UNIVERSITE D'ABOMEY-CALAVI

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FACULTE DES SCIENCES AGRONOMIQUES

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Laboratoire de Biomathématiques et d'Estimations Forestières (LABEF)

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2015 SCIENTIFIC ACTIVITIES REPORT OF THE LABORATORY OF BIOMATHEMATICS AND FOREST ESTIMATIONS

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Introductive letter of the Director

Dear reader,
I am pleased to present to you the annual report of the Laboratory of Biomathematics and Forest Estimations for the year 2015.
The year 2015 was great and full of fine accomplishments. It was the year of setting, building, exploring, networking etc. It was our real first year of activities.
Below are some key milestones we are proud of.

Our new building. We started and finished it within 6 months and inaugurated it in December 28th, 2015. Because we strongly believe that a good working environment is essential to produce outstanding outcomes, we work tirelessly to provide our team with excellent commodities including air-conditioned rooms and free internet Wi-Fi access.

Our website. Since July 2015 the Laboratory is online and this allows us to interact with other research institutions and researchers around the world. We are still working on it as to set it as interactive as possible.

Our incredible team. At the beginning we engaged young outstanding scientists in the discussion that will guide the strategic direction of the Laboratory for the five coming years. The work is still going on. Working with young scientists of this caliber offers us a lot of pride but also a few challenges. In light of their dedication and commitment there is no doubt that LABEF will become in no time a reference in Africa.

Advancement of research. Last year also saw significant improvements in our research programs in Biostatistics, forest methods, forest ecology, forest economics and governance etc. Many papers have been published.

Let's finish with the question people used to ask us: *why LABEF*? *Why now*? There are a number of reasons likely to convince you. But in a simple term, just retain that, our Laboratory was born for science advancement. Using mathematics, we will advance understanding of biological systems including human-nature interactions.

LABEF has started to make distinctive contribution to scientific debate on biological systems including forest resources in Africa. We are convinced that LABEF will continue to advance understanding of biological systems, to develop tools for sustainable assessment and management of forest resources in Africa.

Prof. Dr. Romain Glèlè Kakaï
The Director

Foreword of the head of the research unit of LABEF

Dear readers, thank you for taking your precious time to go through this report

The LABEF is primarily a scientific research institution. Scientific research brings together observations, knowledge and data to solve problems, invent solutions and develop new products for better life. This is also our goal at LABEF. We do believe that by empowering people including decision makers with scientific knowledge, we can contribute to making the world a better place to live in, including us and our future generations.

The LABEF team was born a number of years ago and has been working and growing in numbers until the lab was officially established in 2014.

So far, great research effort has been made, and has covered various domains. Overall, our research falls within four interrelated domains that make up the four research sub-units we have today: Biomathematics & Applied Statistics, Forest Methods, Forest Ecology & Management and Forest & People.

The present report is also to provide a summary of our scientific achievements, and should be viewed as a synopsis of what we have been doing up to date, and not strictly as an annual report for the year 2015.

Personally, I would like to congratulate all our team's members, collaborators and funders for these achievements. These milestones shall not hinder the tremendous work and walk. It is just a starting point as we still have more to do to make this world better.

We invite you to learn more about our work by exploring this first report.

Many thanks

Dr. Valère K. Salako

Head of Research Unit/LABEF

1. Presentation of the laboratory

1.1. Brief description

The Laboratory of Biomathematics and Forest Estimations (LABEF in French) is part of the school of Environment Planning and Management, Faculty of Agronomic Sciences . The Laboratory is headed by Prof. Romain Lucas GLELE KAKAÏ, Full Professor of Biometry and Forest estimations. LABEF is a research institution which aims to enhance the understanding of biological systems through effective use of Biomathematics tools for a sustainable forestry and development. Activities of the Laboratory focus mainly on fundamental and applied research in Forestry and Agroforestry with key emphasize on biological modeling and socio-ecological phenomena.

Using these insights, the Laboratory works on developing and popularizes innovative statistical methods and innovative solutions for forest restoration and management, for the optimal delivery of their multiple ecosystem services.

1.2. History, Mission, Objectives, Vision

In spite of being a fundamental tool in understanding, modelling and prediction, mathematics in general and biostatistics in particular has received little attention in biological sciences and particularly forestry in Africa. To address this issue, the LABEF was created on May 27th, 2014 by Romain GLELE KAKAÏ. Before its creation in 2014, members of LABEF had already been working synergistically and with other partner laboratories since 2008.

The Laboratory of Biomathematics and Forest Estimations aims at analyzing the applicability of mathematics tools in life sciences and at understanding the interactions between ecological processes, anthropogenic factors and structure of terrestrial ecosystems, with a clear link to management and policy.

Our mission is to enhance understanding of biological systems through effective use of biomathematical tools for sustainable forestry and development. The vision of the Laboratory is to be a leading institution in developing mathematical tools for biologists and supporting decision makers in Forestry for better life. In addition, LABEF has a good background in scientific writing and statistical analysis and is frequently solicited by other national and international institutions for statistical analysis.

1.3. Organisation of the Laboratory (Units) with a focus on the research

LABEF is organized in three units namely: Social life, Administrative and Research. The last unit is divided to four interrelated sub-research units namely: Biomathematics and Applied statistics; Forest Methods; Forest Ecology and Management and Forest and People.

- **The research unit on biomathematics and applied statistics** falls into biology and mathematics and are interested in applications of mathematics in the field of biology. This unit is interested not only in the use of mathematical theories in biology but especially publishing scientific notes describing the application of different mathematical tools in life sciences.

- **The Forest Methods unit** falls thus into the overall perspective (assess the wood resources, biomass, mineralomass and carbon stock available in forest ecosystems). Hence, it provides essential information for policy planning and forest resources management of the development of accurate and robust methods for estimating forest resources.
- The goal of **Forest Ecology and Management** is to understand these ecological processes and patterns (forest ecosystems and forest ecosystem services, patterns and processes that govern the ecology of species and the system of which these species are parts, seed ecology and systems) and to develop accordingly clear and applicable management policies for forest managers and decision makers.
- The **Forest & People research unit** is in line with this issue and undertakes investigations on forest governance approaches, their effectiveness and replicability, their socio-economic and ecological outcomes, decision making process, benefit sharing etc.

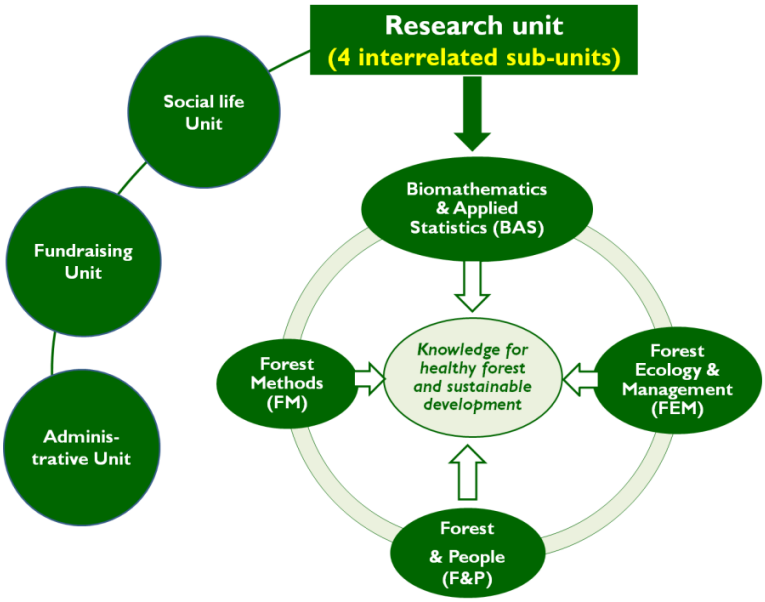


Figure 1: Map showing the description of the research unit.

1.4. Training offer at the Laboratory

The LABEF offers the Master program in Biostatistics at the Faculty of Agronomic Sciences at the University of Abomey-Calavi, Republic of Benin. The Laboratory offer also some short trainings and monthly conference. We offer possibility of capacity building program and internship possibility etc.

1.5. Official inauguration ceremony

The Laboratory of Biomathematics and Forest Estimations was held its opening ceremony on December, 29, 2015. The first lecture was given by Expedite Evariste AGO, doctorate student at the University of Liege, Belgium. Below are some pictures showing the highlights of the inauguration. Apart from the presence of the Vice chancellor of the UAC and of the Dean of the FSA, some teachers, students, laboratory managers, government structures and non-government organizations and journalists were also present. After the opening ceremony, the ribbon was cut-off at the entrance of the laboratory by the rector of the UAC followed by a guided tour of the laboratory. Finally, a cocktail was offered to all guests.

Figure 2: Inauguration of the LABEF head office.

2015 AT A GLANCE

01 Conference room
01 Classroom
01 Library
08 Offices

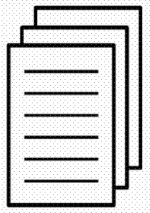
45 affiliates

05 Small Research Grants
01 Medium Research Grant
01 Large Research Grant

04 Projects

18 MSc students
12 PhD students

02 Awards



36 Papers

23 Conferences

2. Data collection and analysis

Data collection for this report was mainly based on research activities performed by researchers and students of the Laboratory during the year 2015.

Firstly, information related to dissertations (ongoing doctorate and masters' studies), scientific articles (published, in press or under review) in peer-review journals (with impact factor or not) and those published through proceedings, books of abstracts and technical reports were used. For each type of publication, the relevant field of specialization was assessed. Then, two categories of papers were obtained: articles with Impact Factor and articles without Impact Factor. The publications of which address of authors and/or co-authors refer to LABEF were only considered. Furthermore, collaborations and co-publications with scientists from developed countries and African countries have been detailed throughout the report. Moreover, the ratio between the number of publications produced individually or by co-publication with national, regional or international teams and the total number of publications in the laboratory was computed. English/French ratio for the published papers was also computed.

Information related to the conferences and seminars (organized by the laboratory and the ones to which the researchers from the laboratory have participated), research projects, grants, prices and awards are presented in the report.

An "appendices" section has been inserted at the end of the report as well as the abstracts of the published papers in the peer review journals in order to allow the assessment of the full references used to compute this report.

3. Scientific activities in LABEF in 2015

3.1. Trend in scientific publications at LABEF until 2014

From 2009 to 2014, members of LABEF published more scientific papers in journals with impact factors (Figure 3a), except in 2009 and 2010 where the number of papers in journals without impact factor was higher than the one published in impact factor journals.

Moreover, the total number of scientific papers published by LABEF's members until 2014 is 115 with relatively higher number of papers published in impact factor journals (Figure 3b).

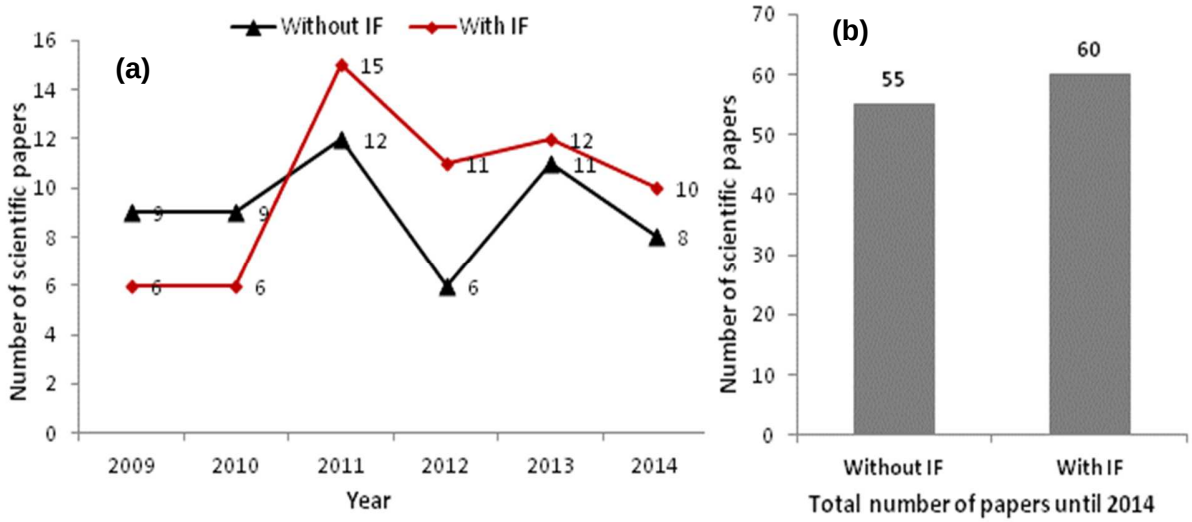


Figure 3: Trend in scientific papers published until 2014.

3.2. Research and publications of LABEF in 2015

3.2.1. *Type of research in LABEF*

During the year 2015, the published articles were mostly produced through national teams. About 37.5 % of the original research papers from the Laboratory were published in international journals with Impact Factor. In total, 24 scientific papers were published in 2015. (Figure 4).

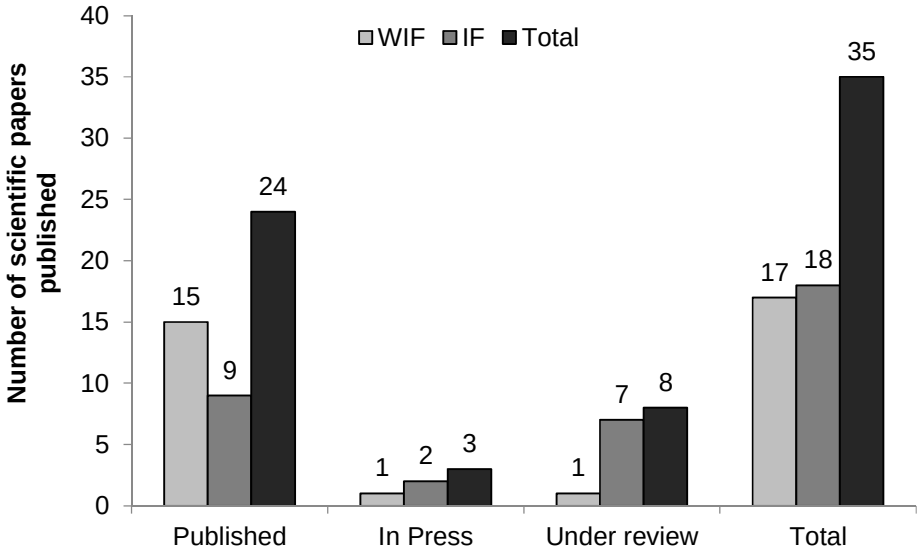


Figure 4: Spectrum of scientific productions of LABEF in 2015.
Legend: IF = Impact Factor; WIF = Without Impact Factor

3.2.2. *Publications in LABEF in 2015*

LABEF works with a wide partnership of local and international research and capacity building institutions. Research teams within LABEF used to publish their research papers in collaboration with national and international scientists (Figure 5). At country level, most of the publications were written with researchers from Benin (57 %). However, some high collaboration could be noticed with scientists from Denmark, Burkina-Faso and Germany (Figure 5).

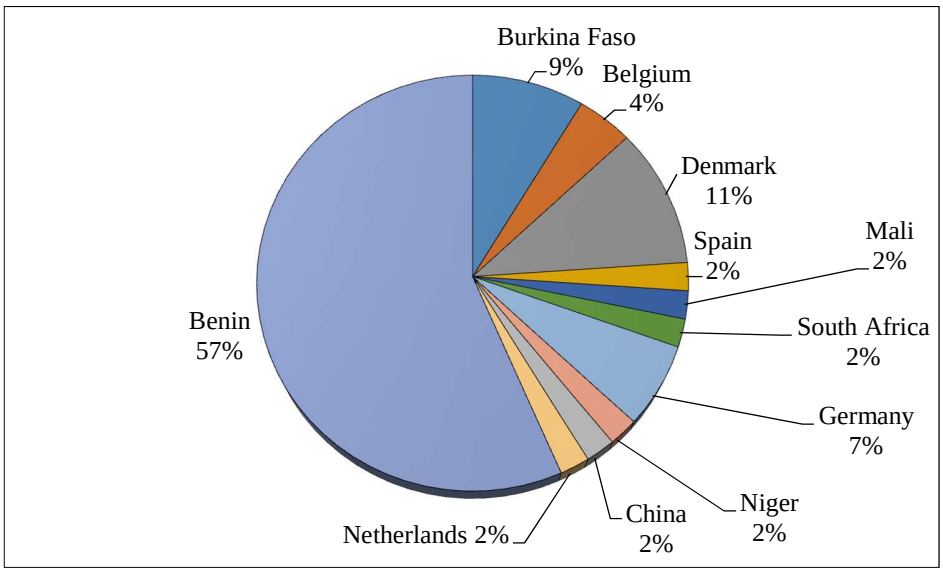


Figure 5: Diversity in indices of the LABEF co-publications in peer review journals at countries scale in 2015.

At the continent level, most of the publications were produced in collaboration with researchers from Africa (72 %; Figure 6) whereas America and Australia were not represented at all in scientific collaborations.

Moreover, the overall English/French ratio of the paper published in 2015 is 7, meaning that 7 papers were published in English and 1 paper was published in French.

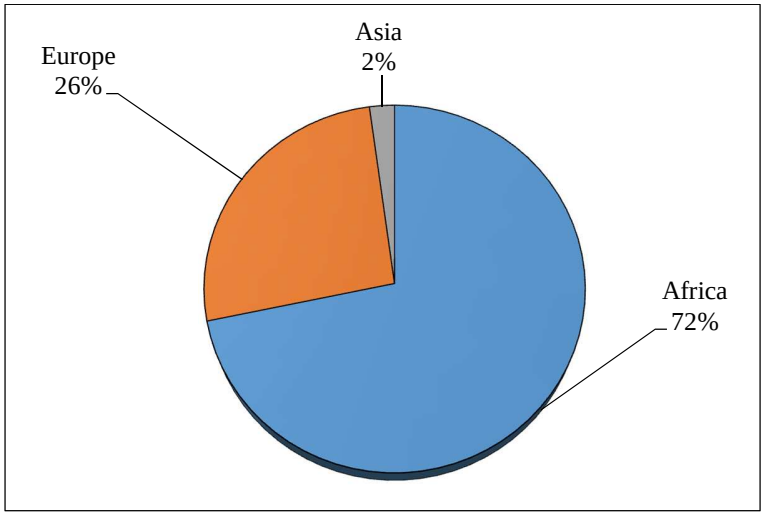


Figure 6: Diversity in indices of the LABEF co-publications in peer review journals at a continent level in 2015.

Theses in LABEF (defended and ongoing)

During the year 2015, LABEF has some 10 doctorate candidates under the supervision of the Director of the Laboratory or other guest researchers and associate members of the Laboratory. Most theses are of the Forest and Ecology management field (Figure 7). Number of doctorate students have already defended their theses by the year ended 2015. In the laboratory of biomathematics and forest estimations, half of the Doctorate students are in the third year of researches (Figure 8).

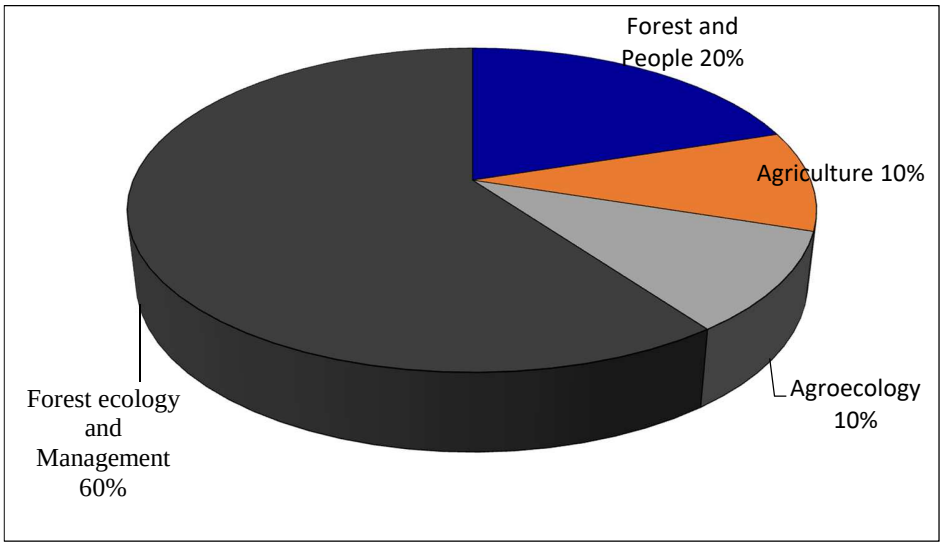


Figure 7: Spectrum of ongoing Doctorate thesis and related field of research in 2015.

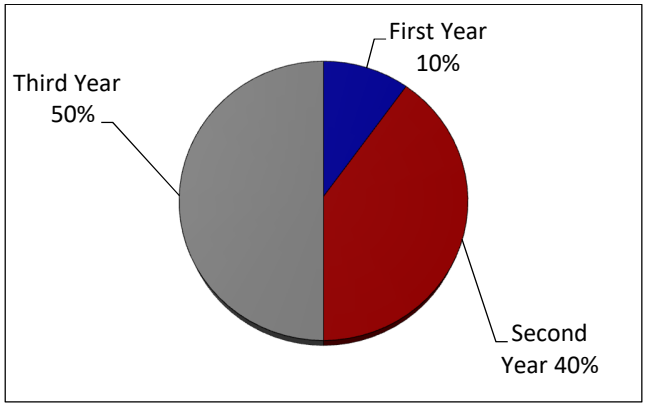


Figure 8: Typology of Doctorate students in LABEF based on the number of year related to their research activities.

Master in LABEF

The number of enrolled students in Master degree in LABEF was 8. These students are enrolled in Master in Biostatistics and Master in Natural resources management.

Articles in LABEF

a) Published articles

During the year 2015, half of the paper published in peer reviewed journals with Impact factor has been of Forest methods and biostatistics and plant ecology while the least represented category was Ethnobiology (Figure 9).

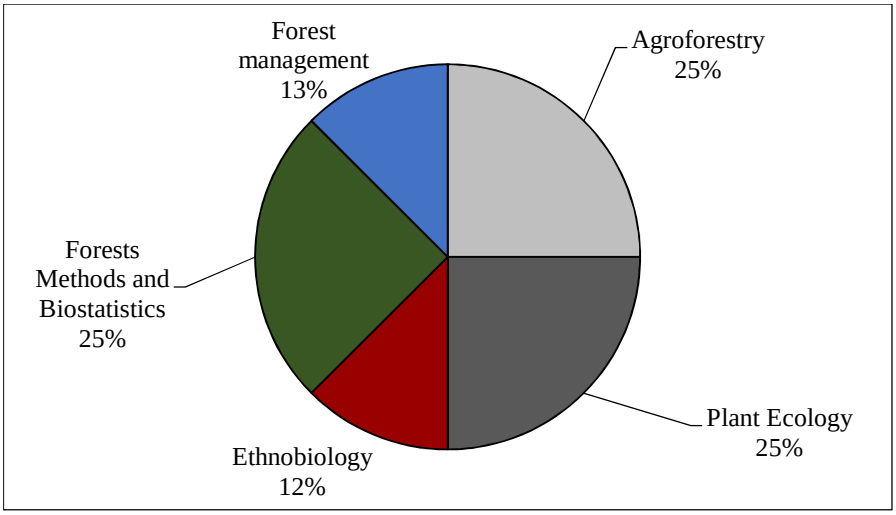


Figure 9: Articles published in journals with IF according to the main fields of research in 2015.

During the year 2015, most of the peer reviewed papers published by researchers without impact factor were of Forest ecology and management field (29 % Figure 10) while few publications were of Environment and health field (6 %).

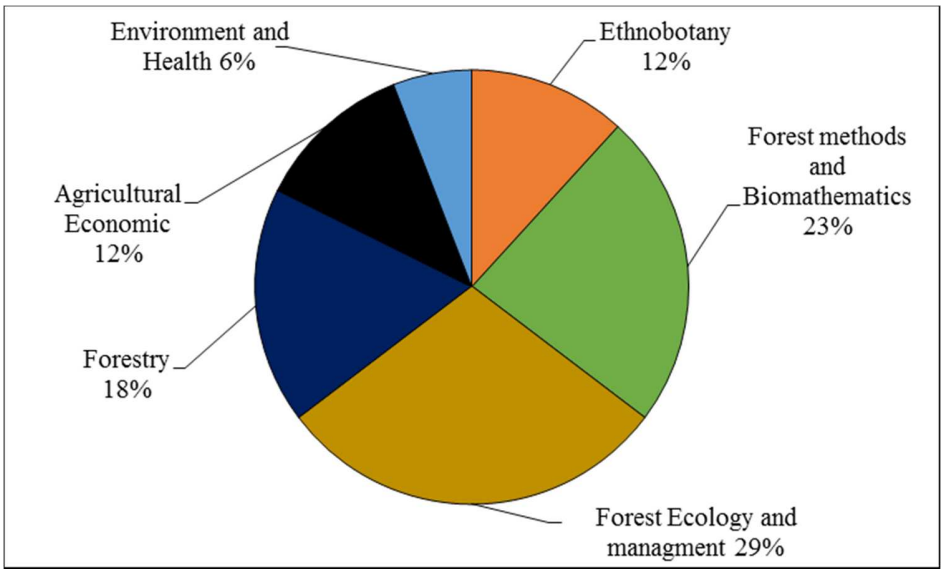


Figure 10: Articles published in journals without IF according to the main fields of research in 2015.

b) Articles in press

Most of the articles in press in LABEF in 2015 belong to Forest ecology and management field (37 %) whereas Ethnobotany (15 %) and Forest and people (15 %) represent the least (Figure 11).

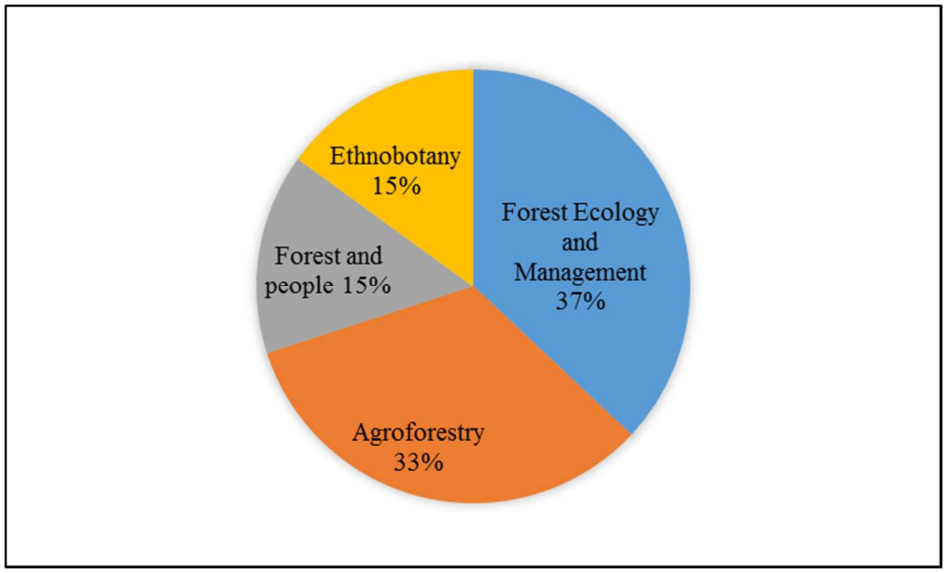


Figure 11: Articles in press according to the fields of research in 2015.

c) Articles under review

Researchers from LABEF submitted papers which are under review in 2015 and it is mainly belong to Plant ecology (37 %) and Forest and People (37 %) research areas (See Figure 12).

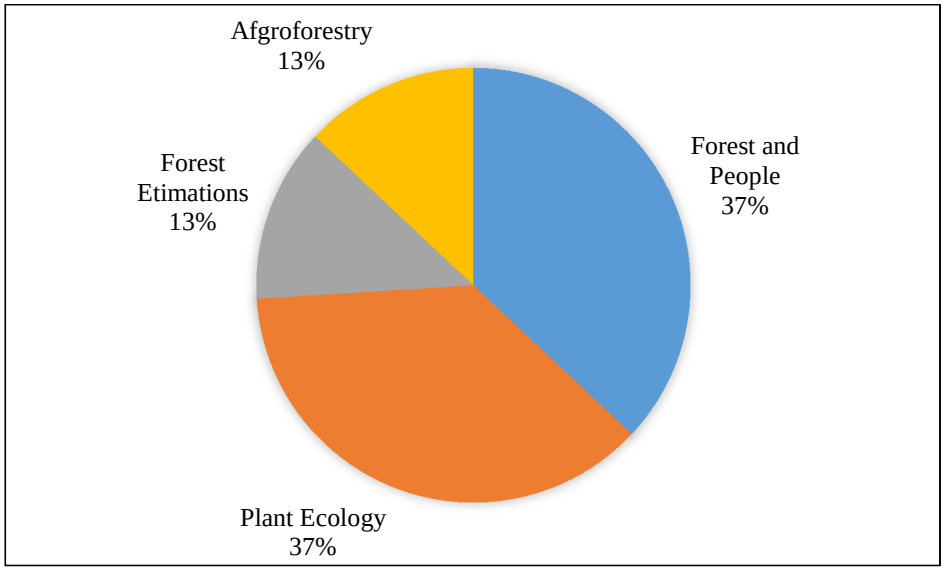


Figure 12: Articles under review according to the fields of research in 2015.

Participation in international conferences and workshops

LABEF has registered participation of several of its researchers to local and international conferences (Figure 13). The researchers of the Laboratory have participated to more conferences and seminars in Africa than elsewhere. In 2015, researchers participated in 21 conferences/workshops. About 67 % of these conferences were held in Africa, 23 % in Europe, 4.77 % in Asia, and 4.77 % in USA (Figure 14). Details related to these conferences/workshops are listed in appendix 15. Most of the conferences and seminars at which the researchers at LABEF have been fully or partially been supported by the University through competitive funds for researches of the University of Abomey-Calavi or through support by international organizations (appendices 1-12). These seminars mainly addressed modelling ecological niche, populations' patterns analysis, animal-plant relationship, environmentally friendly agriculture for livelihoods improvement, better forest management. Moreover, internal seminars have been set in LABEF and take place monthly.

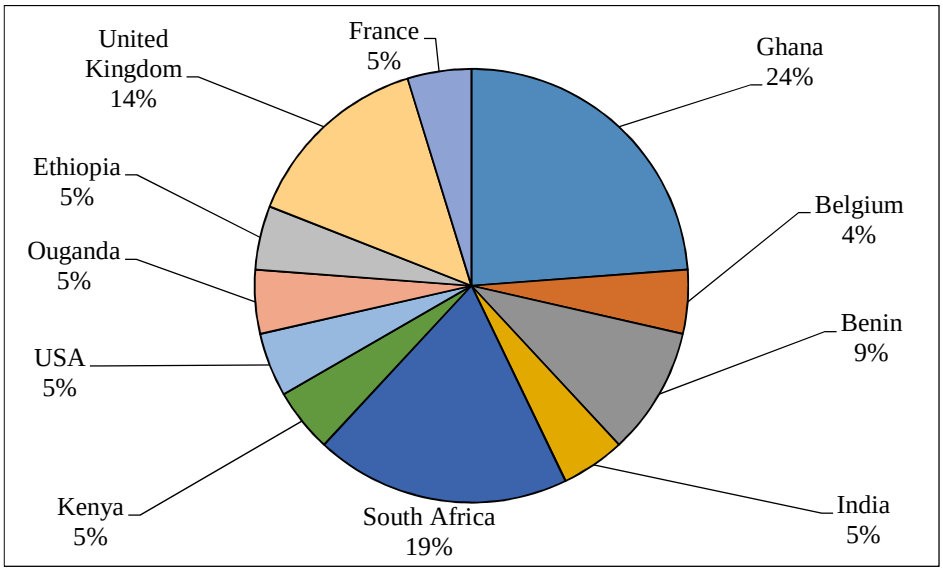


Figure 13: Level of participation of LABEF's researchers to workshops/conferences.

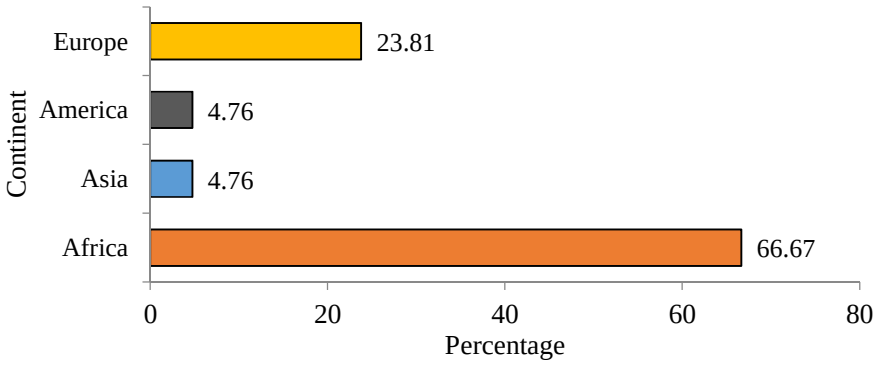


Figure 14: Level of participation to conferences/workshops at the continent level.

Outcomes from the conferences have been often published in books of abstracts. Most of the published abstracts are of the field of Ethnobiology (Figure 15).

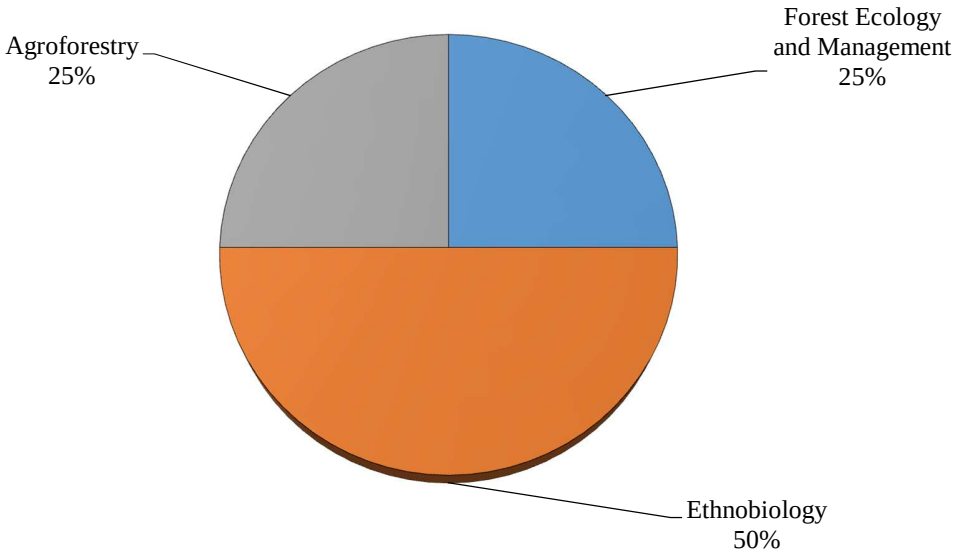


Figure 15: Indices of publications specialization in books of abstracts in 2015.

3.3. Projects, research grants and awards

The research activities in LABEF were mainly funded by international foundations and institutions (small research grants: 56 %), regional and international co-operation projects (Project Jatropha with African Union, Sustainable Cotton Production in Africa with Danish partners, Insect as feed for West Africa with Switzerland partners, Integrated sweet potato weevil (*Cylas spp.* With Bill & Melinda Gates Foundation, promoting environmentally friendly practices for sustainable baobab leaves production with RUFORUM, Assessing the Effects of

Land Uses on Ecosystem Services provided by Trees and Forests in a Landscape Context with African Forest Forum, etc.). Sixty-two percent of these supported projects are still ongoing (Figure 16). Most of the doctorate students and other researchers are involved in these projects. Details (objectives, status, etc.) on these projects and grants are described in appendices 1-13.

Four of LABEF researchers have received special award for outstanding research or participation to international conferences (see appendix 1-12).

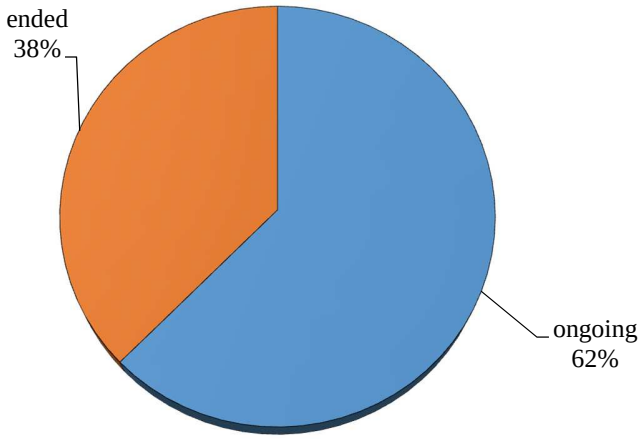


Figure 16: Grants received by LABEF researchers during the year 2015.

4. The master programme in Biostatistics

The Master in Statistics with major in Biostatistics offers an extensive and unique training in recent statistical methods and tools toward their applications in Life sciences. At the end of the training, graduated students can easily go into professional life as Biostatistician or engage in research in Biostatistics by integrating a doctoral school. This training is open to Bachelor Degree holders in Life Sciences domains (agronomy, health, biology, environment, etc.), or in Mathematics/Statistics or Master Degree holders wishing to acquire knowledge and know-how in the field of data collection and analysis. The Master in Biostatistics has fully trained a batch of students who defended their thesis (appendix 3) and is currently holding its 3rd batch of students. Distribution of students according to years and nationalities are illustrated by Figure 17 and 18. From two nationalities for the first cohort (Togo and Benin), the programme includes twelve nationalities for the third cohort, meaning an expansion of the master scope in Africa (Figure 17).

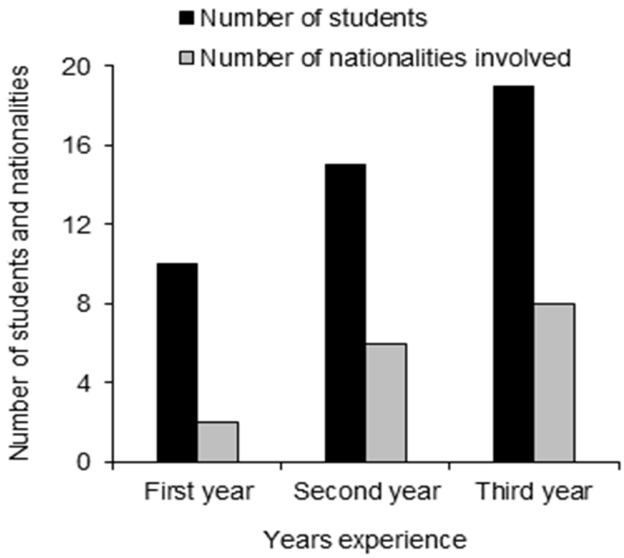


Figure 17: Number of students and nationalities involved in the master programme in Biostatistics.

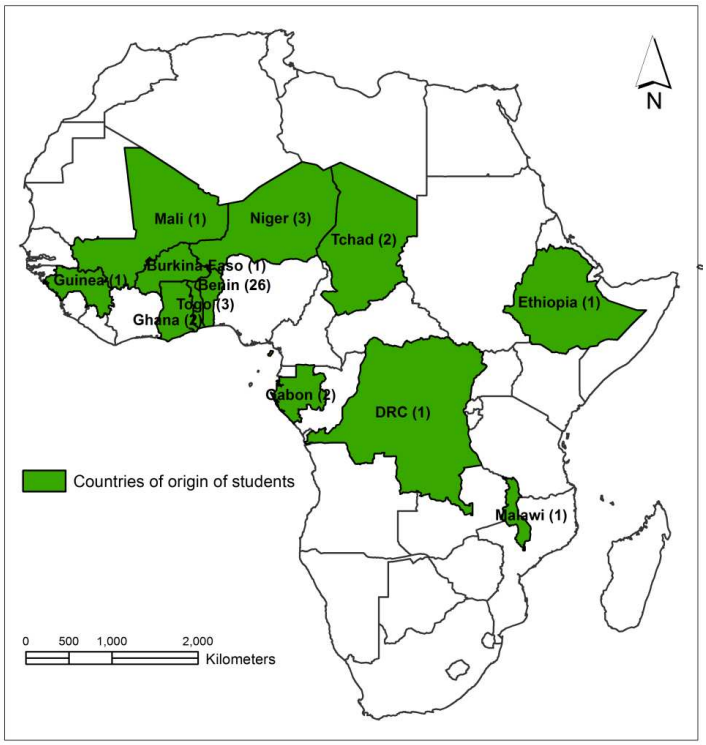


Figure 18: Map of Africa showing the countries involved in the master programme.

The map of Africa showing the countries that have already participated in the training (Figure 18) reveals that several African sub-regions (Eastern, Central, Southern and Western) are

involved in the programme. However, very little participation of women is noticed. Indeed, only three women from the third year are registered for the three-year experience. The programme is supported by an Intra-ACP Academic Mobility Programme (AGREEMENT NUMBER 2013-4177/001-001) that offers grant to students to register and follow the course. Moreover, some other partnerships have been established with different African institutions (PPAAO Benin, PPAAO Niger, IRAG Republic of Guinea, ITRAD Tchad, etc.).

What are Professional perspectives?

The field of Biostatistics is expanding. It deals with various sectors. The abilities this training gives in data collection, management, statistical analysis and valorization allow graduates to practice job of Biostatisticians in charge of Statistical Studies in various sectors. Biostatisticians are needed in Food Enterprises, Projects, Health Sector (Units of Clinical research), Department of Medical Information, ...), Public and Private Research Institutions, Non-Governmental Organizations (NGO), International Organization (FAO, UNDP, World Bank, etc.); Education and International Research Institutions.

What are required conditions?

Applicants should hold a Bachelor or a Master degree in agronomic sciences, biological sciences, pharmaceutical sciences, environment sciences or mathematics. Admission to the training is based on the quality of application (and if necessary an interview). Selection takes into account academic records, professional experience, prerequisites in Statistics/Mathematics and Motivation.

How to apply?

Visit the website www.labef-uac.org and fill in the online application form (http://labef-uac.org/application). Candidates from Benin could submit their applications to the secretary of the programme, located at the Laboratory of Biomathematics and Forests Estimations.

Required documents

Required documents for the Master are as follows:

- Motivation letter (to the Coordinator of the Master)
- Academic degrees
- Academic transcripts
- Certified copy of the Certificate of Birth
- Curriculum vitae
- Program of the courses already followed by the applicant.

5. Visiting researchers and Internships in LABEF

Four internships have been previously hosted by the LABEF from elsewhere. Details of this internship are below (Table 1). Summaries of the studies implemented by each of the internships are found in Appendix 4.

Table 1. List of interns hosted by LABEF until 2015

Name	Home country	Institution	Type of internship	Duration
CAMARA Mariama	Senegal	WASCAL	Research (PhD) data analysis	01 December 2015 to 8 January 2016.
CODOU Laurice	Senegal	WASCAL	Research (PhD) data analysis	06 November to 16 December 2014
SAGBOHAN Harris Dieu-Donné	Nigeria	University of Ilorin	Academic	2 to 30 September 2013
GORGON Igor	Togo	University of Lome	Academic	01 to 31 January 2013

6. General discussion and conclusion

Various types of publications were produced by researchers in 2015 as it was the case in previous years. From year to year, researchers from LABEF try to publish more papers in journals with impact factor. The global trend of published papers in peer review journals in LABEF, is increasing since 2009. This can be explained by the increase of researchers, research projects and grants for holding a doctorate thesis, doctorate students and MSc students since 2009. Indeed, with more projects and grants, more papers were published with lower cost per publication and impact factor unit. It is also due to increase in collaborations and partnerships with outstanding international Universities (E.g. University of Kansas in USA, University of Stellenbosch in South Africa, etc.). The number of published articles in journals with Impact Factor has considerably increased since 2009. This means that researchers are improving their publication skills and the quality of their investigation.

Another reason for this is the change in the requirements before defending a doctorate thesis at the Faculty of Agronomic Sciences which hosts LABEF (i.e. having published in the time frame of the doctorate studies at least 2 original research papers). As such, the scientific capacity of research teams in the laboratory is high. Published articles in 2014 were mostly produced at African level (76 % of them are mainly Beninese).

Published articles in peer review journals were mostly produced by teams of local and national level compared to international level. This could be explained by the fact that

researchers find it easier to have a paper fast published when all team members are together and belong to the same institute than the contrary. However, more international collaborative researches and projects are suggested. Agroforestry and Forest Ecology and management are currently the main fields producing scientific publications in the laboratory.

The Master in Biostatistics has fully trained a batch of students who defended their theses and is currently holding its 3rd batch of students. Trends of the origin of students involved showed an interesting variability and a good coverage of African regions. This is really promising and reveals a relatively good sharing of the programme across Africa. However, for the coming years, an increase in the current number of nationalities being involved would denote the trust in the programme and its successfulness in capacity building.

For now, little scientific collaboration are ongoing with scientists from Latino America, Australia, Middle East and northern Africa. This is due to the fact that few of LABEF researchers travelled to these parts of the world and did not really connect with researchers for scientific collaborations. Thus, it suggests the need of more and sustainable efforts for building cooperative research networks basically using interactive research topics and funds from these parts of the world. Moreover, since 2009, articles have been mostly published with researchers from Africa than elsewhere. As such, regional scientific collaborations should be maintained while international collaborations should be really encouraged for more scientific impact and more achievement for the following years.

The laboratory hosted only 4 researchers for internships until 2015. Those researchers were all from the West African regions. This is relatively low compared to the laboratory expectations but constitutes a good starting for a new institution and should be highly encouraged in the coming years as it will increase visibility of the laboratory.

Based on the findings from the present report, it is suggested that the laboratory:

(1) increases its visibility through one open day per year for the laboratory;
(2) improves its current research achievement in order to increase the number of papers published;
(3) develops more research collaboration with researchers from currently poorly known areas;
(4) encourages participation of the researchers to international meetings;
(5) encourages researchers in more international project development.

Acknowledgements

We would like to thank all the great contributors to the current report especially the different heads of sub-units from the Laboratory and Romeo J. Tohoun for his unconditional help.

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http://scientific.thomson.com/products/wos/

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http://www.labef-uac.org/

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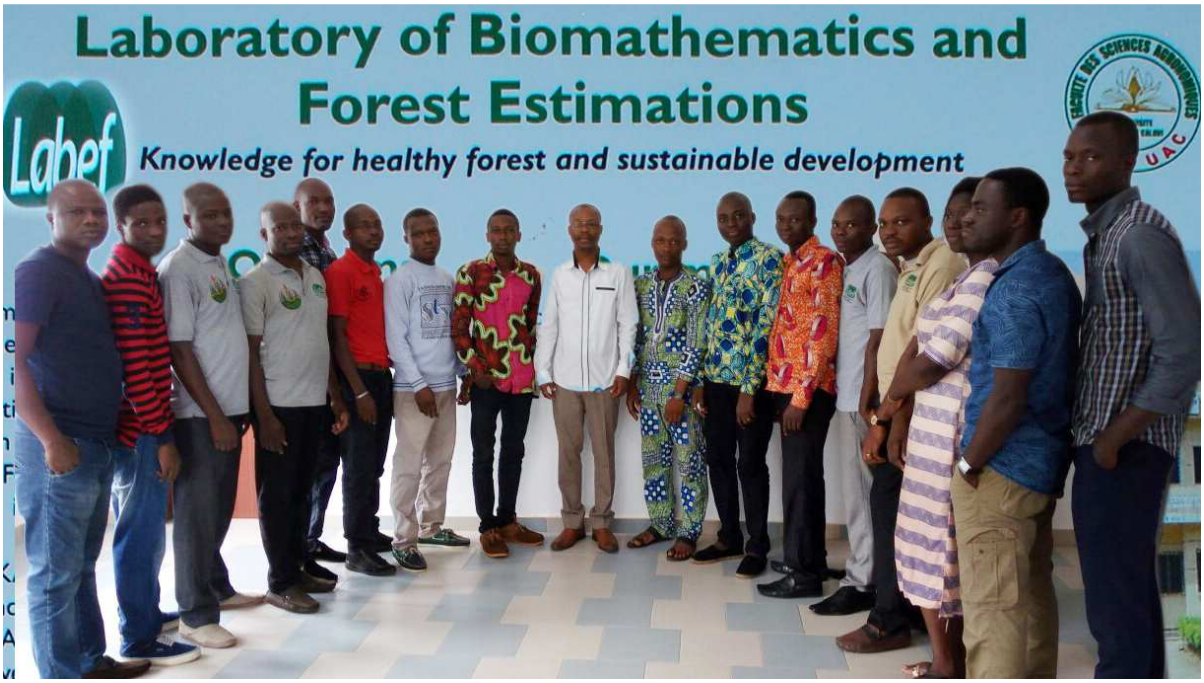

Group photo of some members of LABEF

Appendices

Appendix 1. Scientific activities report of the Laboratory of Biomathematics and Forest Estimations (LABEF)

Appendix 1-1. Ongoing doctorate theses

N°	Student full name	Level	Research topics	Field of Research
1	IDOHOU Alix Frank Rodrigue	3rd year	African wild palms: Ecological patterns, knowledge gaps, conservation and domestication in Benin	*Forest resources management*
2	SALAKO Kolawolé Valère	3rd year	Population ecology, pattern of uses and conservation of the dioecious palm tree *Borassus aethiopum* Mart. (Arecaceae) in Benin, West Africa	*Forest resources management*
3	HOUNKPEVI Achille	3rd year	Conservation and ecological adaptations of the black plum (*Vitex doniana* sweet) to climatic conditions in Benin, West Africa	*Forest Ecology and Management*
4	DONOU HOUNSODE Tadogbè Marcel	3rd year	Usage, Ecologie et Biologie de la Conservation des palmiers raphias au Bénin (Afrique de l'Ouest)	*Forest resources management*
5	SINASSON SANNI Koupamba Gisèle	3rd year	Ethnobotany and Ecology of Conservation of *M. andongensis* and M. kummel in Benin (West Africa)	*Plant ecology and conservation*
6	AKPONA T. Jean Didier	2nd year	Inventory, prioritization and population viability analysis of timber species involved in logging in Benin (West Africa)	*Forest resources management*
7	GBEDOMON Castro Rodrigue	2nd year	Home gardens: Potential, opportunities and challenges for agrobiodiversity conservation	*Agroecology*
8	KISITO Gandji	2nd year	Modelling ethnobotanical patterns of *Moringa oleifera* Lam. in Benin (West Africa)	*Ethnobotany, Conservation Biology, Neglected and under-utilized species*
9	MENSAH Sylvanus	2nd year	A quantitative framework to assess key ecosystem services provided by trees and forest in a landscape context	*Forest estimation Biodiversity, Ecosystem function and services*
10	ECLOU Innocent	1st year	Assessment and analysis of agro-ecological aspects of cotton farming systems for a sustainable cotton production in Benin.	*Environmental chemistry and agronomy*

Appendix 1-2. Completed Master degree in 2015

N°	Student full name	Research topics	Field of Research
1	LOKONON E. Bruno	Generalized linear models with Poisson family: applications in ecology	*Biostatistics*
2	AMAGNIDE Aubin	Longitudinal data analysis: fitting an optimal variance-covariance structure under linear mixed effects models framework	*Biostatistics*
3	HOUNMENOU Castro	Estimation of population pharmacokinetic parameters with sparse data in Nonparametric nonlinear mixed effect model	*Biostatistics*
4	SAVI Merveille	Empirical assessment of relative performance of three permutation methods in one way analysis of variance framework	*Biostatistics*

N°	Student full name	Research topics	Field of Research
5	TCHANDAO MANGAMANA Essomanda	Application of common components and specific weights method to analyze local perception patterns of land degradation in northern Benin (West Africa)	*Forest and Ethnobotany*
6	ADJOBO CHABI Ayédesso Marc Aurèle	Production unit's efficiency analysis using metafrontier: Application to conventional and organic cotton in Benin	*Agriculture*
7	DOULABE Kossi Naténa	Semiparametric and parametric proportional hazards models: Application to survival of HIV/AIDS patients on antiretroviral treatment	*Biostatistics*
8	MOUSSA ALI Abdourazak O	Performances agro-morphologiques des variétés locales et améliorées de maïs (*Zea mays* l.) au sud-ouest du Niger	*Agriculture*
9	VIANOU Aldrich	Impact of climate change on geographic distribution of suitable areas of *Mondia Whitei* (hook.f.) Skeels (apocynaceae), in Dahomey-gap	*Forest Ecology*
10	AMADOU ISSA Safi	Diversité, prioritisation et connaissances ethnobotaniques des espèces prioritaires dans la commune rurale de Tondi kiwindi au Niger	*Biodiversity and Ethnobotany*

Appendix 1-3. Ongoing Master degree

N°	Student full name	Research topics	Field of Research
1	ANAGO CODJO Vêtindo Mélain	Perfomences agroécologique de trios systems de production de coton	*Biodiversity*
2	SERO Baro Nadejda	Effectiveness of different contrast methods in selecting the optimal baobab leaves production techniques in Benin.	*Biostatistics*
3	GOSSOU BAH Daniel	Geographical distribution, population structure of *Pterocarpus erinaceus* Poir across ecological regions in Benin	*Forest and ecology*
4	HINSON Abel Dieudonné	Analyse des interactions spatiales entre espèces du sous-bois et de la strate arborescente dans la Forêt Classée de la Lama: implications pour les enrichissements	*Forest ressources management*
5	ZANVO Serge G. E. M.	Approche méthodologique de quantification du stock de Carbone dans une forêt marécageuse: cas de la forêt de Lokoli (Sud-Bénin)	*Forest Estimations*
6	HOUNSOU-DINDIN		

Appendix 1-4. Articles published in peer-review journals with IF in 2015

Disciplines	N°	Authors' Names	Title of the article	Reference	Impact Factor
Agroforestry	1	AKPONA T. J. D., AKPONA H. A., DJOSSA B. A., SAVI M. K., DAÏNOU K., AYIHOUENOU B., GLÈLÈ KAKAÏ R.	Impact of land use practices on traits and production of shea butter tree *(Vitellaria paradoxa* C.F. Gaertn.) in Pendjari Biosphere Reserve in Benin	*Agroforestry Systems xx-xxx DOI 10.1007/s10457-015-9847-1*	1.215

Disciplines	N°	Authors' Names	Title of the article	Reference	Impact Factor
Plant domestication	11	IDOHOU R., ASSOGBADJO A.E., HOUEHANOU T., GLELE KAKAI R., AGBANGLA C.	Variation in *Hyphaene thebaica* Mart. Fruit: physical characteristics and factors affecting seed germination and seedling growth in Benin (West Africa).	*Journal of Horticultural Science & Biotechnology 90: 291–296*	0.54
Ethnobiology	2	GBEDOMON R.C., FANDOHAN A.B., SALAKO K.V., IDOHOU A.F.R, GLÈLÈ KAKAÏ R., ASSOGBADJO A.E.	Factors affecting home gardens ownership, diversity and structure: a case study from Benin	*Journal of Ethnobiology and Ethnomedicine 11:56*	2.00
Forest management	3	TOVISSODÉ F.C., HONFO H.S., SALAKO V.K., GNANGLÈ C.P., MENSAH S., GLÈLÈ KAKAÏ R.	Population structure of two bamboo species in relation to topographical units in the Republic of Benin (West Africa): implications for sustainable management	*Acta Botanica Gallica: Botany Letters, 16: 89-96.*	0.479
Forest methods	4	GNONLONFOUN I., GLÈLÈ KAKAÏ R., SALAKO V.K., ASSOGBADJO A.E., A. OUÉDRAOGO	Structural analysis of regeneration in tropical dense forest: combined effect of plot and spatial distribution patterns.	*Acta Botanica Gallica. 162: 79-87.*	0.479
Animal-plant interactions	6	SALAKO V.K., AZIHOU A.F., ASSOGBADJO A.E., HOUÉHANOU T.T., KASSA B.D., GLÈLÈ KAKAÏ R.L.	Elephant-induced damage drives spatial isolation of the dioecious palm Borassus aethiopum Mart. (Arecaceae) in the Pendjari National Park, Benin.	*African Journal of Ecology 54:9-19*	0.688
Plant ecology	7	SALAKO V.K., ASSOGBADJO A.E., ADOMOU A.C., AGBANGLA C., GLÈLÈ KAKAÏ R.L.	Latitudinal distribution, co-occurring tree species and structural diversity of the threatened palm *Borassus aethiopum* (Arecaceae) in Benin, West-Africa.	*Plant Ecology and Evolution 148: 335–349*	1.197
Forest methods	9	DONOU HOUNSODE M.T, GLELE KAKAI R., AZIHOU F., OUEDRAOGO A.	Efficiency of inventory plot patterns for the estimation of woody vegetation recruit density in a tropical dense forest in Benin	*African Journal of Ecology 53: 355–361*	0.688

Appendix 1-5. Articles published in peer-review journals without IF in 2015

Disciplines	N°	Authors' Names	Title of the article	Journals
Plant Ecology and modeling	1	GBEMAVO D.S.J.C., GANDJI K., GNANGLÈ P.C., ASSOGBADJO A.E., SOKPON N., GLÈLÈ KAKAÏ R.L.	Adaptation écologique et modélisation du rendement du *Jatropha curcas* L. en fonction des caractéristiques morphologiques des plants le long d'un gradient climatique.	*Agronomie Africaine. 27: 201-211*
Ethnobotany	2	HOUÈTCHÉGNON T.,	Ethnobotanical knowledge and traditional	*The Journal of Ethnobiology and*

Disciplines	N°	Authors' Names	Title of the article	Journals
		GBÈMAVO D.S.J.C., OUINSAVI C., SOKPON N.	management of African mesquite (*Prosopis africana* Guill., Perrot. et Rich.) populations in Benin, West Africa.	*Traditional Medicine. 125: 1124-1135*
Biodiversity Informatics	3	IDOHOU R., ARINO A., ASSOGBADJO A.E., GLÈLÈ KAKAÏ R., SINSIN B.	Diversity of wild palms (Arecaceae) in the Republic of Benin: finding the gaps in the national inventory by combining field and digital accessible knowledge.	*Biodiversity Informatics 10: 45-55*
Forestry	4	HOUÈTCHÉGNON T., GBÈMAVO D.S.J.C., OUINSAVI N.C., SOKPON N.	Morphological Variability of *Prosopis africana* (Guill., Perrott. Et Rich.) Taub in Benin, West Africa.	*American Journal of Plant Sciences. 6, 1069-1079*
Forestry	5	GBEMAVO D.S.J.C., GANDJI K., GNANGLÈ P.C., ASSOGBADJO A.E., GLÈLÈ KAKAÏ R.L.	Variabilité morphologique et conservation des morphotypes de *Jatropha curcas* L. (Euphobiaceae) au Benin.	*Journal of Agriculture and Environment for International Development. 109: 55 - 69*
Forestry	6	HOUÈTCHÉGNON T., GBÈMAVO D.S.J.C., OUINSAVI N.C., SOKPON N.	Structural Characterization of *Prosopis africana* Populations (Guill., Perrott., and Rich.) Taub in Benin.	*International Journal of Forestry Research. Volume 2015:101373*
Ecology	7	DADEGNON S. GBEMAVO C. OUINSAVI C. SOKPON N.	Morphological Variation and Ecological Structure of *Chrysophyllum albidum* G. Don.	*International Journal of Plant & Soil Science. 5:25-39*
Environment and health	8	HOUEVOGANWA M.C., OUINSAVI C., GOUDEGNON E., GBEMAVO C., SOKPON N., AKPONA S.	Dynamique spatio-temporelle de la végétation et des simulies vecteurs de l'onchocercose cécitante au Bénin.	*International journal of biological and chemical sciences. 8:1669.*
Agricultural Economics	9	SODJINOU E., HENNINGSEN A., KOUDANDÉ D.O., BIAOU G., MENSAH G.A.	Consumers' preferences for "bicycle poultry" in Benin: Implications for the design of breeding schemes	*Review of Agricultural and Environmental Studies. 388-8441*
Agricultural Economics	10	SODJINOU E., GLIN L.C., NICOLAYG., TOVIGNAN S., HINVI J.	Socioeconomic determinants of organic cotton adoption in Benin, West Africa	*Agricultural and Food Economics 3:12*
Forest management	11	HONFO HS, TOVISSODÉ FC, GNANGLÈ CP, MENSAH S, SALAKO VK, ASSOGBADJO AE, AGBANGLA C, GLÈLÈ KAKAÏ R	Traditional Knowledge and Use Value of Bamboo in Southeastern Benin: Implications for sustainable management	*Ethnobotany Research & Applications 14:139-153*
Ethnobotany	12	LALEYE FOA, MENSAH S, ASSOGBADJO AE, AHISSOU H	Diversity, knowledge and use of plants in traditional treatment of diabetes in Republic of Benin	*Ethnobotany Research & Applications 14:231-257*
Plant ecology	13	FANDOHAN A.B., SALAKO V.K., ASSOGBADJO A.E.,	Effect of climatic conditions on flowering and fruiting of *Tamarindus indica*	*Journal of Horticulture and Forestry. 7: 186-192*

Disciplines	N°	Authors' Names	Title of the article	Journals
		DIALLO B.O., VAN DAMME P., SINSIN B.	(Fabaceae).	
Forest ecology and management	14	AMAGNIDÉ A.G., SALAKO V.K., DONOU HOUNSODÉ M., SINSIN F., ORÉKAN V., DAN C., GLÈLÈ KAKAÏ R.	Ecological consequences of anthropogenic pressure in Wari-Maro Forest Reserve (Benin, West Africa).	*Journal of Agriculture and Environment for International Development. 109 (2): 271-289*
Plant Domesticación	15	AGOYI E.E., PADONOU E.A., AMOUSSA W., ASSOGBADJO A.E, GLÈLÈ KAKAÏ R., SINSIN B.	Morphological variation, cultivation techniques and management practices of Moringa oleifera in Southern Benin (West Africa)	*International Journal of Agronomy and Agricultural Research 6:97-105*

Appendix 1-6. Articles in press in peer-review journals with IF 2015

Disciplines	N°	Authors' Names	Title of the article	Journals	Impact Factor
Forest ecology	1	MENSAH S, HOUÉHANOU DT, ASSOGBADJO AE, ANYOMI K, OUEDRAOGO A & GLÈLÈ KAKAÏ R	Latitudinal variation in the woody species diversity of *Afzelia africana* Sm. habitats in West Africa	*Tropical Ecology. xx-xxx*	0.887
Animal-plant interactions	2	SALAKO V.K., HOUÉHANOU T.T., YESSOUFOU K., ASSOGBADJO A.E., AKOÈGNINOU A., GLÈLÈ KAKAÏ R.L.	Patterns of elephant utilization of *Borassus aethiopum* Mart. and its stand structure in the Pendjari National Park, Benin, West Africa	*Tropical Ecology xx-xxx*	0.887

Appendix 1-7. Articles under review in peer-review journals with IF in 2015

Disciplines	N°	Authors' Names	Title of the article	Journals	Impact Factor
Plant ecology	1	HOUNKPÈVI, A., KOUASSI, K. E. GLÈLÈ KAKAÏ, R.	Effects of climatic variability and local environment patterns on the ecology and population structure of the multipurpose plant species, *Vitex doniana* Sweet (Verbenaceae) in Benin	*Tropical Ecology*	0.887
Agroforestry	2	IDOHOU R., ASSOGBADJO A. E., AZIHOU F., GLELE KAKAÏ R., ADOMOU A.	Influence of the landscape context on stand structure and spatial patterns of the doum palm (*Hyphaene thebaica* Mart.) in the Republic of	*Agroforestry systems*	1.215

Disciplines	N°	Authors' Names	Title of the article	Journals	Impact Factor
			Benin (West Africa)		
Plant morphology	3	HOUNKPÈVI, A., AZIHOU A. F., KOUASSI K. E., POREMBSKI, S. & GLÈLÈ KAKAÏ, R.	Climate-induced morphological variation of black plum (*Vitex doniana* Sw.) in Benin, West Africa	*Genetics Resources and Crop Evolution*	1.461
Community forestry	4	GBEDOMON R.C., FLOQUET A., MONGBO R., SALAKO K.V, FANDOHAN A.B, ASSOGBADJO A.E., GLÈLÈ KAKAÏ R.	Socio-economic and ecological outcomes of Community based forest management: A case study of Tobe-kpobidon forest in Western Africa	*Forest Policy and Economics*	1.85
Social Forestry	5	GANDJI K., SALAKO V. K., ASSOGBADJO A. E., OREKAN V. O. A., GLÈLÈ KAKAÏ R.L., SINSIN B.	Sustainability of participatory management of forest plantations: Case study of the Wari-Maro Forest Reserve, Benin (West Africa)	*Southern Forests*	0.904
Plant ecology	6	SINASSON G. K. S., SHACKLETON C. M., GLÈLÈ KAKAÏ R. L., SINSIN B.	Impact of Forest Degradation and Invasive Species on the Population Structure of *Mimusops andongensis* (Sapotaceae)	*Biotropica*	2.084
Forest estimation	7	MENSAH S, VELDTMAN R & SEIFERT	Allometric Models for Height and Above Ground Biomass of Dominant Tree Species in South African Mistbelt Forests	*Southern Forests*	0.9

Appendix 1-8. Articles under review in peer-review journals without IF in 2015

Disciplines	N°	Authors' Names	Title of the article	Journals
Ethnobotany	1	HOUNKPEVI, A., FANDOHAN, A. B., KOUASSI K. E., KOUAME, N. F. & GLELE KAKAÏ, R.	Use values and traditional ecological knowledge on impacts of climate change on the black plum (*Vitex doniana* Sweet)	*SpringerPlus*

Appendix 1-9. Abstracts in books of abstracts in 2015

Field of research	N°	Authors' Name	Title	Full References
Social forestry	1	GANDJI K., SALAKO V K., ORÉKAN VO.A., ASSOGBADJO A. E., GLÈLÈ KAKAÏ R L., SINSIN B.A.	Assessment of the participatory management of forest plantations: Case study of the Wari-Maro Forest Reserve, Benin (West Africa)	Abstract book of the Pre-XIV World Forestry Congress Workshop, Forest People and Environment: Some Perspectives From Africa, 4-6th

Field of research	N°	Authors' Name	Title	Full References
				September 2015, Durban, South Africa, pp: 3.
Ethnobiology	2	G. SINASSON, SHACKLETON C., SINSIN B.	Local knowledge, diversity and pattern of use of Mimusops species in Benin	Department of Environmental Sciences Annual Research Forum, 8 & 9 October 2015, Rhodes University, South Africa
Ethnobiology	3	SINASSON G., SHACKLETON C., SINSIN B.	Ethnobotanical study of *Mimusops andongensis* Hiern in Benin (West Africa)	Proceedings of the Indigenous Plant Use Forum (IPUF) & Society for Economic Botany (SBE) Joint Conference on "Global Vision on Indigenous Plants and Economic Botany". Clanwillian, Western Cape, South Africa, 28th June-2nd July 2015
Animal-plant interactions	5	SALAKO V.K., GLELE KAKAÏ R.	Stand-level spatial analysis of elephants-induced damages predicts spatial isolation in the dioecious palm *Borassus aethiopum* Mart. (Arecaceae) in the Pendjari National Park	Tropical Biology Association Alumni Group (TAAG) conference, 9-12 June 2015. Accra, Ghana. Oral communication.

Appendix 1-10. Technical Reports and books in 2015

N°	Authors' Name	Title	References
1	ARODOKOUN U., ODOULAMI R., IDOHOU R.	Méthodes d'animation et d'intervention en milieu réel. Village de Hinvi Dovo, Commune d'Allada au Sud-BENIN	Editions Universitaires Européennes. 20 p

Appendix 1-11. Participation at workshops/conferences in 2015

N°	Title and period	Type of presentation (oral, poster)	Name of the participants from LABEF
1	Towards Sustainable Indigenous Mahogany Timber Production in Ghana: Refining the Silvicultural "Tool Kit" and Practical Training for Industrial-Community Farmers and Foresters". 2-6 march 2015 (Ghana)	Oral presentation	AKPONA T. Jean Didier
2	2nd TAAG African Students Conference on Conservation Science. 9-12 June 2015 (Ghana)	Poster presentation	AKPONA T. Jean Didier
3	Training in Measuring Reporting and Verification of Biodiversity indicators, 26 September to 03 October 2015 (Belgium)	Oral Presentation	AKPONA T. Jean Didier
4	Training in resilience of farming systems in the context of	Oral Presentation	AKPONA T. Jean Didier

	the Climate Change using DIVA-GIS, 16 to 18 December 2015 (Benin)		
5	Student Conference on Conservation Sciences, 8-11 Sept 2015 (Bangalore, India)	Oral Presentation	GBEDOMON Rodrigue Castro
6	Student Conference on Conservation Sciences (SCCS), Beijing, 5-9th November 2015 (Beijing, China)	Poster presentation	GANDJI Kisito
7	XIV World Forestry Congress Workshop, Forest People and Environment: Some Perspectives From Africa, 7-11th September 2015 (Durban, South Africa)	Oral Presentation	GANDJI Kisito
8	Pre-XIV World Forestry Congress Workshop, Forest People and Environment: Some Perspectives From Africa, 4-6th September 2015 (Durban, South Africa)	Oral Presentation	GANDJI Kisito
9	Indigenous Plant Use Forum (IPUF) & Society for Economic Botany (SBE) Joint Conference on "Global Vision on Indigenous Plants and Economic Botany". Clanwillian, Western Cape, South Africa, 28th June-2nd July 2015 (South Africa)	Poster presentation	SINASSON S. K. Gisèle
10	Training on "Analysis of tree rings for the study of tree growth dynamics". ICRAF Nairobi, Kenya, 14 July-13 August 2015 (Kenya)	Attendance	SINASSON S. K. Gisèle
11	Provisioning Ecosystem Services, Relevance and Use within Local communities in South Africa From 9th to 13th 2015 (South Africa)	Poster presentation	MENSAH Sylvanus
12	Scientific writing and publishing course organized by Elsevier in Acrra (Ghana)	Attendance	IDOHOU Rodrigue
13	Biodiversity Diagnoses Course organized by teachers from the University of Kansas (USA) in Entebbe (Uganda)	Attendance	IDOHOU Rodrigue
14	"How to write a scientific paper, or How to avoid Snoopy's problem" by Martin Fisher, Editor of Oryx, Fauna & Flora International, Cambridge (UK).	Attendance	IDOHOU Rodrigue
15	"Raising funds for your conservation project" by Dr Rosie Trevelyan, Tropical Biology Association, Department of Zoology, University of Cambridge, (UK).	Attendance	IDOHOU Rodrigue
16	Participation in First Tropilakes conference to be held in Bahir Dar (Ethiopia),	Oral presentation	IDOHOU Rodrigue
17	Participation in the TDWG 2015 Annual Conference, Nairobi (Kenya),	Poster	IDOHOU Rodrigue
18	Participation in 2nd Tropical Biology Alumni Association (Ghana),	Oral presentation	IDOHOU Rodrigue

19	Participation in the Student conference in Conservation Science in Cambridge (United Kingdom),	Poster	IDOHOU Rodrigue
20	27th International Congress for Conservation Biology and 4th European Congress for Conservation Biology (Montpellier, France.)	Poster presentation	SALAKO Valère
21	Tropical Biology Association Alumni Group (TAAG) conference, 9-12 June 2015 (Accra, Ghana)	Oral presentation	SALAKO Valère
22	Impacts of harvest intensity on Raphia hookeri G.Mann & H. Wendl., populations in South-Benin (West Africa) Vième Colloque de l'UAC des sciences, cultures et technologies. 28 Septembre au 03 Octobre 2015. (Abomey-Calavi / Benin)	Oral Presentation	DONOU HOUNSODE Tadogbè Marcel

Appendix 1-12. Research projects of LABEF in which you have been involved in 2015

N°	Title of the project	Sources of Funding	Objectives of the project	Status (ongoing or ended)
1	Insect as feed for West Africa	Switzerland Programme	Main objective: Contribute to food security. Specific objectives: - Value the fly larvae in the diet of local chickens -Improve Food rations for poultry protein.	ongoing
2	Sustainable Cotton Production in Africa (SCOPA)	DANIDA	To develop and apply an interdisciplinary framework for assessing the various aspects of sustainability of different existing and innovative ways of cotton production in SSA, e.g. pesticide residues, soil fertility, greenhouse gas emissions, and economic and social conditions along the value chains.	ongoing
3	Integrated sweet potato weevil (*Cylas spp.*) control for sustainable sweet potato production in Benin and Ghana	Bill & Melinda Gates Foundation	To develop methods to control SP weevils using insect parasitic nematodes	ongoing

N°	Title of the project	Sources of Funding	Objectives of the project	Status (ongoing or ended)
			and resistant cultivars, and train farmers and extension experts in their use.	
4	Assessing the Effects of Land Uses on Ecosystem Services provided by Trees and Forests in a Landscape Context	African Forestry Forum	Quantification of ecosystem services under different land uses	ongoing
5	Promoting environmentally friendly practices for sustainable baobab leaves production for food and nutritional security in smallholders farming systems in Benin (West-Africa).	RUFORUM	Promoting environmentally friendly practices for sustainable baobab leaves production for food and nutritional security in smallholders farming systems	ongoing
6	Understanding and combating desertification to mitigate its impact on ecosystem services. FP7-ENV-2009-1. Scientists	European Union		ended
7	Amélioration de la résilience aux changements climatiques des écosystèmes agricoles le long des bassins-versants par le développement participatif de systèmes agroforestiers anti-érosifs et fertilisants dans six pays ouest africains, 2013. Coordinator for Benin	CORAF/WECARD		ended
8	Projet de mise au point de technologies de production et d'utilisation durables de biocarburant de *Jatropha curcas* pour une réduction de la pauvreté rurale en Afrique de l'Ouest.	African Union		ended
9	Les palmiers sauvages du Bénin : utilisation, biodiversité, écologie, importance économique, et conservation, 2012.	University of Abomey-Calavi		ended
10	Projet *Jatropha* UA	African Union	Main objective: - Contribute to sustainable development in rural areas; - Improve the standard of living and well-being of rural people. Specific objective: Developing sustainable production and use of biofuel technologies of *J. curcas*	ended

Appendix 1-13. Research Grants in 2015

N°	Title of Grant	Beneficiaries	Status (ongoing or ended)
1	Research grant		Ongoing
2	International Foundation for Science (IFS) Individual Research Grant	GBEDOMON Rodrigue Castro	Ongoing
3	Organization for Women in Science for the Developing World (OWSD) Postgraduate Fellowship and co-supervision in South Africa	SINASSON S. K. Gisèle	Ongoing
4	Research grant on land use, land use change and forestry linked to climate change	MENSAH Sylvanus	Ongoing
5	RUFORUM Graduate Research Grant: Promoting environmentally friendly practices for sustainable baobab leaves production for food and nutritional security in smallholders farming systems in Benin (West-Africa).	ASSOGBADJO Achille, SALAKO Valère, IDOHOU Rodrigue, Romain GLELE KAKAI	Ongoing
6	Robert S. McNamara Fellowships Program (RSM) for internships programme, The World Bank, completed at the University of Kansas, US	IDOHOU Rodrigue	Ended
7	Rufford Small Grant (RSG) for Nature Conservation, Combining ecological data and local community participation to set long-term conservation plans for dum palm in Benin.	IDOHOU Rodrigue	Ended
8	IDEA-WILD equipment grant for assessing impact of elephant pressure on spatial pattern of *Borassus aethiopum* Mart in the Pendjari National Park.	SALAKO Valère	Ended

Appendix 1-14. Prizes and nomination in 2015

N°	Title of prize / nomination	Nominee
1	Second Prize of the Global Development Awards Competition 2015, Japanese award of outstanding research on Development	IDOHOU Rodrigue
2	Best student talk on conservation sciences	GBEDOMON Rodrigue Castro
3	Organization for Women in Science for the Developing World (OWSD) Postgraduate Fellowship Addendum for Conference attendance	SINASSON S. K. Gisèle
4	2015 ICCB-ECCB Travel Awards	SALAKO Valère
5	Full Professor in Biostatistics and Forestry (CAMES)	GLELE KAKAÏ Romain
6	Member of the advisory committee of AGNES (African German Network for Excellence in Sciences)	GLELE KAKAÏ Romain

Appendix 1-15. Visitors received in 2015

N°	Full names of visitors	Provenance	Contact person in LABEF	Topics
1	Prof Yves Brostaux	Belgium	Prof Romain GLELE KAKAI	1.Courses: Generalized linear models 2.Seminar on “Classification methods” 3.Plenary Conference by Prof. Brostaux
2	Dr Orou Gaoue	USA	Prof Romain GLELE KAKAI	Matrix Populations models

Appendix 2: Abstracts of the publications in LABEF in 2015

1-Morphological variation, cultivation techniques and management practices of *Moringa oleifera* in Southern Benin (West Africa)

Agoyi E.E.[1,2], Padonou E.A.[1]*, Waliou A.[3]., Assogbadjo A.E[1], Glèlè Kakaï R.[4], and Sinsin B.[1]

[1]Laboratory of Applied Ecology, University of Abomey-Calavi, Cotonou, Benin.
[2]Department of crop science, Makerere University of Uganda, Kampala, Uganda,
[3]Department of Nutrition and Food Sciences, University of Abomey-Calavi, Cotonou, Benin.
[4]Laboratory of Biomathematics and Forest estimations, University of Abomey-Calavi, Cotonou, Benin
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Abstract: This study examined the phenotypic variation and the modalities for integrating *Moringa oleifera* in agroforestry systems in southern Benin in order to contribute to sustainable management of the species. Morphological characterization of *M. oleifera* based on measurements taken on the trees, leaves, leaflets and fruits, and ethnobotanical survey on cultivation techniques and management of plantation of the species were performed. The morphological analysis showed significant variation between populations of *M. oleifera* in the phytodistricts considered in relation to tree height, leaf length, petiole diameter, length and width of leaflets ($P < 0.001$); length, median diameter and fresh weight of pods ($P < 0.01$). In the phytodistricts considered in the southern Benin, the culture of *M. oleifera* was mainly by cuttings (92.85 to 97.8%) and row planting (91.83 to 98.03 %). The adoption rate of *M. oleifera* varied between 89.79 and 97.05%. There was significant dependence between the management practices and the willing for adoption ($\Delta G2 = 5.59$, $P = 0.018$), between management practices and the origin of planting materials ($\Delta G2 = 5.50$, $P = 0.019$).
Keywords: *Moringa oleifera*, Phenotypic variation, Management practices, Phytodistricts.

2-Impact of land use practices on traits and production of shea butter tree (*Vitellaria paradoxa* C.F. Gaertn.) in Pendjari Biosphere Reserve in Benin

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Agroforestry Systems, 1-9 (in Press) DOI 10.1007/s10457-015-9847-1

Abstract: Dendrometric parameters such as tree DBH, height, crown diameter and size characteristics of leaves and fruit production collected from *Vitellaria paradoxa* subsp. growing in three land use types in Pendjari Biosphere Reserve (PBR) were analyzed. A total of 36 circular plots of 15 m diameter were randomly set in the three main land use sites of the PBR. Thus, Shea butter production was estimated from 90 trees (30 trees in each site) selected randomly. Our results revealed a significant difference in trees traits which increase from the park and hunting zone to the farmlands. The highest production of the selected Shea trees was reported from the farmland. Thus, there is high variability between leaf sizes of trees within the sites while for the fruits the greatest variability is between fruits from same tree. The findings of this study showed that the morphological traits and the production of Shea butter trees could be affected by land use systems.
Keywords: Production, Dendrometric parameters, Parks, *Vitellaria paradoxa*, Benin

3- Ecological consequences of anthropogenic pressure in Wari-Maro Forest Reserve (Benin, West Africa)

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Abstract: This study assessed ecological consequences of anthropogenic pressure in Wari-Maro Forest Reserve (WMFR). First, the dynamics of the forest cover was assessed using a diachronic analysis of land cover maps from Landsat images of 1986, 1995 and 2006. Then, structure of the forest was described. To this end, twenty-five (25) one-hectare plots were established using a stratified random sampling technique. The strata were the two main vegetation types (Tree savannah versus woodland) in the WMFR. Within each one-hectare plot, two subplots of 50 m x 30 m were established. All stumps of logged trees and all trees of diameter at breast height (DBH) ≥ 10 cm were counted and identified in the one-hectare plots to reveal the most logged tree species. In the subplots, all standing tree species of DBH ≥ 10 cm were measured for DBH and total height. Stumps of logged trees in the subplots were also measured for diameter at 0.10 m. Data of subplots were used to estimate volume of trees from which we derived carbon stock and carbon loss using conversion and expansion factors. For the two periods 1986 to 1995 and 1995 to 2006, there was a general decline in forest cover, which was however slowed down in the second decade (0.196 %. year-1 versus 0.083 % ,year-1 respectively). Top five (5) targeted species in illegal logging were: *Pterocarpus erinaceus* Poir., *Afzelia africana* Sm., *Isoberlinia spp*., *Anogeissus leiocarpa* Guill., and *Daniellia oliveri* (Rolfe) Hutch. & Dalziel. Mean values of carbon stock and carbon losses for the whole forest was 147.84 tons C.ha-1 and 17.57 tons C.ha-1 respectively and did not depend on the vegetation type. Results from this study suggest that management strategies should focus on selectively logged species. Monitoring should be enhanced to reduce the illegal logging pressure under a certain level over which survival of the targeted species might be problematic.
Keywords: anthropogenic pressure, forest cover, structure, carbon stock, Wari-Maro forest reserve, Benin.

4-Efficiency of inventory plot patterns for the estimation of woody vegetation recruit density in a tropical dense forest in Benin

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African Journal of Ecology *53*(3), 355-361.

Abstract: This study assessed the effectiveness of plot patterns for estimating recruit density of woody species in the dense forest of Lama Reserve (Benin). The experimental design consisted of thirty 0.04 ha plots randomly settled in the forest and each subdivided into four hundred 1-m² quadrats. Within each quadrat, recruits (dbh ≤10 cm) were counted and saplings (h ≥ 2 m and 2 cm ≤ dbh < 7 cm) and young trees (h ≥ 2 m and 7 cm≤ dbh < 10 cm) were measured in dbh. In each 0.04 ha plot, seven different plot shapes and sizes were considered by grouping adjacent 1-m2 quadrats. Relationship between mean square error of the estimation of the density of recruitments and the plot sizes was modeled using the Smith law.

Results obtained showed an average value of density of recruitments of 10.7 plants/m^2 with Green index value of 0.01. Shape and size of plots highly influenced the estimation of the density of recruitments. Rectangular plots of length/width = 2 and size of 72 m² (12 m 9 6 m) were most efficient for the estimation of the density of recruitments in tropical dense forest with standard error of 0.79 plants/m2.
Keywords: Benin, dense forest, efficiency, plot shape, plot size, recruitment density

5-Effect of climatic conditions on flowering and fruiting of *Tamarindus indica* (Fabaceae)

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Journal of Horticulture and Forestry 7 (8) 186-192, 2015

Abstract: This study examined effects of climatic conditions on patterns of flowering and fruiting of tamarind *(Tamarindus indica* L.). Data were recorded over a period of 26 months in two contrasting climatic zones. The monitoring revealed that irrespective of climatic zones, flowering starts by the end of the dry season when hygrometry begins to rise and lasts two to three months. Fruiting begins around the peak of the rainy season and reaches the ripening stage six to eight months later during the dry season. Flowering and fruiting abilities weakly varied with climatic conditions. Flowering durations and active phases seemed to be significantly longer ($p < 0.001$) under wetter climatic conditions (Sudan-Guinea zone) while fruiting parameters showed the opposite trend. Flowering length was found to be weakly correlated to climatic conditions while the latter variable was positively correlated to fruiting length. A negative correlation was observed between fruiting length and trees diameter; suggesting that the younger the tree, the longer the fruiting phase. These results provide insights into the patterns of phenological events of tamarind that could help in managing its populations and anticipating its flowering and fruiting shifting response to climate changes. Thorough research should however focus on modeling the combined effect of climate, soil, land use regimes and age of trees on the inter-annual variation of flowering and fruiting patterns and productivity.
Keywords: Indigenous fruit trees, phenology, climate, Benin, West Africa.

6-Factors affecting home gardens ownership, diversity and structure: a case study from Benin

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Journal of Ethnobiology and Ethnomedicine 11(1) 2015

Abstract: Home gardens (HGs) provide perspectives for conservation of plant genetic resources while contributing to improving livelihoods. However, knowledge of local factors shaping their ownership,

plant diversity (PD) and structure is still limited especially in West-Africa, where food insecurity is acute. This is critical to ensure effective mainstreaming of HGs into future biodiversity conservation and food production policies. Socio-economic and PD data were obtained from individual interviews (n = 470) and gardens inventories (n = 235) spanning humid, sub-humid and semi-arid zones of Benin. Generalized Linear Models, Hierarchical Cluster Analysis, Principal Component Analysis and Simple Correspondence Analysis were performed to examine socio-economic characteristics (age, gender, education level and main economic activity) affecting HGs ownership, and their effect coupled with intrinsic HGs characteristics (size, age) on PD and structure within HGs, across contrasting bio-geographical regions. HG ownership was significantly dependent upon a complex relationship between ages, gender and education level of the farmers. The probability to own HG increased with age with an early involvement in home gardening for women. PD increased with increasing owner age and size of the HG. Larger and more diversified HGs were found in sub-humid and semi-arid zones while smaller and less diversified HGs were encountered in the humid zone. HGs were multi-layered. Based on the prevailing plant groups, three categories of HG were distinguished: Herb based gardens, Herb and Shrub/Trees based gardens, and Palm and Liana based gardens. Results suggest effects of complex interactions between socio-economic factors on HG ownership, and influence of these effects combined with intrinsic characteristics of HGs on PD. The early involvement of women in home gardening and their particular interest in herbs and shrubs are important assets for future conservation strategies based on HG and food production. Interventions are required to interfere with declining PD in HG across generations to accommodate multiple ecosystem service benefits.
Keywords: Home gardens, Ownership, Plant diversity, Socio-economic, Conservation, West Africa

7- Variabilité morphologiques et conservation des morphotypes de *Jatropha curcas* Linn. Euphorbiaceae) au Bénin

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Journal of Agriculture and Environment for International Development 109 (1): 55 – 69, 2015

Abstract: This study is a contribution to *J. curcas* cultivation and seeks to analyze the morphological variability and identification of morphotypes of *J. curcas*. The study was conducted in 44 communities equitably distributed among 22 towns (populations) and geographically widespread in the 10 phytodistricts of Benin. Per population, at least 30 individuals of the species spaced at least 20 meters apart were randomly selected for the collection of morphological data. In total, 840 individuals, 714 leaves, 2294 fruits and 3465 seeds of J. curcas were measured in all the country. The part of the variability of *J. curca*s morphological traits due to individual, populations, phytodistricts, climatic zones were determined using the variance component analysis. The stepwise discriminant analysis was performed on *J. curcas* populations to identify the morphological traits which discriminate them and the numeric classification was realized to regroup *J. curcas* populations. The results show that variability of *J. curcas* morphological traits is generally larger at individual level or between individuals of the same population than between populations, phytodistricts and climatic zones except fruits and seeds weight whose variability is larger between populations. Ten of twenty-one morphological traits studied were identified as the most discriminant variables of *J. curcas*. Four morphological groups of *J. curcas* were distinguished in Benin considering 10 discriminant variables.
Keywords: morphological traits, variability, *J. curcas*, Benin

8-Multivariate statistical methods used in ecology

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In press

Abstract: This article addresses the multivariate statistical methods such as ordination and classification methods commonly used in ecology. The ordination methods summarize the information in the matrix of data by minimizing the loss. The ordination methods are the Principal Component Analysis; the Principal Coordinate Analysis; the Correspondence Analysis; the Multiple Correspondence Analysis; the Detrended Correspondence Analysis; the Canonical Redundancy Analysis; the Canonical Correspondence Analysis; the Non-metric Multidimensional Scaling; and the Canonical Discriminant Analysis. The classification methods group as possible similar individuals. They are the agglomerative classification (also called hierarchical cluster); the Typological analysis; the Decisional Discriminant Analysis; and the Multivariate Analysis of Variance (MANOVA). These methods have the advantage of allowing the extraction of the main information in a multivariate matrix.
Keywords: Multivariate statistical methods; ordination methods; classification methods.

9-Sampling techniques in vegetation studies

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In press

Abstract: Decisions in forest management are based on estimations of the stock and evolution of their potential. As such, accuracy of these estimations is crucial for reliable decisions. Sampling techniques are methods developed to allow good estimations based among others on the objectives, the extent of the vegetation, the features of the forest and the available resources. There is however a huge number of sampling techniques in the literature which often make difficult the choice for a non-specialized user. This papers deals with the review of the most used sampling techniques, conditions of their utilization and their advantages and limits.
Keywords: Sampling, Estimation, Methods, Forest Management

10- Structural analysis of regeneration in tropical dense forest: combined effect of plot and spatial distribution patterns

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Acta Botanica Gallica 162 (1)79–87, 2015

Abstract: This study assessed the combined effect of the size and shape of inventory plots on the analysis of the density and diameter structure of saplings and juvenile trees. Thirty square plots of 400 m² were

randomly laid out and each one was divided into 400 quadrats of 1 m². Stem number of recruits was recorded for all tree species and their diameter at breast height was measured in the quadrats. Seven types of subplots with different shapes and sizes were considered by grouping adjacent quadrats of 1 m². The Green index was used to assess the spatial distribution of regeneration and Weibull distribution was applied to model stem diameter distributions. Box–Cox transformations and weighted regression were used to model the relationship between the Green index, the plot patterns and the standard error of the estimation of the regeneration density. The same analyses were applied to model the relationship between the Green index, the plot patterns and the mean absolute error of the shape parameter of the Weibull distribution. The Green index and the plot size had a significant impact on the error of the regeneration density estimation. For clumped distribution of individuals, the plot shape had a significant impact on the error of their density estimation. As for stem diameter distribution, only the plot size had a significant effect on the mean absolute error of the stem diameter structure. The rectangular plots and square plots of 100 m² (14 m × 7 m and 10 m × 10 m) appeared more suitable for an effective structural analysis of woody species regeneration in the tropical dense forest for an aggregated distribution and a random distribution, respectively.

Keywords: plot size and shape; regeneration; Green index; structure; dendrometric analysis; dense forest; Benin; West Africa; tropical forest.

11- Traditional Knowledge and Use Value of Bamboo in Southeastern Benin: Implications for sustainable management

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Ethnobotany Research & Applications 14:139-153, 2015

Abstract: Traditional knowledge (TK), use, and economical values of three bamboo species—*Oxytenanthera abyssinica* (A. Rich.) Munro, *Bambusa vulgaris* Schrad. Ex J.C.Wendl., and *Dendrocalamus asper* (Schult. & Schult. f.) Backer ex K. Heyne were assessed in southeastern Benin. Individual interviews were used in 90 randomly selected villages, which cut across 10 socio-cultural groups. We tested and found evidence to support the hypotheses that (1) age, gender, and socio-cultural groups are predictors of TK and plant ethnobotanical use value and (2) bigger bamboo species are more expensive on the market. Bamboo was used for 44 purposes, but the common food use of bamboo shoots was not reported. Men and older people had more knowledge and valued bamboo more than women and younger people, respectively, indicating that they are key stakeholders for conservation actions. The culm was the most harvested part of bamboo, and its selling price was location- and size-dependent. The implications of these results are discussed with respect to conservation and management strategies for bamboo.

12- Morphological Variability of *Prosopis africana* (Guill., Perrott. Et Rich.) Taub in Benin, West Africa

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American Journal of Plant Sciences 6, 1069-1079, 2015

Abstract: The morphological variability of *Prosopis africana* in its natural range (which includes three climate zones: Guinean zone, Sudano-Guinean zone and Sudanese zone) of Benin was studied on the basis of forest inventory carried out in three different vegetation types (savannah, fallow and field). The data recorded in 139 plots of 1000 m2 each related to the diameter at breast height (1.3 m over the ground level), the bole height, the height to the first branch, crown height, the crown diameter, number of branches on each individual tree. In these plots, 143 sheets were used to determine the length of leaf, the pinna length, leaflets' length, numbers of pinna, the number of leaflets, and the stalk diameter. In addition, 735 cloves were measured to determine the fruit pods' diameter, pod length, the total fruit weight and number of seeds per fruit, the seed length, the weight of a seed, and pulp weight. Analysis of variance components shows that the variability of *Prosopis* is generally greater among individuals than within vegetation types and climatic zones. Discriminant analysis showed that of the 19 morphometric characters seven (7) in the vegetation types and twelve (12) in climate zones revealed a statistically significant discriminating pattern r (prob. <0.001). From ascending cluster of 481 *P. africana* trees measured, 10 morpho-groups were depicted on the basis of 19 morphometric characteristics (R^2 = 52.6 %).
Keywords: Morphological Variability, Climate Zone, *Prosopis africana*, Benin, West Africa.

13- Structural Characterization of *Prosopis africana* Populations (Guill., Perrott., and Rich.) Taub in Benin

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International Journal of Forestry Research, 2015 DOI: 10.1155/2015/101373

Abstract: The structural characterization of *Prosopis africana* of Benin was studied on the basis of forest inventory conducted in three different vegetation types (savannah, fallow, and field) and three climate zones. The data collected in 139 plots of 1000m2 each related to the diameter at breast (1.3m above ground), total height, identification, and measurement of DBH related *P. africana* species height. Tree-ring parameters such as Blackman and Green indices, basal area, average diameter, height of Lorey, and density were calculated and interpreted. Dendrometric settings of vegetation type and climate zone (Guinea, Sudan-Guinea, and Sudan) were compared through analysis of variance (ANOVA).There is a significant difference in dendrometric settings according to the type of vegetation and climate zone. Basal area, density, and average diameter are, respectively, 4.47m2/ha, 34.95 stems/ha, and 37.02 cm in the fields; 3.01m2/ha, 34.74 stems/ha, and 33.66 cm in fallows; 3.31m2/ha, 52.39 stems/ha, and 29.61 cm in the savannahs. The diameter distribution and height observed at the theoretical Weibull distribution show that the diameter and height of the populations of the species are present in all positively skewed distributions or asymmetric left, a characteristic of single-species stands with predominance of young individuals or small diameters or heights.

14- Knowledge of diversity of wild palms (Arecaceae) in the republic of Benin: finding gaps in the national inventory by combining field and digital accessible knowledge

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Biodiversity Informatics, 10, 45-55, 2015

Abstract: Despite efforts by researchers worldwide to assess the biodiversity of plant groups, many locations on Earth remain poorly surveyed, resulting in inadequate or biased knowledge. Robust estimates of inventory completeness could help alleviate the problem. This study aimed to identify areas representing gaps in current knowledge of African palms, with a focus on Benin (West Africa). We assessed the completeness of knowledge of African palms, targeting geographic distance and climatic difference from well-known sites. Data derived from intensive fieldwork were combined with independent data available online. Inventory completeness indices were calculated and coupled with other criteria. Results showed a high overall value for inventory completeness, as well as an even distribution of well-known areas across the country. However, poorly-known areas were identified, which were in remote locations with low accessibility. This study illustrates how biodiversity survey and inventory efforts can be guided by existing knowledge. We strongly recommend the combination of digital accessible knowledge and fieldwork, coupled with expert knowledge, to obtain a better picture of inventory completeness in tropical ecosystems.
Keywords: Biological databases, GIS, inventory, sampling efficiency, spatial resolution.

15- Variation in *Hyphaene thebaica* Mart. fruit: physical characteristics and factors affecting seed germination and seedling growth in Benin (West Africa)

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Journal of Horticultural Science & Biotechnology 90 (3) 291–296, 2015

Abstract: *Hyphaene thebaica* (dum palm) is an important tree species that grows wild in the semi-arid regions of tropical Africa. Increased knowledge on the effect of stress on the propagation and establishment of these plants is needed to optimize its domestication. This study assessed the physical characteristics of *H. thebaica* fruit harvested from three phytodistricts in Benin. The germinability of the seeds, before and after water-soaking and removal of the seed coat, was tested, and the number and size of the leaves produced in the resulting seedlings were measured. Hierarchical classification of the characteristics of fruit revealed the existence of three morphotypes. A Factorial Discriminant Analysis performed on these morphotypes revealed highly significant differences ($P \leq 0.001$). Morphotype 3 (48 seeds) had the highest rate of seed germination (49.99%) and the widest leaves (28 mm) over the 154 d of the experiment. Seedlings of morphotype 2 and morphotype 3 (48 seeds each) had the highest number of leaves (two per seedling), whereas only morphotype 2 seedlings had the longest leaves (35 mm). Results

from Analysis of Variance revealed that the time of germination and water-soaking had significant effects ($P \leq 0.05$) on seed germination. The study also showed that the growth of seedlings differed with the time of germination, and that these differences varied with morphotype. These results may be used to improve current propagation and conservation strategies in this species in its areas of origin.
Keywords: Dum palm, germination, treatment, phytochorological zones, West Africa

16- Changement climatique, mécanisme actuel de prévention et de gestion des conflits entre agriculteurs et éleveurs en zone agro pastorale de production cotonnière au nord Bénin : cas de la commune de Banikoara

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African Crop Science Journal, 23 (1), 9-26 2015

Abstract: Conflicts between farmers and breeders have always been marked by various losses with management methods are mostly inappropriate. Thus, in a context of climate change, this study aims to understand the current mechanism for preventing and managing conflicts between farmers and breeders in agropastoral areas of cotton production in Northern part of Benin. For this purpose, semi-structured individual interviews were conducted with 694 breeders (Peulh) and farmers (Bariba) randomly selected, followed by direct observations in the field. The results obtained show that there has been a decrease of conflicts. The establishment of a local committee of conflict management, a proper monitoring of animals, breeders awareness, and crackdown of defendants are the most important adaptation strategies developed in the district. These actions have provided the plinth for additional measures to maintain the dynamic of conflicts prevention and its management. These actions are easy to apply in the current context of decentralization and climate change.
Keywords: Adaptation, agro-pastoral conflicts, Banikoara, Benin, climate change

17- Accounting for tree spatial distribution in a comparison of plot sizes and shapes in dense forest and woodland in Benin (West Africa)

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African Journal of Ecology, 54, 87–94, 2016

Abstract: The study examined simultaneously, the effect of tree spatial distribution, inventory plot size and shape on the estimation error of basal area in two contrasting environments. Twenty and fifteen square plots of 1 ha each (divided into 100 quadrats of 0.01 ha) were randomly set in dense forest and

woodland, respectively. Thirteen subplots of various shapes and sizes were obtained from the association of adjacent quadrats. Estimation error was calculated using residual mean square of one-way ANOVA, based on replications of subplot within 1 ha plots. Tree spatial distribution was measured using Green index. Weighted linear regression and mixed effect models were applied to Box & Cox transformed data. In general, the estimation error of basal area decreased with increase in subplot size. However, the effects of tree spatial distribution and plot shape varied with the vegetation type. Where trees tended to be aggregated, estimation error increased with degree of aggregation, and rectangular plots of 0.24 ha produced an acceptable precision. It was concluded that 0.24 ha rectangular plots can be used in tropical environments where the target parameters vary con- stantly according to one direction, while square plots of the same size are optimal for reliable analysis in case of randomness.

Keywords: estimation error, inventory plot, nonrandomness, structural parameters, vegetation, West Africa

18- Investigations of on farm seedling productivity of the rare and declining *Caesalpinia bonduc* in Benin (West Africa) by aid of simulation modelling

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International Journal of Agronomy and Agricultural Research, 6 (3)116-131

Abstract: *Caesalpinia bonduc* is overexploited and threatened due to its importance in medicine. This study aims at assessing on farm seedling productivity of *C. bonduc* by aid of simulation modelling in order to design its appropriate plantation techniques, harvesting intervals, and soil conditions. Data were collected from nursery and field experiments by measuring stem height, collar diameter, number of leaves and tap root length during 180 days. The simulation model was based on a metabolic pool type model calibrated first to simulate the observed growth data from the nursery (calibration). Following it was used to simulate the growth of plants from field experiments, first by an optimization of the utilization of leaves or roots only, and second by an optimization of the utilization of both leaves and roots at the same time at different plant densities and nitrogen levels. The models show that in order to optimize the utilization of *C. bonduc* it should be planted at high densities with high nitrogen levels. Leaves and roots harvesting should take place every 50-60 days, and maximum 15% of the biomass of roots and leaves should be harvested at each harvesting event.

Keywords: *Caesalpinia bonduc*, Simulation model, Harvesting intervals sustainable use, Plantations.

19- Impact of climate on seed morphology and plant growth of *Caesalpinia bonduc* L. in West Africa

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International Journal of Agronomy and Agricultural Research, 6 (3) 86-96, 2015

Abstract: *Caesalpinia bonduc* L. is an important medicinal plant threatened by overexploitation. In the present study, the impact of climate on seed morphology, germination capacity, seedling and plant growth

of *C. bonduc* were evaluated. A total of 2000 seeds were collected in Sudanian and Guinean climate zones of Africa and their length, width, thickness, weight and color were recorded. A hierarchical classification and canonical discriminant analysis were applied to the above traits of seeds from the different climatic zones. An analysis of variance with repeated measures was applied to seeds morphotypes identified by the hierarchical classification to test for the effect of these morphotypes on seed germination, seedling and plant growth. Hierarchical classification helped to identify four seed morphotypes. Canonical discriminant analysis performed on these morphotypes revealed highly significant differences. Morphotypes 1 and 3 comprised green seeds mainly from Sudanian zone while morphotypes 2 and 4 gathered grey seeds mainly from Guinean zone. Morphotype 3 had the longest seeds while the shortest seeds were from morphotype 1. The heaviest seeds were found in morphotype 4 whereas the lightest ones were from morphotype 1. Seeds of morphotype 4 were the thickest and widest, while the slimmest and most narrow ones were grouped in morphotype 1. Moprhotype 3, consisting of large green seeds mainly from Sudanian zone, was superior in terms of seedling and plant growth among all morphotypes and should be the best choice for planting purposes of the species.

Keywords: Sudanian and Guinean climate zones, Hierarchical classification, Canonical discriminant analysis, Morphotypes.

20- Spatial distribution of bowal and differences in physicochemical characteristics between bowal and woodland soils in Benin, West Africa

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Catena, 124, 45–52, 2015

Abstract: Bowal, is degraded land surface characterized by ferricrete exposure due to soil surface erosion. This study aims at assessing the spatial distribution of bowé in Benin and the physicochemical differences between bowé and soil of adjacent woodlands. Bowé surfaces were identified during field investigations and mapped. Soil samples were taken on the bowé surfaces and nearby woodland. Mann–Whitney test was applied to analyze the different physicochemical characteristics of bowé and woodland. The results show that bowé were directly related to ferruginous soils and rainfall regime. Bowé soils are characterized by significantly lower values of electrical conductivity, organic matter, extractable phosphorus, silt and total nitrogen than woodland soils, while potassium exchangeability of bowé soils is higher. Bowé can be expected wherever ferruginous soils and/or ferricretes are observed under unimodal rainfall regimes condition. The disaggregation of bowé ferricretes may improve the soil physicochemical characteristics and sustain the regrowth of forest under more humid conditions.

Keywords: Bowal Ferricrete, Ferruginous soil, physicochemical soil characteristics, Phytogeographical district, Benin

21- Tree-ring: a suitable implement for spatial and temporal fire distribution analysis in savanna woodland and dry forest

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Journal of Forestry Research, 26 (2), 435-446, 2015

Abstract: Based on 120 stem discs collected during 3 months of fieldwork along a 12 km route, the history of fires in the Wari Maro Forest (09-1000 N–02-1000E) over the past century in savanna woodland and dry forest was reconstituted. Three major ecological areas are characterized: one highly burnt zone located between two relative less burnt areas. By analyzing tree rings, 246 fire scars were identified. The scars were caused by 51 fire years, occurring at a mean interval of 2.23 years. From 1890 to 1965, only 6 years with fires were recorded from sampled trees. Since 1966, no year has passed without fire. The fire frequency point scale reached 14 years. This was the case of *Burkea africana*, which has been identified as a species tolerant to fire and could be planted to create a natural firewall. In contrast, *Anogeissus leiocarpa* is highly sensitive to fire, and in a dry forest ecosystem that burns seasonally, it requires a special conservation plan. Two new concepts are described: the rebarking of trees after fire and Mean Kilometer Fire Interval. The first concept was tested with *Daniellia oliveri* (Rolfe) Hutch & Dalz trees, and the second concept was used to evaluate spatial fire distribution. We demonstrate that savanna woodland and dry forest were subject to a degradation process caused by destructive fires related to vegetation cover clearance and illegal logging.
Keywords: Fire ecology, Tree-rings, Savanna woodland, Dry forest, Conservation strategies

22- Méthodes et dispositifs d'inventaires forestiers en Afrique de l'Ouest : état des lieux et propositions pour une harmonisation

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Annales des Sciences Agronomiques (In press)

Abstract: Forest inventories are tools generally intended to assess the quantitative and qualitative importance of plant material and its evolution over time. Inventory techniques used in different countries in West Africa are numerous and diversified; this situation negatively impacts comparison of forest inventory results between different countries and decision making at regional level. The aim of this work is to propose suggestions for adequate harmonization of forest inventory techniques and designs in the West African countries. These recommendations follow several regional meetings between experts of flora and vegetation of West Africa.
Keywords: vegetation; inventory; techniques; variability; harmonization; West Africa.

23- Population structure of two bamboo species in relation to topographical units in the Republic of Benin (West Africa): implications for sustainable management

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Abstract: A study was carried out in two phytodistricts (Ouémé-valley and Plateau) to assess the population structure of two bamboo species (*Oxytenanthera abyssinica* (A. Rich.) *Munro* and *Bambusa vulgaris* Schrad. ex J.C. Wendl. in two topographical units: plateau and wetlands. In each phytodistrict, bamboo stands were randomly selected in each topographical unit for inventory using a 0.25-ha square plot. Structural parameters of bamboos were computed and compared using a Wilcoxon rank test. Spatial distribution of the two bamboos was also assessed using the method of neighborhood density in relation to a focal point. The observed culm diameter distribution was established for each stand and adjusted to the two-parameter Weibull distribution. *Oxytenanthera abyssinica* showed the highest culm and clump density values in both wetlands and plateau whereas B. vulgaris showed greater values of mean diameter and dominant height whatever the habitat. Diameter structures of bamboo stands showed a right asymmetric distribution and bamboo spatial distribution was highly aggregative, especially in wetlands. No significant difference in mean relative neighborhood density between species was noted. However, a significant difference was observed between wetlands and plateau ($p < 0.001$) indicating strong influence of the topographical units on the relative neighborhood density of bamboo species. All of these findings are determinants in designing suitable management strategies for bamboo populations in Benin, particularly with the increasing demand to build fish-traps and shelter in the traditional fishing systems "Acadja".
Keywords: bamboo populations; structure; spatial patterns; Benin; West Africa

24- Modeling vulnerability of protected areas to invasion by *Chromolaena odorata* under current and future climates

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Ecosystem Health and Sustainability 1.6 : 1-12.

Abstract: Invasive plant species and climate change are among the biggest threats to the ecological integrity of many ecosystems, including those of protected areas. Effective management of invasive plants requires information regarding their spatial distributions. Using maximum entropy, we modeled habitat suitability for an invasive plant species *Chromolaena odorata* under current and future climatic conditions (HadGEM2-ES and MIROC5) in protected areas of four West African countries (Benin, Côte d'Ivoire, Ghana, and Togo). Under current climatic conditions, approximately 73% of total land area within the protected areas was suitable for colonization by *C. odorata*. Under future climate projections, the total area of suitable habitats for this invasive plant was projected to decrease by 7–9% (HadGEM2-ES) and 12–14% (MIROC5). Country specific patterns suggest that major protected areas in Cote d'Ivoire and Ghana will be more vulnerable to invasion by *C. odorata* than those in Benin and Togo under both current and future climatic scenarios. To maintain normal ecosystem functioning and provisioning of ecosystem services within the protected areas studied here, locations that have been identified as most vulnerable to invasion by *C. odorata* should be accorded proportionately higher priority when formulating appropriate management strategies.

Keywords: *Chromolaena odorata*; climate change; HadGEM2-ES; maximum entropy; MIROC5; representative concentration pathways; risk assessment; Siam weed; West Africa.

25- Genetic diversity of bitter and sweet African bush mango trees (Irvingia spp., Irvingiaceae) in West and Central Africa

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African Journal of Biotechnology 14.45 (2015): 3062-3074.

Abstract: Economically important food tree species in sub-Saharan Africa should be domesticated to enhance their production within agro forestry systems. The African bush mango trees (Irvingia species) are highly preserved and integrated in agro forestry systems in tropical Africa. However, the taxonomic debate related to the species or varietal status of the bitter and sweet fruited African bush mango trees hinders their domestication process and rational use. Amplified fragment length polymorphisms (AFLPs) and chloroplast simple sequence repeats (cpSSRs) were used in this study to assess the genetic diversity of African bush mango trees and to test the distinction between bitter and sweet fruited trees, sampled across Togo, Benin, Nigeria and Cameroon. Both the AFLPs and cpSSRs showed low genetic diversity for the Dahomey Gap bitter trees population. This is due to the higher fragmentation and the continuous reduction of this small sized population occurring in a limited forest ecosystem. The higher polymorphism and genetic diversity of the sweet mango tree populations in Benin and Togo showed the effects of domestication of materials of different geographical origin coupled with the frequent long distance transfer of genetic materials. When used separately, the AFLPs and cpSSRs failed to consistently discriminate the populations and type of trees. From the combined dataset, both markers differentiated geographically recognizable groups; bitter from sweet mango trees. However, Nigerian sweet mango trees clustered with the bitter ones. The suitability of AFLPs and cpSSRs to test our hypotheses within Irvingia needs to be thoroughly reassessed.
Keywords: AFLP, Benin, cpSSR, Togo, Dahomey Gap, Irvingia, taxonomy, domestication.

Appendix 3: Abstracts of doctoral research proposals of students in LABEF in 2015

Valère K. SALAKO (Doctorate student)
Topic: *Population ecology, pattern of uses and conservation of the dioecious palm tree Borassus aethiopum Mart. (Arecaceae) in Benin, West Africa*

Abstract: *Borassus aethiopum* Mart. is a common dioecious wild palm species native to Africa. *B. aethiopum* has high subsistence importance for local people and is a characteristic species of traditional agroforestry landscapes especially in semi-arid and sub-humid zones. There is however increasing concerns on overexploitation of the species by local people over its distribution range. Yet we know little about actual effect of how uses pattern affect the species conservation. Today, most of researches have focused on its uses pattern and properties of its stem in construction. Besides, in protected areas where it may be thought to be out of pressure and then well conserved, it may also be threaten by overexploitation by elephants who feed on it. To guide actions toward sustainable management and conservation, this PhD research aims to: (i) identify factors determining distribution and abundance of *B. aethiopum*, (ii) assess how *B. aethiopum* interacts with other tree species (plant-plant interactions) in natural ecosystems along a climate gradient, (iii) assess uses diversity and preferred plant part by local people and how these correlate with socio-demographic characteristics of users and the species availability, (iv) assess how harvest intensity of preferred plant part combined with land use types affect structure and spatial arrangement of *B. aethiopum* individuals, (v) investigate pattern of elephants utilization and impacts on *B. aethiopum* conservation in protected areas and (vi) combine geographical pattern of *B. aethiopum* tree abundance with habitat suitability to vulnerability of *B. aethiopum* to Climate Change. The study is being conducted in Benin, a West African country where three contrasting climatic conditions (humid sub-humid, dry sub-humid and semi-arid) are distinguishable. The country also has a good protected areas network including the Pendjari National Park where both elephants and *B. aethiopum* co-occur.

Keywords: Distribution, plant-plant interactions, conservation, elephant-plant interactions, anthropogenic pressure, climate change

Rodrigue IDOHOU (Doctorate student)
Topic: *African wild palms: Ecological patterns, knowledge gaps, conservation and domestication in Benin (West Africa)*

Abstract: Tropical areas harbor most of global biodiversity, but they also frequently hold burgeoning human populations. As a result, increasing demand for food, fuel, and land for agriculture exerts high pressure on limited resources. All of these factors are under the additional pressure of climate modification over recent decades and into the future. Palms raise non-timber forest product potential, as they represent a very important botanical family throughout the tropics and subtropics. They rank among the most commonly mentioned plant families in the ethnobotanical literature and constitute keystone resources for subsistence of local people. Unfortunately palm distributions in the tropics are particularly poorly documented and their uses are not well known. All these contribute to a raise of the threats on the species and shorten their ability to meet the increasing demand of commercially important species' organ. This study aims to assess the impacts of biotic and abiotic factors on wild palms conservation in Benin. Specifically it aims to: (i) illuminate the distributions of native, medium to wide-ranging, wild palm species, (ii) assess the diversity of uses and the factors affecting wild palm uses in Benin, (iii) assess the spatial patterns and the threats on the species, and (iv) test for effective propagation of the species.

Keywords: Conservation, domestication, wild palms, knowledge, modelling, remote sensing,

Achille HOUNKPEVI (Doctorate student)
Topic: *Conservation and ecological adaptations of black plum (*Vitex doniana *Sweet) to climatic conditions in Benin, West Africa*

Abstract: In the context of climate variability and change, it is recognized that ecosystems and their living organisms are facing unpredictable challenges. To face these challenges, climate proofing key sectors such as agroforestry should therefore be given the highest priority, mainly in sub-Saharan African regions seen as the most affected and least capable to face the projected negative effects. In this sense, several agroforestry species are being promoted. However, it is still unclear which of these species are more likely to withstand climate change. Through this research project, we are using *Vitex doniana*, an important agroforestry species occurring in tropical Africa, to understand some of the mechanisms developed by plants to fit in various climatic environments. Therefore, this study aims at improving knowledge on the ethnobiology of *Vitex doniana* and on the adaptive mechanisms used by the species to fit in various climatic zones of Benin in order to predict how the species may respond to future climate change. Specifically, its objectives are to: (i) Capitalize traditional knowledge on uses values of *V. doniana* and perceptions of local people on climate change and its impacts on the biology and productivity of the species; (ii) Identify and describes the ecological conditions under which *V. doniana* occurs and characterize the structure of its population; (iii) Assess the climate-induced morphological variability of the species; (iv) Analyse the radial growth and wood anatomical patterns of the species in relation to climatic conditions, and (v) Model habitat suitability of the species for its cultivation and in situ conservation under current and future climates. The study is being carried out in the three climatic zones of Benin Republic in West Africa, with a multidisciplinary approach including social survey, ecological and morphological assessments, tree-rings analysis and species distribution modelling.

Keywords: Agroforestry, Benin, climate change, ethnobiology, neglected and underutilized species, plant ecology, *Vitex doniana*, wood anatomy.

Marcel DONOU (Doctorate student)
Topic: *Use, Ecology and Conservation Biology of raffias' species in Benin (West Africa)*

Abstract: Non-timber forest products (NTFP) have been harvested by human populations for subsistence and trade. Palm trees, like any other NTFPs contribute to household economy and strengthen food security through the use of their organs such as spine, sap and stipe. But several palm trees are threatened in Africa because of overexploitation and habitat loss. For example, in Benin there are wild palms like *Raphia hookeri*, *Raphia vinifera* and *Raphia sudanica* used by local populations for food, construction and craft industry. But social or environmental changes in Benin leads to a change of NTFPs uses mainly the raffia's species. It is therefore important to determine the socioeconomic and ecological impacts of raffia's use for a better management of their populations. In the absence of long-term studies, investigations on population structures, which can be easily achieved from single surveys of size class distributions, are one of the best ways to obtain urgently needed data to investigate the demographic health of harvested populations. The present proposal aims to assess the socioeconomic context of raffias' species exploitation, the raffias' uses ant it impact on socioeconomic characteristics, the propagation ways and the impact of traditional ecological knowledge on conservation of raffias' species. These informations are important in order to (i) obtain an indication on the status of the raffia populations, (ii) assess its harvesting tolerance and (iii) estimate to what extent their actual use is sustainable. The project will be carried out in all departments of nine phytogeographical areas spread over the three climate zones of Benin. Ethnobotanical and forest inventories will be used for the data collection.

Keywords: Use, raffia, harvest intensities, land-use, TEK, Benin.

Gisèle K. SINASSON (Doctorate student)

Topic: *Ethnobotany and Ecology of* Mimusops andongensis *Hiern and* Mimusops kummel Bruce ex A. DC*: implications for the species management and conservation in Benin (West Africa)*

Abstract: Forest resources in general and NTFP (Non-Timber Forest Products) species in particular are facing threats to their conservation and rational management, because of the many services they provide for human wellbeing. Likewise, many NTFP species also face multiple pressures such as land use change, altered fire regimes or increased herbivory from domestic livestock and competition from invasive species. Current environmental stress from climate change added to abovementioned threats significantly modify species habitats and model their growth, survival and success in reproduction. However, our understanding of the effects of multiple stressors on useful species is limited. Hence, a better understanding of the species uses along with their autecology, in the context of both individual and multiple threats is crucial for conservation and management issues. This needs species to be well described and easily recognizable within their habitats. Agroforestry using vegetative propagation is seen as an important mean to maintain local uses of indigenous species and promote long-term sustainable conservation, especially if natural regeneration is low and viable seeds difficult to get. Useful species includes species still neglected by development and conservation agencies, and yet exploited by local people such as *Mimusops andongensis* and *Mimusops kummel*. Therefore, this project seeks to (i) clarify which of the two *Mimusops* species exists in the different climatic zones of Benin, (ii) assess the ecological habitat of both species and impacts of change in ecological factors, (iii) assess local knowledge on the species uses, occurrence habitat and threats faced, (iv) characterize their population structure and phenology according to ecological gradients, (v) characterize their growth dynamics in their habitats and (vi) assess their vegetative propagation potential. For that purpose, we are using a multidisciplinary approach including social survey, phenological monitoring, taxonomic, ecological and morphological assessment, niche modeling, tree-rings analysis and propagation experiments.

Keywords: Ethnoecology, growth dynamics, neglected and underutilized species, niche modeling, plant ecology, plant morphology, plant phenology, taxonomic differentiation.

Tèwogbadé Jean Didier AKPONA (Doctorate student)

Topic: *Management strategy of endangered timber species in Benin: prioritization and population stability analysis*

Abstract: Forests and protected areas in West Africa are valuable cultural landscapes. They provide a wide range of ecosystem services for human well-being. Besides agricultural activities, harvesting of timber and non-timber forest products (NTFP) is crucial for household income, food, and health. To maintain these important ecosystem services, some frequently used tree species are spared when land is cleared for agriculture. However, most indigenous timber species are affected by high anthropogenic pressure. The ongoing exploitation of natural resources affects plant population structure. Though Benin is a moderate forest country with vegetation dominated by savannahs and woodlands, forest logging takes an important place in population activities around protected areas. This situation could be explained by population increase, poverty, agriculture, etc. Many species are used in forest exploitation, yet very low information is available in their sylviculture. To fill this gap, this PhD project aims to (i) document the current timber species involved in logging according to climatic zones ; (ii) prioritize timber species involved in logging in order to propose a national conservation strategy; (iii) assess the combine effect of land use and climate on population structures of priorities timber species; (iv) conduct germination tests and seedling growth of priorities timber species; (v) document the diversity of pollinators and local perception on ecosystem services provided according to different habitats in Benin ; (vi) model distribution and habitat suitability of priorities species in Benin. The findings of this research will help to redefine reforestation program in Benin.

Keywords: Inventory, timber species logging, prioritization, distribution, modeling, anthropogenic pressure, Pollinator's, climate change.

Rodrigue Castro GBEDOMON (Doctorate student)
Topic: *Home gardens: Patterns and Potential of Home gardens for Agrobiodiversity conservation in Benin, West Africa*

Abstract: Home gardens (HGs) are land use ecosystems, generally adjacent to household or slightly further away but easily accessible. Despite these advantages and promising perspective for in situ agro-biodiversity conservation and food security, globally, information on African home gardens (as compared to their Latin American and Asian counter parts) are relatively poor. Additionally available information is generally descriptive and failing to test hypotheses and developing general principles to be used either in agro-biodiversity assessment or in their conservation or their use for food security. These principles are important guidelines for national or regional strategies of conservation or innovative solution for food security based on home gardens. Thus, this PhD research project aims to advance understanding of home gardens and explore their potential for local agro-biodiversity conservation and food security. Specifically it seeks at (i) reviewing the existing literature on Home gardens in Africa for future prospect; (ii) exploring the spatial configuration of home gardens in Benin; (iii) exploring the ownership, diversity and structure of home gardens; (iv) assessing the typology and functions of home gardens; (v) assessing the spatial and seasonal variation in home gardens plant diversity in Benin; (vi) assessing how far home gardens in Benin are contributing to the conservation of local agro-biodiversity; (vii) assessing the potential of home gardens as solution to bridge some nutrient deficiency in Benin. This project is addressing multidisciplinary issues including social and ecological sciences. As such the data collection and analysis framework is based on socio-ecological system (SES) approaches to take into account both social and ecological dimensions of home gardens as well as their interactions. Findings of this PhD research will provide decision makers and researchers with basic information and directive for the formulation of national strategy of conservation based on home gardens.

Keywords: Home gardens, Agrobiodiversity, socio-ecological system, Conservation, Benin.

Kisito GANDJI (Doctorate candidate)
Topic: *Modelling ethnobotanical patterns of Moringa oleifera Lam. (Moringaceae) in Benin (West Africa)*

Abstract: *Moringa oleifera* Lam. is an agroforestry food plant native to India, is produced and used in many countries in Africa, Asia, Latin America, and the Caribbean. *M. oleifera* can be used as a climate change mitigation strategy. The effects of climate change are making droughts more of a norm than an exception. This is a pattern that places some of the most vulnerable communities in an increasingly precarious position when it comes to meeting basic food needs. Shortages and hunger reach "emergency" levels and warrant aid; and families, communities, agricultural practices and lands will have suffered greatly. Moringa can play a key role in the fight against desertification because it grows fast and well in dry areas, and in areas where strong winds and long dry spells occur simultaneously causing serious soil erosion. Compared to all others vegetables, *M. oleifera* has the highest content of vitamins A and C with good amounts of protein, phosphorous and calcium. To know which aid is really durable to combat food shortages and efficient for climate change mitigation, it is good to look at the potential that is already available in developing and third world countries. *M. oleifera* is a very simple and readily available solution. Despite its very high nutritional value and its important role in climate change mitigation, *M. oleifera* is still underutilized and neglected. The species grows in countries where there are the highest

rates of malnutrition and where there are the strong impacts of climate change. This constitutes an opportunity to these populations. This PhD research aims to sustainably contribute to the improvement of the level of use and cultivation, and also to a better biomass production of *M. oleifera* in Benin. This will be achieved through: (i) critical review of the existing literature on *M. oleifera*; (ii) assessment of the impact of sample size on the precision of ethnobotanical indices of *M. oleifera*; (iii) quantitative assessment of ethnobotanical patterns of *M. oleifera*; (iv) identification of key factors driving cultivation and use of *M. oleifera;* and (v) assessment of the morphological diversity of *M. oleifera*. The study is being conducted in Benin, a West African country based on the main ethnic groups consuming and using the species and within each of the three biogeographical zones of the country. The outcomes will be very useful for increasing of the promotion of the species, for mitigation of climate change effects and for food security.

Keywords: *Moringa oleifera* L., neglected and underutilized species, sample size, ethnobotanical indices, ethnobotanical patterns, cultivation, use, morphological diversity, Benin.

Sylvanus MENSAH (Doctorate student)

Topic: *A Quantitative Framework to Assess Key Ecosystem Services Provided by Trees and Forests in a Landscape Context*

Abstract: Terrestrial ecosystems are sources of multiple goods and benefits for humans. Natural and planted forests are important biophysical units, which provide regulating services such as climate regulation at global and local scale, water purification, biological control, etc., as well as important physical goods and benefits such as timber, non-timber forest products, medicinal resources, and forage. With the growing human population and the adverse effects of climate change, landscape management has become a central topic of major political debate. Decision on landscape management to provide optimal quantity of a large variety of services in a context of climate change, requires understanding of contribution of different land uses to the provision of multiple functions and services holistically. Besides, the provision of an ecosystem service in a landscape is not guaranteed to contribute to human well-being, because people gain benefits from services differently, and according to their accessibility to these resources. The social perceptions towards ecosystem services from different land uses are relevant to identify the trade-off and the most important services to people, which could be included into future management policy. The overarching goal of this PhD project is to understand the contribution of land-uses to the provision of multiple services at landscape scale. The project goes across the following bullet points: (i) Biomass and carbon stocks of natural forests in a landscape; (ii) Potential provision of managed honey bee forage in natural forests; (iii) Relationship between diversity and ecosystem function (examples on forage and carbon); (iv) Impacts of land-uses on the provision of multiple ecosystem services in a landscape; (v) Importance and use of ecosystem services in local communities. The study is being carried out in a landscape of both natural forests and plantations in the Limpopo province in South Africa, and the results of these investigations will contribute to minimize the occurrence of conflicts between land uses and support the decision for sustainable and holistic landscape management.

Keywords: Diversity; carbon stock; ecosystem service; land use; honey bee forage; Mistbelt forest; valuation; pollination; South Africa

Innocent Sènandé ECLOU (Doctorate candidate)

Topic: *Assessment and analysis of agronomic and ecological aspects of cotton farming systems for a sustainable cotton production in Benin (West Africa)*

Abstract: Cotton is the main cash-crop in Sub-Saharan Africa whose estimated population of 856 million in 2010, is projected to exceed two billion shortly after 2050. It plays a very important role in the

economy of several African countries, including Benin Republic. However, most current cotton production systems are not sustainable and this could become a significant obstacle to the future development of these countries. Particularly in Benin Republic (West Africa), the massive use of pesticides and other agrochemicals in conventional cotton production methods results in severe environmental and health problems. But No study was conducted in Benin Republic on persistence and degradation of pesticide residues in soils under cotton cultivation. Yet we know that Organic cotton which by definition is cotton produced without chemicals, appears as a solution. However, low productivities observed in biological or organic cotton production systems are an obstacle to the adoption by farmers of these cropping systems. Nevertheless, the existence of biological or organic cotton shows that it is possible to produce cotton without using chemicals. It is in this context this study intends to evaluate and analyse the agro-ecological impacts not only of conventional and organic cotton production systems currently used in Benin but also some innovative cotton production methods which could give good yields and protect more environment and human health. This doctoral thesis study seeks to: (i) review the existing literature on cotton production in Africa, (ii) analyse effects of different cotton production practices on its agronomical performances, (iii) analyse effects of different cotton practices on soil fertility characteristics, (iv) assess pesticide residues impacts following different cotton farming systems, (v) Quantify pyrethroid and organophosphate pesticide residues in soils from cotton production area and (vi) analyse pyrethroid and organophosphate pesticides persistence and degradation in incubation study. This study is being conducted in two different cotton agro-ecological zones of Benin Republic. This research project is funded by the Kingdom of Denmark.

Appendix 4: Abstracts of Master Theses in LABEF in 2015

Cossi Natena DOULABE

Topic: *Semiparametric and parametric proportional hazards models: Application to survival of HIV/AIDS patients on antiretroviral treatment*

Abstract: In survival analysis, the most focused goals are: estimating (by Kaplan-Meier nonparametric method) and comparing survival curves by logrank test and modelling with regression models by the semiparametric and parametric methods. One important task is the prognostic factors (predictors) analysis in order to assess their effect on some quantities. Proportional hazards (PH) regression models evaluate the effect of these predictors on the hazard function when the PH assumption holds. That is the Cox PH model as semi-parametric and, Exponential, Weibull and Gompertz model as parametric. The goal of our thesis is to compare these four models. Then we evaluated their performance in multiple settings with binary and uniform covariates through a simulation study. We considered three sample sizes (50, 150 and 300), three censoring percent (10 %, 30 % and 60 %) and two "true" coefficients β 0.5 and 1 with the two covariates. We used bias, standard error and mean square error for evaluation. Based on bias, Cox model is the less biased. Regarding standard error and mean square error of each model, we obtained that Weibull model performs better at 10 % and 30 % whereas at 60 % Cox model is the preferred. We applied the four models to a dataset of HIV/AIDS patients undergoing antiretroviral treatment. A prognostic factors analysis revealed age at the entry of the study, sex, baseline weight, baseline CD4 cell counts and WHO stage to be significant. The pH assumption and goodness-of-fit are also checked based on residuals plotting. We used the Akaike's information criterion (AIC) to assess the comparison between the four models. The Cox model appears to have the smaller AIC and then is considered to be the best fitted model.

Keywords: Cox model, parametric PH models, HIV/AIDS, predictors, antiretroviral treatment, Akaike's information criterion.

Merveille Koissi SAVI

Topic: *Empirical assessment of relative performance of three permutation methods in one way analysis of variance framework*

Abstract: Permutation tests constitute one of the best alternatives to the traditional Analysis of Variance (ANOVA) when the data do not fulfil parametric assumptions. Three models were considered as the best permutation methods according to different simulation studies. These permutation methods are permutation of residuals under full, reduced and modified model. All the three methods, apart from the residuals that is common for them, basically share the same procedure of probability value (p_{value}) computation. This computation generally leads to the inflated behaviour of the test. This study addressed (1) the issue of the implementation of exact probability computation for the three permutation methods and (2) assessed the relative simulation based performance of the three residuals permutation methods. The first part of this study clarifies the concept of permutation and different procedures available in the literature as well as their implementation in the R software. Objectives (1) and (2) were reached through Monte Carlo simulation study. A total of 198 simulations were run under the unique scenario of balanced and homoscedastic design. For each simulation, 1000 datasets were generated and 999 time permutations were done on each dataset residual. The outcome of these simulations showed that, when the exact p_{value} is used, the behaviour of the residuals permutation tests changes. Moreover there is not an absolute permutation for every situation. However when residuals follow a lognormal distribution, the permutation of residuals under reduced model method gave best performance. When the residuals

follow cubed exponential distribution, the use of permutation of residual under pooled model is recommended. The permutation of residuals under modified model revealed a conservative character and could be advice.

Keywords: Permutation test, Analysis of Variance, Simulation, Relative performance

Essomanda Tchandao MANGAMANA

Topic: *Application of common components and specific weights method to analyze local perception patterns of land degradation in northern Benin (West Africa)*

Abstract: Common components and specific weights analysis (CCSWA) is a relatively recent multi-block statistical method that constitutes an extension of principal components analysis (PCA) in the case where different sets of quantitative variables have been measured on the same set of individuals. We described in this thesis the principle of CCSWA and its application in R software on real data to analyze farmers' perception of land degradation and soil erosion in northern Benin (West Africa). The data considered bear on 5 sociocultural groups and variables are linked to the causes of land degradation (dataset 1), soil erosion factors (dataset 2), land use practices against soil erosion (dataset 3) and techniques of improvement of the soil fertility and crops productivity (dataset 4). On these datasets, we also applied PCA in order to show the improvement of CCSWA compared to PCA. The results of CCSWA showed that the common component q_1, opposing Djerma to Haussa farmers according to local perception of land degradation and soil erosion, expressed 60.4 %, 45.3 %, 10 % and 73.5 % of the total inertia of datasets 1, 2, 3 and 4 respectively. Djerma farmers think that land degradation is due to erosion, agricultural settlement and wildfire. Run-off and slope are the main soil erosion factors according to them. They also think that crops productivity can be enhanced by using plows and carts. Regarding Haussa farmers, deforestation is the main cause of land degradation, whereas soil type is the main soil erosion factor. Against soil erosion, they set up stony lines and use manure and household rubbishes to improve the soil fertility and crops productivity. The common component q_2 explained 5.4 %, 30.8 %, 70 % and 9.4 % of the total inertia contained in datasets 1, 2, 3 and 4 respectively and opposed Dendi to Djerma farmers about local perception. Dendi farmers acknowledge animal stamping and soil type as main soil erosion factors and practice fallow to improve the soil fertility and crops productivity. As regards Djerma farmers, they cover their lands and till orthogonally to the normal flow of water in order to overcome soil erosion. Globally, the results of CCSWA and PCA are almost the same but the improvement that CCSWA brings is the knowledge of how different datasets cooperate to form the common components.

Keywords: CCSWA, PCA, multivariate analysis, multiblock analysis, perception, land degradation.

Castro HOUNMENOU

Topic: *Estimation of population pharmacokinetic parameters with sparse data in Nonparametric nonlinear mixed effect model*

Abstract: Estimation of population PK parameters and predictive performance of models are difficult statistical and computational task with sparse dataset. Toward this end, an important number of programs based on different methods and algorithms have been developed and used for estimating PK parameters. But these methods differ in the way they express the parameter distribution and maybe influence clinical decisions and safe drugs. Thus, the goal of this study was to analyze the behavior of nonparametric method using exact likelihood function (NPAG) in relation to parametric method using approximate likelihood functions (FOCE) in R software with sparse PK data (neonatal data). One compartment model with intravenous bolus administration and first order elimination was used to describe the pharmacokinetics of phenobarbital. The data concerned 59 children who received multiple doses of this

drug which prevents them from seizures. Average number of observations per neonate is about 2.69 ± 0.49. Tow algorithms (NPAG and FOCE) were used to estimate the PK parameters and implemented in R with "Pmetrics" and "nlme" packages respectively. The performance of NPAG method was assess by comparing these outputs to ones of FOCE. Mann-Whitney test was used to analyze the predict individual and population performance. Probability densities plots and boxplot relative to PK parameters were realized to investigate the nature of PK parameters distribution. Also some statistic properties were computed (OF, AIC, BIC, bias, precision and convergence time) and compared to evaluate predictive performance of models. Both methods statically give the same predict individual performance and differ at population level with median difference value of 3.86 µg/l. The best runtime to reach the convergence is obtained by FOCE after 4 iterations while the difference with NPAG (87 iterations) is of 1:4681. This method presents the lower values of bias and precision but the exam of probability densities plots and boxplots of PK parameters (CL and V) distribution show a non-normal distribution with subpopulations or outliers. Besides, NPAG is the best method because it gave the lower values of OF, AIC and BIC. NAPG presents the statistic predictive properties consistent with sparse data for estimating PK parameters than FOCE and is able to detect some subpopulations and outliers. Its default is relatively large runtime to attain the convergence. Influence study of the sample size and the number of sampling points upon the quality of pharmacokinetic modeling and neonate population parameters estimation are required to take a good biomedical decision.

Keywords: Population PK parameters, estimation, NPAG and FOCE.

Ayédesso Marc Aurèle CHABI ADJOBO
Topic: *Production unit's efficiency analysis using metafrontier: Application to conventional and organic cotton in Benin*

Abstract: Comparisons of unit's efficiencies operate under different technologies remains an important issue in economic studies. This paper tries to shed light on the sensitivity of empirical results to the selection of the estimation method. The primary avenue of comparison in this analysis will be to assess the sensitivity of technical efficiency predictions to the choice of estimation method. Real data was used to compare metafrontier estimation methods. Three methods are compared in this study: stochastic frontier using all data, stochastic metafrontier and Data Envelopment Analysis (DEA) metafrontier. Data used to compare methods were collected in the framework of the Project SYPROBIO (SYstèmes de PROduction BIOlogique diversifiés) during the agricultural campaign 2012–2013.To handle performance of MF, the percentage of underestimated firm's efficiency was calculate using poled data SF, SMF and DEA metafrontier. The paired-t test and Spearman's rank order correlation were used to compare efficiency and TGR derived from the approaches. Results showed that the stochastic frontier using pooled data did not return the optimum output set. For both the stochastic metafrontier production function and the data envelopment analysis metafrontier, there are very large differences in the technical efficiencies. While the predicted technical efficiencies vary widely across farms for both estimations, the variations, across the two estimation methods, are significant. But no methods can be considered as significantly better than other. Difference between two methods depends only on linear programming function's used to obtain metafrontier, technologies gap ratio and the fact that the DEA frontier is not stochastic.

Keywords: DEA metafrontier, stochastic metafrontier, technical efficiency, technologies gap ratio.

Bruno LOKONON
Topic: *Generalized linear models with Poisson family: applications in ecology*

Abstract: Ecological data are often discrete and do not follow the assumptions of the General linear model and its variants (linear regressions, ANOVA, etc.). Discrete response variables, such as count data, often contain many zero observations and are unlikely to have a normally distributed error structure even if transformed. To solve these problems, Generalized Linear Models (GLM) have been more recently developed. The basic GLM for count data is the Poisson model with log link. Frequently, count data are often overdispersed (variance of the response variable greater than the mean) and invalidating the use of the Poisson distribution. In these conditions, some extensions of Poisson model are usually used to deal with overdispersion, including the Negative binomial, Quasi-Poisson, zero-inflated Poisson (ZIP) models and Zero Inflated Negative Binomial (ZINB). The main objective of this study was to empirically assess the robustness of Poisson model and its extensions to overdispersion situations in ecological count data. The simulation plan considered took into account the overdispersion k (k=2, 4, 8, 10, 12 and 20), the sample size, n (n=25, 50, 100, 500 and 1000) and the proportion of zeros in the sample p (p=0.20, 0.40, 0.60 and 0.80). Two models have been considered: simple model (one explanatory variable) and 2-variables model. The comparison criteria were the mean bias (B), the mean relative error (RE) and the root mean-squared error (RMSE) of the slopes, Akaike Information Criterion (AIC) and Vuong statistic. Results obtained showed that no model perform better in all situations but Negative binomial and Zero Inflated Poisson models recorded overall good performances. Applications of these results in ecology revealed that the number of wilted plants is overdispersed because of the preponderance of zeros in the data set. The results proved that zero inflated models performed better on the number of wilted plants within pineapple cultivars in Benin.

Keywords: Poisson models and its extensions, overdispersion, simulation, ecological data.

Aubin AMAGNIDE

Topic: *Longitudinal data analysis: fitting an optimal variance-covariance structure under linear mixed effects models framework*

Abstract: Repeated measures also known as longitudinal data are multiple responses taken in sequential from same experimental unit over time. In practice, the observations within each experimental unit are more likely to be correlated. So, an efficient analysis of repeated measures design requires the selection of the suitable covariance structure of these units. The linear mixed effects model has become a widely used method for analysing longitudinal data due to its ability to overcome some limitations found using standard statistical methods such as analysis of variance on repeated measures or multivariate analysis of variance. In this study, we (i) assessed the performance of 5 fit statistics (AIC, BIC, CAIC, HQIC and AICC) to determine the correct within-subject covariance structure in longitudinal data analysis and (ii) investigated the consequence of misspecification of within subject covariance structure. Firstly, a simulation study was achieved in 192 cases taking into account six characteristics of the data sample (sample size, measurement periods, magnitude of growth parameter, size of G matrices, covariance structure and distribution of the within-subject error). For each combination of these parameters, the hit rate of each search statistics is computed and helps to compare the 5 fit statistics according to their performance. At a second step, based on 32 restricted simulation conditions, the effect of misspecification in within subject covariance structure was assessed by computing the mean relative bias and mean relative errors of the coefficients of fixed effects and random components. These two parameters were then explored descriptively and inferentially through the simulation conditions considered. Results showed an overall best performance of the HQIC, BIC and CAIC for searching AR (1) and MA(1) covariance structures. With regards to ARMA (1,1) covariance structure, AIC, AICC and HQIC presented the overall best performance. Moreover, results obtained from the simulation study found no bias in the fixed effects, with however some bias when the magnitude of growth parameter tended to be small. On contrary, there was evidence of bias in the random components of the model regarding the relative bias. All the considered factors as well as some interactions explained significant variation in the bias of the

random components. The largest amounts of bias were found when the fitted structure was generally misspecified or overspecified for fixed effects and underspecified for random effects.

Keywords: repeated measures, fit statistics, within subject covariance structure, misspecification, simulation.

Appendix 5: Abstracts of interns hosted by LABEF until 2015

Mariama CAMARA

Summary of study: This study focuses on characterization of the habitat quality of the endangered western Giant Eland (*Taurotragus derbianus derbianus*, Gray, 1847) in its last wild refuge: Niokolo Koba National Park South-Eastern Senegal. The Niokolo Koba National Park (NKNP) in Senegal is the last refuge of the critically endangered antelope of the subspecies Derby Eland (*Taurotragus derbianus derbianus* Gray, 1847). Woody plants, that provide shelters and food for the Eland in NKNP, were assessed for their floristic diversity to characterize its confined habitat. Hence, 156 square plots of 20m x 20m were established randomly in the confined area of the Derby Eland. In each plot, list of plants species, their number of individuals, and the environmental factors (soil hardness and type, altitude, percentages of tree and herbaceous cover and fire occurrence) were noted. Fifty (50) trees species belonging to 40 genera and 29 families were recorded. The most represented families were Combretaceae (13.92%), Leguminosae-mimosoideae (12.66 %), Leguminosae-Caesalpinioideae (11.39 %), Leguminosae-papilionoideae (7.59 %), Rubiaceae (7.59 %) and Tiliaceae (6.33 %). The most abundant species were Combretum glutinosum Perr. ex DC., (28.79%), *Pterocarpus erinaceus* Poir. (12.42%), *Crossopteryx febrifuga* (Afzel. ex G. Don) (7.30%), *Strychnos spinosa* Lam. (7.18%) and Hexalobus monopetalus (A. Rich.) Engl. & Diels (7.06 %). Altitude, fire occurrence and vegetation cover were the most important environmental factors influencing the distribution of plants species. Results suggest conservation defenders of eland, for a sustainable management plan, to invest in in-situ fencing in order to increase possibilities of conservation of this critically endangered species in its native area.

Harris Dieu-Donné SAGBOHAN

Summary of the study: The *J. curcas* seedlings growth from different localities was studied in a Guinea-Congolese zone (6°25'N-7°30'N) in the commune of Abomey-Calavi (CRA/Agonkanmey). Three samples of *J. curcas* seeds were taken from 3 localities for the experiment: A (Tori-Bossito), B (Pobè) and C (Kalalé). Two parameters were used to test the effect of provenance on growth patterns of seedlings of J. curcas in this experiment (diameter and height). The experimental design is in a Randomized Complete Block Design (RCBD) with 4 replications and three treatments (Tori-Bossito, Pobè, Kalalé). Squared plots of 7.5 m aside (56.25 m²) were installed in the site (CRA/Agonkanmey). The plantation spacing is of 2.5m between the lines and on the line. In total 12 experimental units were installed in the site. The results of the analysis of variance revealed a high significant difference ($p< 0.01$) between the accessions concerning their effect on the collar diameter increasing. The Student-Newman-Keuls test reveals that the provenances from Pobè and Kalalé have almost the same behavior.

Igor Gorgon TOUCKIA

Summary of study: *Jatropha curcas* L. (Euphorbiaceae) is a multi-purpose plant to which particular attention is paid, due to the effects of climate change and energy crisis. In Central African Republic (CAR), this resource is chosen by the government in the framework of the policy of biofuel promotion in the country. However, reliable data for the adoption of this plant in farming for biofuel production in the country's edaphic and climatic conditions are lacking. This study aims to contribute to a better understanding of this resource and its agronomic and agroforestry performances in line with the edaphic and climatic conditions of the CAR. To achieve this aim, ethnobotanical surveys were conducted in ten prefectures and the respondents were people of different age groups, both sexes and different ethnic groups. In order to characterize the germination, growth and evaluate the agronomic and agroforestry performances of local accessions of *J. curcas*, an experimental plot with a randomized block design was

installed in the village of Nzila at 12 km from Bangui, the capital city of CAR. The study of the agronomic performance allowed us to measure the variability between the growth and productivity parameters of the local accessions of *J. curcas* seedlings according to two modes that are direct seedling and transplanting the seedlings in the tree nursery after. Finally, the impact of peanut intercropping with *J. curcas* and maize intercropping with *J. curcas* on the growth and production parameters of *J. curcas*, maize and peanut according to different types of spacing were assessed.

Laurice CODOU FAYE

Summary of study: The study focuses on the Dynamic of vegetation and carbon stock in managed forest: the case of Missirah Forest in Senegal. The general objective of this study is to assess dynamic of the vegetation and biomass stocks in Missirah Forest and to provide management guidelines for a sustainable biomass stock. The following hypotheses were set. Hypothesis 1: Missirah Forest experiences a continual degradation of its vegetation. Hypothesis 2: The stock of wood volume is not renewed. Hypothesis 3: Vegetation dynamics has direct and underlying causes. Hypothesis 1 was tested based on the comparison of vegetation data collected in 2002 and 2013. The parameters compared are the biodiversity, the Importance Value Index (IVI) of species the structure, and the dendrometric characteristics. The statistical analyses were performed using R, Minitab, and SAS software. This hypothesis was tested through the use an analysis of variance with two fix factors. Three variables are used the total wood fuel volume, the total volume of targeted species, and the total volume of timber species. To determine the factors cited by population as vegetation dynamic drivers the socio-professional data collected was used. After identifying the different drivers, local population were asked to use an importance order according to their contribution to vegetation dynamic to rank them. The scores given by local population for each driver was used to compute a matrix made of the average score of each driver. These scores were combined with socio-professional group made of the ethnic group, the membership to group and the main economic activity. The matrix was subjected to a Principal Component Analysis (PCA) to see how the different socio-economic groups perceive the vegetation dynamic drivers. Furthermore, to identify the most important drivers the scores for each one were combined by the number of respondents that enumerated the driver to do a regression. The flora of Missirah Forest is estimated to 50 species in 2002 and 42 species in 2013. Both combined gives a composition floristic of 60 species made of 32 common species, 18 missing species and 10 new found in 2013. The result of the non-supervised classification through the K-means methods shows three classes defined based on the IVI class centres means.

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