 | Annual Activity Program

Outputs / Activities	Responsible	Year I (months) *1												Year I I (months)												Year III (months)											
		1	2	3	4	5	6	7	8	9	10	11	12	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 *Mahogany spectra databank and the statistical model transferred from laboratory instrument to the portable equipment;*																																					
Activity 1.1.1 Acquisition of the portable equipment *2	NC *3																																				
Activity 1.1.2 Transfer methodology from lab to portable	NC																																				
Output 1.2 *Field tests with NIRS portable equipment carried out on a pilot scale;*																																					
Activity 1.2.1 Establishing two testing sites	NC																																				
Activity 1.2.2 Pilot tests	NC																																				
Activity 1.2.3 Evaluating the portable equipment	NC																																				
Output 1.3 *A databank of Mahogany spectra is prepared based on samples from two regions of occurrence in Brazil and two other Latin American*																																					
Activity 1.3.1 Collecting of native samples and obtaining spectra	NC																																				
Activity 1.3.2 Collecting of plantation samples and obtaining spectra	NC																																				
Activity 1.3.3 Collecting samples from other countries and obtaining spectra	NC																																				
Output 1.4 *Three academic works and a demonstrative video will be prepared for dissemination.*																																					
Activity 1.4.1 Training students	NC																																				
Activity 1.4.2 Producing a demonstrative video	NC																																				

Table 3 | Changes made in the budget.

Budget Components		Initial Amount (US$)	Executed (US$)	Percentage implemented (%)
10.	**Activity Personnel**	16,200.00	2,431.97	15.01
20.	**Sub-contracts**	21,500.00	27,798.86	129.30
30.	**Duty Travel**	21,600.00	34,672.50	160.52
40.	**Capital Items**	48,800.00	45,458.05	93.15
50.	**Consumable Items**	14,900.00	2,128.72	14.29
60.	**Miscellaneous**	1,800.00	13,732.35	762.91
70.	**Executing Agency**	12,480.00	13,728.00	110.00
.	**TOTAL**	**139,950.45**	**139,950.45**	**100.00**

As the hiring of consultants for the project was restricted to occasional work of short duration, most of the project funds were allocated to the purchase of portable equipment and the carrying out of field missions. Changes to the original amount of the components are justified for the following reasons (See Annex 3):

i. A large amount of money allocated for the item 10. Activity Personnel (Fellowship and Training) was spared, due to the approval of 7 scholarships supported by Brazilian funding agencies for research and development at the national level (CNPq, and CAPES). Only three scholarships were provided by ITTO-Cites Program (for detailed information see Table 5 ahead).

ii. The variation of the initial budget for item 20. Sub-contracts originated with the expansion of six additional months to the project. Thus, an extra field mission to a mahogany cultivated area, two scholarship funds for graduate and post-graduate students and the production of a demonstrative video for dissemination are being executed. One factor that contributed to saving funds is related to the consultant chosen to indicate two locals from which to collect mahogany spectra in Brazil. The consultant did not charge the project.

iii. Item 30. Duty Travel has undergone a significant modification because field missions are quite costly. For the implementation of the activities, transportation and a daily allowance for at least four people were needed. The decision of the project coordination to pay all individual travel expenses, instead of the daily full amount, for each team member on a work trip also

helped save funds. This allowed the project to execute four field missions (two in Brazil and two abroad), foreseen by the project, and an additional visit to the Forest Products Laboratory/USDA (Madison), unplanned before. This special mission was included into the project due to the unique opportunity to obtain spectra of samples that are considered as reference (wood collected with botanical material). The majority of wood species (listed in Table 2) were endangered and has their international trade regulated by CITES.

iv. Some money from item 40 which refers to the acquisition of a second portable device manufactured by MicroNIR was saved (around US $ 13,000.00). The acquisition had already been approved by the Program ITTO-CITES but this device was acquired by EMBRAPA/Cenargen, which maintains close partnership with the Mahogany ID Project and allow us to use it for woods discrimination without any cost.

v. Item 60 shows a wide variation relative the original due to the amount of unforeseen events that emerged during the project execution. Also, the variation of the dollar exchange rate, which resulted in a revaluation of the local currency and rising costs of the project, also caused some rearrangement of the activities. However, this situation could be kept under control, not causing major setbacks to the project's activities.

Annex 1 presents project financial statement and Annex 2 shows project cash flow statement,

4 Project Outcome, Target Beneficiaries Involvement

4.1 Project Achievements

The specific objectives of the project were achieved entirely within the prescribed time from the start of implementation of activities. Only one activity, on site collection of spectra (Belém, PA) was delayed because of bad weather earlier this year.

Two main sets of models were generated for field use. The first one discriminates dry wood mahogany from three anatomically similar Brazilian species. With the second set of models it is possible to identify the source or origin of mahogany

wood: Bolivia, Brazil, Guatemala, Mexico, and Peru. It is important to mention the support of the Regional Coordinator for Latin America, which was always ready to articulate the missions of the project abroad, both in Bolivia and Guatemala. Therefore, we had the full support of thelocal government and non-governmental forest community to successfully accomplish our work abroad.

The NIRS technology for wood identification was presented and evaluated by Dr. Ian Thompson, a consultant hired by the ITTO-CITES Program, during the field mission in Brasilia, in March 2015. A demonstration of the efficiency and speed of identifying wood with NIRS portable device in field was made to the Executive Director of ITTO, who was visiting the LPF/ SFB, in March 2015. A similar demonstration was made to the public who participated in the "ITTO & CITES: Collaboration on Threatened tropical tree species" side event, at the XIV World Forestry Congress held in Durban (South Africa), in September 2015.

4.2 Situation after completion of the project compared to the previous situation

i. NIRS Technology is recognized as promising tool for wood identification

Thanks to funding from the ITTO-CITES Program, the NIRS-ID project gained worldwide visibility. Today it is recognized as a new technology for wood identifying with great potential for expansion. The high point of this project was the inclusion of the NIRS Technology in the "Best practice guide on forensic timber identification" document, to be published soon by the United Nations Office on Drugs and Crime – UNODC/UNO. According to this guide, there are currently two automated methods under development to assist in the rapid field identification of timber. Near infrared spectroscopy (NIRS) is one of these mentioned methods.

ii. NIRS Technology is recognized as a promising tool for identification of timber's geographical origin/provenance

The identification of the geographical provenance of a timber sample is an important task for law enforcement authorities. Illegal activities can occur at all stages of the timber supply chain and range in complexity from local illegal harvesting to international commercial supply chains. NIRS analysis can provide robust results for geographical provenance identification of the wood sample. An important Outcome of this project is that the mahogany wood samples collected

in Bolivia, Brazil, Guatemala, México, and Peru were separated presenting a highly correct classification rate ranging from 89.1 to 100%.

iii. Increase in the number of studied threatened species identified using NIRS

A special mission at the Forest Products Laboratory/USDA (Madison) was included in the project due to the unique opportunity to obtain spectra of samples that are considered as reference (wood collected with botanical material). The majority of wood species listed in Table 2 are endangered and their international trade is regulated by CITES or are prohibited from being cut down by the Brazilian government as is the case with *Bertoletia excelsa*. The following new wood species were incorporated into the spectra database:

Table 2. New wood species incorporated into the NIRS ID spectra databank.

1. Bertoletia excelsa	
2. Cariniana domestica	*3. Cariniana estrelensis*
4. Cedrela fissilis	*5. Cedrela angustifolia*
6. Dalbergia latifolia	*7. Dalbergia cearensis*
8. Dalbergia nigra;	*9. Dalbergia frutecenses*
10. Dalbergia sisso	*11. Dalbergia retusa*
12. Dalbergia stevensoni	*13. Dalbergia spruceana*
14. Dalbergia tucurensis	
15. Lecitys pisonis	*16. Scheweilera parviflora*
17. Scheweilera couriacea	
18. Swietenia humilis	

iv. Dissemination of the NIRS Technology

An identification model specially built for identification in the field of the following wood species in dry conditions: *Swietenia macrophylla* (mahogany), *Cedrela odorata* (cedar), *Micropholis melioniana* (curupixá), and *Carapa guianensis* (crabwood) has now been made available. In order to increase the number of researchers investigating this issue, since each country has its inherent necessities for wood identification, seminars were realized in the two mahogany producer countries visited. The first one (4 hours) was in Santa Cruz de la Sierra (Bolivia) for 25 participant including researchers, wood producers, forestal research institutions, and governmental representatives. The other one was a short course (16 hours) on NIRS Technology in the Guatemala City (Guatemala) to attend 22 interested persons, including professors and students of the University of San Carlo

de Guatemala (USCA), representatives of government, as CONAP and INAP, and NGO institutions as Nature for Life. The mini-course was divided into three correlated topics: NIRS technology for similar woods identification (Tereza C. M. Pastore.); Identification using Wood Anatomy Characters (Vera T. R. Coradin) and Notions of Chemometrics (Jez W. B. Braga).

v. 10 students trained in Fellowship and Training

In Fellowship and Training item, it was initially planned to include three undergraduate and two graduate students, using ITTO-CITES program fund. However, Brazilian national agencies for research and development (CNPq, CAPES and MMA/SFB) approved 05 additional grants. Table 3 relates the type of fellowships granted to the project.

Table 3. Total number of scholarships and students trained in NIRS ID Project.

Student's name	Type of fellowship	Funding agency	Duration (month)
Maria Cecília J. Bergo	Master degree	CAPES	24
Rosylaine Elaine C. Lopes	Master degree	CNPq	24
Diego C. da Silva	Undergraduate	MMA/SFB	24
Diego C. da Silva	Undergraduate	ITTO-Cites Program	12 (in course)
Liz Franco Soares	Undergraduate	CNPq	24
Liz Franco Soares	Master degree	ITTO-Cites Program	8 (in course)
Nayara Guimarães	Undergraduate	CNPq	24
Filipe Snel	Undergraduate	MMA/SFB	24 (in course)
Lucas Lamare	Undergraduate	ITTO-Cites Program	12
Pedro Rogério Pereira Júnior	Undergraduate	CNPq	8 (in course)

vi. Increase in the spectra databank

At the beginning of this project there were less than 500 spectra in the databank to discriminate woods of the following native anatomically similar species: *Swietenia macrophylla* (mahogany), *Cedrela odorata* (cedar), *Micropholis melioniana* (curupixá), and *Carapa guianensis* (crabwood).

The database of mahogany and cedar species has been updated during the execution of the missions in the field. These missions were held in the following locations: Seringal Novo Macapa Farm (Acre); three sawmills in Brasilia (DF), one sawmill in (Bolivia), and five sawmills in Escuintla and Petén (Guatemala). Therefore, the number of total spectra of mahogany and cedar is now estimatedat 11,000 spectra. Impressive considering that only the two portable devices were used. Additionally, a total of 870 spectra were collected in the Forest Products Laboratory in Madison, Wi (USA) that were taken from the new species related in Table 2. All spectra were added to the data bank, and models are being built.

vii. Dissemination of NIRS Technology

During the project implementation period, the team members participated in various events, conferences and seminars as a way to publicize and disseminate the NIRS Project ID. Table 4 shows quantitative data:

Table 4. Number of publications and others forms of dissemination of the project.

Midia	**Quantity**
Paper published in scientific magazines	2
MSc Dissertation	2
Speech in International and National Congresses	10
Poster presented in International and National Congresses	12
Other form of dissemination	5

4.3 Target beneficiaries involvement

Sawmills in Brasilia (Brazil), Santa Cruz de la Sierra (Bolivia), and the regions of Escuintla and Petén (Guatemala) gave assistance, machinery, workspace and wood to accomplish fieldwork. In addition, the forest community actively participated in the two training courses held in Santa Cruz de la Sierra and Guadalupe city.

4.4 Project sustainability

The NIRS technology for the identification of dry wood is ready to be used in Brazil for the following species: *Swietenia macrophylla* (mahogany), *Cedrela odorata* (cedar), *Micropholis melioniana* (curupixá), and *Carapa guianensis* (crabwood). A complementary research step for the models adjustment involving wood moisture necessarily should be performed. It is expected that at the end of these

adjustments, the government authorities of the Brazilian environmental protection institutions will adopt this timber identification NIRS technology for their monitoring and supervision activities.

The project's activities continue to maintain their development and the spectral database of mahogany, cedar and other endangered species continues to be updated by the technical team through the LPF / SFB studies in partnership with the University of Brasilia. Both government institutions collaborate, support, and encourage this project.

5 Assessment and analysis

5.1 Project rationale

The forest species *Swietenia macrophylla* and *Cedrela odorata* are respectively in Appendices II and II of the protected species list of CITES. For the sustainable management to be effective, with consequent preservation of the species, it is necessary to exercise strict control and monitoring throughout all steps of the chain of custody. In everyday practice, identification problems of wood and wood-products begin because the timber has already been logged and typically only boards are available for analysis. So, the material is devoid of its botanical features (leaves, flowers fruits, and seeds of the tree). A wood anatomist to perform the identification is not always accessible and there are not enough experts to meet the actual demand.

At present, the methodology to identify wood is restricted to visual examination of macroscopic and microscopic characters and comparison with the reference wood, which leads to costs resource and time.

Thus, this project aims to develop a methodology by using near infrared spectroscopy with the goal of identifying wood in field in few minutes with. The final purpose is to provide an effective and reliable tool for monitoring, control, and supervising the forest community, saving time, effort and financial resources. It is important that the results of this project are disseminated among the technicians of the forestry and environmental institutions for use in field and for wood certification.

5.2 Effectiveness of the project

This project is a scientific contribution to Brazil and Latin America, when it focuses on the identification of timber species *Swietenia macrophylla* and *Cedrela odorata*. However, as the NIRS technology can be used to identify any timber-producing species around the world, the contribution has the potential to be applied globally. The results of this project are very significant, as it provides a fast, reliable, secure, robust and less costly solution to the problem when compared to the conventional methodology.

5.3 Critical differences

The main differences between the planned activities and the ones actually implemented by the project are listed below:

a) Inclusion of 18 endangered species or similar (as *Dalbergia nigra*, *S. humilis Cedrela fissilis*, etc) in the spectra database;
b) Inclusion of five additional scholarships in the project for a total of ten students trained;
c) Determination of *S macrophylla* provenance of two Latin American countries (Mexico and Peru) further than the planned number (Brasil, Bolívia and Guatemala);
d) Two trainings on the use of NIRS for wood identification (Bolivia and Guatemala) were performed;
e) Field mission to collect wood of cultivated *S. macrophylla*, in Luziânia (DF)
f) Mission to collect spectra of endangered species in the wood collection of the Forest Products Laboratory, Madison (WIS / USA);
g) The activity to collect wood of S. macrophylla cultivated is overdue and should take place in October 2016 in Belém (PA).

Briefly, for an Activity that is currently delayed, seven new (non-planned) Activities were successfully executed.

6 Lessons learned

Project Identification and Design

Since the beginning of the project, the specific objective to be studied in this project, namely the transfer of NIRS technology to identify wood from laboratory conditions to the field conditions, is very well defined and clear. This allowed us to perform most of the activities in an objective manner and within the previously scheduled times.

The project aims to contribute to the CITES authorities and national monitoring institutions through the development of an auxiliary tool for wood identification, especially illegal timber

The beneficiaries of the project results, such as the Brazilian Institute of the Environment and Renewable Natural Resources - IBAMA and the Brazilian Forest Service-SFB have participated and contributed according to their possibilities for the project execution.

The strategy designed for the execution of the project was adequate and quite flexible. The support of stakeholders, always effective, efficient and fast, allowed for all adjustments (execution and budget) needed for the project as external factors have emerged.

In the two missions carried out in other countries (Bolivia and Guatemala), the participation of the Regional Coordination for Latin America of the ITTO-CITES Program was fundamental in the selection process of the countries. The Brazilian technical team received full support of local organizations, government, non-governmental, forestry companies, university, sawmills, etc. to perform all research activities.

The methodology to be used to identify mahogany wood in field is already developed and ready to be used in dry conditions (10 -12% relative moisture). Moreover, the origin of mahogany timber from four countries in Latin America can be identified. This means that the initial specific objective has been fully achieved.

Operations matters

The project was coordinated by the Forest Products Laboratory of the Brazilian Forest Service, which was responsible for monitoring all activities and maintained permanent contact with the Regional Coordination for Latin America of the ITTO-CITES Program.

The management of financial resources was in charge of Foundation for Forest Technology and Geoprocessing-FUNTEC. The flow of resources did not present any problem during the project implementation phases.

The functions of the two institutions were well defined and coordinated. The LPF had sufficient autonomy during the execution of the project, always making the decisions that guided the project.

The accounting documentation of the project is found in the FUNTEC office and technical documentations generated by the project are in the Forest Products Laboratory.

The Regional Coordination for Latin America of the ITTO-CITES Program was in charge of monitoring the project implementation. All the progress reports of the project and manuscripts for the Newsletters publication were sent to Ms. Sofia Hirakuri.

Dr. Ian Thompson, a hired consultant ITTO-CITES Program, visited the project Mahogany ID in Brasilia.One field mission was carried out in two sawmills, where the consultant can observe *in situ* the performance of NIRS technology for the woods: *S. macrophylla*, Carapa guianensis, *Cedrela odorata* and *Micropholis melinoniana* in two local sawmills.

Some external factors that affected the project positively were the increase of four scholarships for students training and the acquisition of second portable NIRS commercial equipment for a partner research institution.

Some external factors that affected the project negatively were the constant variation in the dollar exchange rate against the real and the annual tropical rains (November to March), which delayed the collect of mahogany plantation samples in Para.

7 Conclusions and Recomendations

The methodology to be used to identify mahogany wood in dry condition (10 -12% relative moisture) is developed. Now, the current focus is to extend the identification model for other moisture conditions of mahogany wood. It is expected that this developed methodology will be used by forest authorities, dealers, customs, or any institution for which wood identification is a necessary action. This method is intended to provide an effective tool for the monitoring and control of illegal timber in the field, saving time, effort and resources.

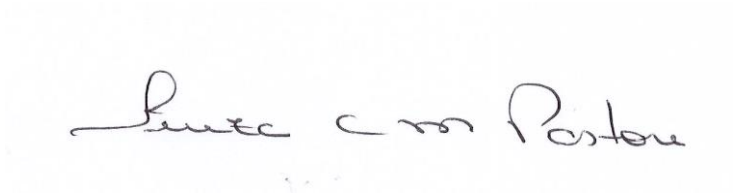
For government institutions responsible for law enforcement to guarantee the good performance of the developed methodology the establishment of a Central Laboratory is recommended. The main functions of this Central Laboratory should be: i) to keep the discrimination model updated; ii) install the updated model in similar portable devices distributed in the principal timber monitoring locations;

and iii) to offer training programs and periodic training for the correct use and standardization of equipment and discriminant models.

It is worth noting that this same methodology can be replicated to monitor other wood species with high commercial value, with minor adjustments.

It is crucial to support research institutions, particularly in countries with large areas of tropical forests, so that reliable basic information can be generated and used in field.

Responsable of the report:



Tereza Cristina Monteiro Pastore

Project Coordinator

Brasília, September, 2016

ANNEX 1 - Project financial statement (in US dollar)

Projeto Nº. Funtec 01			Final em: September 2016			
Título do Projeto: Using the Near Infrared Spectroscopy (NIRS) technique on a pilot scale, as a potential tool for the monitoring of Mahogany trade.						
Componente		Original	Gastos Atuais			Disponível
		Montante (A)	Provisionados (B)	Gastos (C)	Total (D) { B + C }	Fundos (E) { A - D }
10.	**Activity Personnel**					
15.	Fellowships and Training	$ 2.431,97	$ -	$ 2.431,97	$ 2.431,97	$ 0,00
19.	**Component Total**	**$ 2.431,97**	**$ -**	**$ 2.431,97**	**$ 2.431,97**	**$ 0,00**
20.	**Sub-contracts**					
21.	Sub-contracts (with Bruker)	$ -	$ -	$ -	$ -	$ -
22.	Sub-contracts (with Phazir)	$ -	$ -	$ -	$ -	$ -
23.	Sub-contracts (with ahigway agency)	$ -	$ -	$ -	$ -	$ -
24.	Sub-contracts (with wood explorer agency)	$ 27.815,61	$ -	$ 27.798,86	$ 27.798,86	$ 16,75
29.	**Component Total**	**$ 27.815,61**	**$ -**	**$ 27.798,86**	**$ 27.798,86**	**$ 16,75**
30.	**Duty travel**					
31.	Daily Subsistence Allowance	$ 12.772,76	$ -	$ 12.772,76	$ 12.772,76	$ -0,00
32.	Internationl Travel	$ 16.554,53	$ -	$ 16.557,24	$ 16.557,24	$ -2,71
33.	Local Transport Costs	$ 5.342,50	$ -	$ 5.342,50	$ 5.342,50	$ 0,00
39.	**Component Total**	**$ 34.669,79**	**$ -**	**$ 34.672,50**	**$ 34.672,50**	**$ -2,71**
40.	**Capital items**					
44.	Capital Equipment Others	$ 45.458,05	$ -	$ 45.458,05	$ 45.458,05	$ 0,00
49.	**Component Total**	**$ 45.458,05**	**$ -**	**$ 45.458,05**	**$ 45.458,05**	**$ 0,00**
50.	**Consumable itenms**					
51.	Raw materials	$ 118,28	$ -	$ 118,28	$ 118,28	$ 0,00
52.	Spares	$ 1.916,85	$ -	$ 1.916,85	$ 1.916,85	$ 0,00
53.	Utilities	$ -	$ -	$ -	$ -	$ -
54.	Office Supplies	$ 93,59	$ -	$ 93,59	$ 93,59	$ -0,00
59.	**Component Total**	**$ 2.128,72**	**$ -**	**$ 2.128,72**	**$ 2.128,72**	**$ 0,00**
60.	**Miscellaneous**					
61.	Sundry	$ 13.718,31	$ -	$ 13.732,35	$ 13.732,35	$ -14,04
69.	**Component Total**	**$ 13.718,31**	**$ -**	**$ 13.732,35**	**$ 13.732,35**	**$ -14,04**
70.	**Executing Agency Management**					$ -
71.	Costs	$ 13.728,00	$ -	$ 13.728,00	$ 13.728,00	$ -0,00
79.	**Component Total**	**$ 13.728,00**	**$ -**	**$ 13.728,00**	**$ 13.728,00**	**$ -0,00**
100.	**GRAND TOTAL**	**$ 139.950,45**	**$ -**	**$ 139.950,44**	**$ 139.950,44**	**$ 0,01**

ANNEX 2 - Project cash flow statement

Project No. Funtec 01	Period ending on: September 2016

Project Title: Using the Near Infrared Spectroscopy (NIRS) technique on a pilot scale, as a potential tool for the monitoring of Mahogany trade.

	Componente	Date	Amount in US$	Local Currency
A	**Funds received from ITTO:**			
1.	First installment	14/03/2014	$ 50.000,00	R$ 116.406,16
2.	Second installment	23/06/2014	$ 30.000,00	R$ 65.855,72
3.	Third installment	05/03/2015	$ 30.000,00	R$ 89.225,04
4.	Fourth installment	04/01/2016	$ 27.280,00	R$ 109.876,68
	Investment Income (total)	31/08/2016	$ 2.670,44	R$ 7.418,48
	Total funds received:		**R$ 139.950,44**	**R$ 388.782,08**
B	**Expenditures by executing agency:**			
10.	**Activity Personnel**			
15.	Fellowships and Training		$ 2.431,97	R$ 6.756,00
19.	Component total:		**$ 2.431,97**	**R$ 6.756,00**
20	**Sub-contracts**			
24.	Sub-contracts (with wood explorer agency)		$ 27.798,86	R$ 77.225,19
29.	Component total:		**$ 27.798,86**	**R$ 77.225,19**
30.	**Duty travel**			
31.	Daily Subsistence Allowance		$ 12.772,76	R$ 35.482,71
32.	Internationl Travel		$ 16.557,24	R$ 45.995,98
33.	Local Transport Costs		$ 5.342,50	R$ 14.841,45
39.	Component total:		**$ 34.672,50**	**R$ 96.320,14**
40.	**Capital items**			
44.	Capital Equipment Others		$ 45.458,05	R$ 126.282,38
49.	Component total:		**$ 45.458,05**	**R$ 126.282,38**
50.	**Consumable itenms**			
51.	Raw materials		$ 118,28	R$ 328,57
52.	Spares		$ 1.916,85	R$ 5.325,00
54.	Office Supplies		$ 93,59	R$ 260,00
59.	Component total:		**$ 2.128,72**	**R$ 5.913,57**
60.	**Miscellaneous**			
61.	Sundry		$ 13.732,35	R$ 38.148,44
69.	Component total:		**$ 13.732,35**	**R$ 38.148,44**
70.	**Executing Agency Management**			
71.	**Costs**		$ 13.728,00	R$ 38.136,36
79.	Component total:		**$ 13.728,00**	**R$ 38.136,36**
Total expenditures to-date			**$ 139.950,44**	**R$ 388.782,08**
Remaining balance of funds (A-B)			**$ -0,00**	**-R$ 0,00**

Average Exchange Rate 2,777998215

ANNEX 3 – Budget changes

Budget Components		Original (US$)	Rearranged (US$)
10.	**Activity Personnel**		
	15. Fellowships and Training	16.200,00	2.431,97
	19. **Component Total**	**16.200,00**	**2.431,97**
20.	**Sub-contracts**		
	21. Sub-contract (with Bruker)	6.000,00	
	22. Sub-contract (with Phazir)	2.500,00	
	23. Sub-contract (with a highway agency)	3.000,00	
	24. Sub-contract (with logging agency)	10.000,00	27.815,61
	29. **Component Total**	**21.500,00**	**27.815,61**
30.	**Duty Travel**		
	31. Daily Subsistence Allowance	12.000,00	12.772,76
	32. International Travel	4.000,00	16.554,53
	33. Transport Costs	5.600,00	5.342,50
	39. **Component Total**	**21.600,00**	**34.669,79**
40.	**Capital Items**		
	41. Premises		
	44. Capital Equipment	48.800,00	45.458,05
	49. **Component Total**	**48.800,00**	**45.458,05**
50.	**Consumable Items**		
	51. Raw materials	7.500,00	118,28
	52. Spares	3.900,00	1.916,85
	53. Fuel and Utilities	1.000,00	-
	54. Office Supplies	2.500,00	93,59
	59. **Component Total**	**14.900,00**	**2.128,72**
60.	**Miscellaneous**		
	61. Sundry	1.800,00	13.718,31
	69. **Component Total**	**1.800,00**	**13.718,31**
70.	**Executing Agency Management Costs**	12.480,00	13.728,00
	79. **Component Total**	**12.480,00**	**13.728,00**
100.	**TOTAL**	**137.280,00**	**139.950,45**
	GRAND TOTAL		