



# EUROPEAN CONFERENCE OF TROPICAL ECOLOGY | BRUSSELS 6 > 10 FEB 2017

ANNUAL MEETING OF THE SOCIETY FOR TROPICAL ECOLOGY (GTÖ)



**(RE)CONNECTING  
BIODIVERSITY  
IN SPACE AND TIME**

MONDAY 06 FEBRUARY

EUROPEAN BRUSSELS  
CONFERENCE OF  
TROPICAL ECOLOGY | 2017

REGISTRATIONS

Building D

TUESDAY 07 FEBRUARY

Plenary Welcome Randy Bakstovits

Author(s) & Hour(s)	507	508	509	510
Topic	Dry tropical forests: functions as the biodiversity hotspot	Integrating landscape ecology and landscape planning	The integrated landscape approach	From landscape to urban

COFFEE BREAK AND POSTERS

Author(s) & Hour(s)	507	508	509	510
Topic	Dry tropical forests: functions as the biodiversity hotspot	Integrating landscape ecology and landscape planning	The integrated landscape approach	From landscape to urban

LUNCH BREAK

Author(s) & Hour(s)	507	508	509	510
Topic	Dry tropical forests: functions as the biodiversity hotspot	Integrating landscape ecology and landscape planning	The integrated landscape approach	From landscape to urban

COFFEE BREAK

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Topic	Dry tropical forests: functions as the biodiversity hotspot	Integrating landscape ecology and landscape planning	The integrated landscape approach	From landscape to urban

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Topic	Dry tropical forests: functions as the biodiversity hotspot	Integrating landscape ecology and landscape planning	The integrated landscape approach	From landscape to urban

WEDNESDAY 08 FEBRUARY

Plenary Serge Planes

Author(s) & Hour(s)	511	512	513	514
Topic	Evolutionary ecology: from genes to landscapes	Large scale landscape planning and landscape restoration	From landscape to urban	From landscape to urban

COFFEE BREAK AND POSTERS

Author(s) & Hour(s)	511	512	513	514
Topic	Evolutionary ecology: from genes to landscapes	Large scale landscape planning and landscape restoration	From landscape to urban	From landscape to urban

LUNCH BREAK

Author(s) & Hour(s)	511	512	513	514
Topic	Evolutionary ecology: from genes to landscapes	Large scale landscape planning and landscape restoration	From landscape to urban	From landscape to urban

FREE AFTERNOON - GUIDED TOURS  
Botanic Garden Missie  
Royal Museum for central Africa Tervuren  
Natural History Museum Brussels

Departure from Building D

Author(s) & Hour(s)	511	512	513	514
Topic	Evolutionary ecology: from genes to landscapes	Large scale landscape planning and landscape restoration	From landscape to urban	From landscape to urban

THURSDAY 09 FEBRUARY

Plenary Lydie Dargent

Author(s) & Hour(s)	516	517	518	519
Topic	Evolutionary ecology: from genes to landscapes	Large scale landscape planning and landscape restoration	From landscape to urban	From landscape to urban

COFFEE BREAK AND POSTERS

Author(s) & Hour(s)	516	517	518	519
Topic	Evolutionary ecology: from genes to landscapes	Large scale landscape planning and landscape restoration	From landscape to urban	From landscape to urban

LUNCH BREAK

Author(s) & Hour(s)	516	517	518	519
Topic	Evolutionary ecology: from genes to landscapes	Large scale landscape planning and landscape restoration	From landscape to urban	From landscape to urban

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Topic	Evolutionary ecology: from genes to landscapes	Large scale landscape planning and landscape restoration	From landscape to urban	From landscape to urban

Author(s) & Hour(s)	516	517	518	519
Topic	Evolutionary ecology: from genes to landscapes	Large scale landscape planning and landscape restoration	From landscape to urban	From landscape to urban

CONFERENCE DINNER PARTY  
VSB Restaurant

Author(s) & Hour(s)	516	517	518	519
Topic	Evolutionary ecology: from genes to landscapes	Large scale landscape planning and landscape restoration	From landscape to urban	From landscape to urban

FRIDAY 10 FEBRUARY

Plenary Helene Muller-Landau

Author(s) & Hour(s)	523	524	525	526
Topic	Evolutionary ecology: from genes to landscapes	Large scale landscape planning and landscape restoration	From landscape to urban	From landscape to urban

COFFEE BREAK AND POSTERS

Author(s) & Hour(s)	523	524	525	526
Topic	Evolutionary ecology: from genes to landscapes	Large scale landscape planning and landscape restoration	From landscape to urban	From landscape to urban

CLOSING CEREMONY  
MERIAN AWARDS  
Author(s) & Hour(s)

LUNCH BREAK

Author(s) & Hour(s)	W01	W02	W03
Topic	Spatial ecology and biogeography	How to publish a Biodiversity Data Paper in Ecology?	What makes your CV stand out when you are applying for a job?



Author(s) & Hour(s)	W01	W02	W03
Topic	Spatial ecology and biogeography	How to publish a Biodiversity Data Paper in Ecology?	What makes your CV stand out when you are applying for a job?

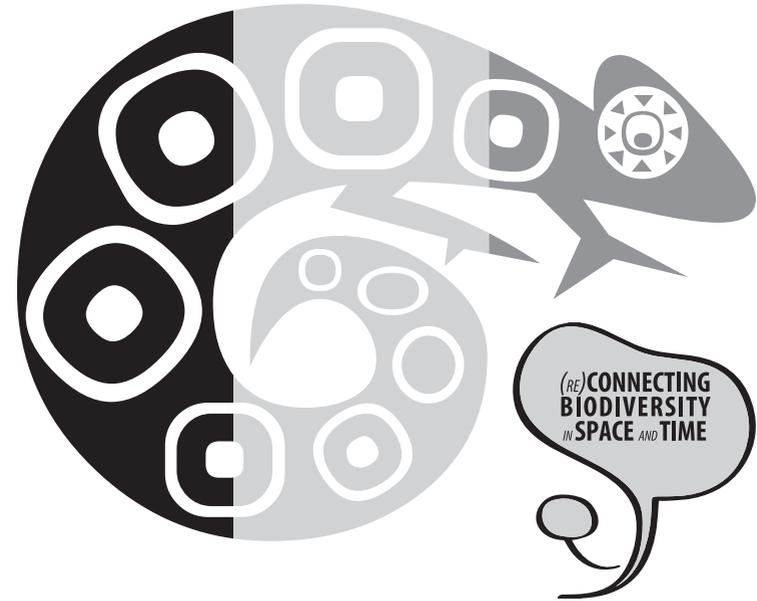


EUROPEAN CONFERENCE OF TROPICAL ECOLOGY



BRUSSELS  
6 > 10 FEB  
2017

ANNUAL MEETING OF THE SOCIETY FOR TROPICAL ECOLOGY (GTÖ)



IMPRINT

Editors

Jérémy Migliore *Université Libre de Bruxelles*  
KCS Kuhlmann *Convention Service*

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Isabelle Bachy (logo)  
*Royal Belgian Institute of Natural Sciences*  
Jérémy Migliore (graphic chart)  
*Université Libre de Bruxelles*

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## LOCAL ORGANIZERS &amp; SPONSORING INSTITUTIONS

The organizing committee and the Society for Tropical Ecology would like to thank the following institutions for their support

ANNUAL MEETING OF THE SOCIETY FOR TROPICAL ECOLOGY (GTÖ)



# EUROPEAN CONFERENCE OF TROPICAL ECOLOGY

BRUSSELS  
6 > 10 FEB  
2017



## TABLE OF CONTENTS

Welcome and Foreword . . . . .	4
Society for tropical ecology (Gesellschaft für Tropenökologie e.V., GTÖ) . . . . .	8
Merian Awards . . . . .	9
Detailed Conference Program . . . . .	16
Monday, 06 February 2017 . . . . .	17
Tuesday, 07 February 2017 . . . . .	22
Wednesday, 08 February 2017 . . . . .	34
Thursday, 09 February 2017 . . . . .	38
Friday, 10 February 2017 . . . . .	46
Plenary sessions – Abstracts . . . . .	50
Public lecture. . . . .	56
Scientific talk sessions – Abstracts. . . . .	60
Session 1 – Traits and functions in the tropics . . . . .	62
Session 2 – Dry tropical woodlands in Africa. . . . .	82
Session 3 – Gene flow in the tropics . . . . .	100
Session 4 – Tropical freshwater microhabitats . . . . .	108
Session 5 – Species delineation in the tropics . . . . .	116
Session 6 – Tropical forest modelling. . . . .	130
Session 7 – Tropical biodiversity for development. . . . .	138
Session 8 – Savanna ecology and functioning. . . . .	156
Session 9 – The mangrove biodiversity enigma . . . . .	170
Session 10 – Forests in space and time . . . . .	182
Session 11 – Fragmentation genetics and biodiversity . . . . .	198
Session 12 – Large vertebrates in a changing world . . . . .	214
Session 13 – Riparian ecosystems in tropical drylands . . . . .	226
Session 14 – Coral reefs at risk . . . . .	232
Session 15 – Food production and biodiversity conservation . . . . .	240
Session 16 – Palaeoecology of tropical ecosystems . . . . .	248
Session 17 – Complete altitudinal rainforest transects . . . . .	260
Session 18 – The tropical forest in a changing climate . . . . .	284
Session 19 – Seed dispersal . . . . .	294
Session 20 – Integrative tropical ecosystems dynamics. . . . .	302
Session 21 – Human-modified tropical forests . . . . .	320
Session 22 – Legacy specimens, future goals . . . . .	332
Session 23 – Economic valuation, certification and conservation . . . . .	340
Session 24 – Including lianas in vegetation models . . . . .	348
Session 25 – Arthropod ecology and conservation. . . . .	356
Scientific poster session – Abstracts . . . . .	364
Informations for Participants . . . . .	472
Social & side events . . . . .	480
All about Brussels . . . . .	486
Acknowledgements . . . . .	494
Index of participants . . . . .	498



# WELCOME AND FOREWORD



## WELCOME LOCAL ORGANIZERS

### Dear colleagues, dear participants

It is a great pleasure for us to welcome you to Brussels for the first time to this 2<sup>nd</sup> edition of the European Conference of Tropical Ecology, which is also the 30<sup>th</sup> Annual Meeting of the Society for Tropical Ecology (gtö). The latter was founded in Germany and has internationalized steadily for the past few years, contributing to the exchanges between researchers and stakeholders across the world who are interested in tropical ecology. This second conference is organized jointly by members of three Belgian universities and four research-museum institutions based in or around Brussels. It reflects the importance of tropical ecology research conducted in Belgium, where, for historical reasons, we have maintained a strong focus on - but not limited to - Central Africa.

One of the main objectives of this conference is to foster scientific exchanges between researchers, and especially to allow young researchers to share their results with experienced ones in 25 dedicated thematic sessions. Although electronic communication has increased our daily interactions very efficiently, face-to-face communication remains highly beneficial when developing new interactions. As those interactions are often easier within smaller groups, this year, for the first time, we have included two special half days: one offering the possibility of a guided tour to scientific institutions and another devoted to thematic workshops. The number of registrations received for these extra activities shows that they really meet a demand. Other interactions will also be possible during coffee breaks, the welcome reception, the conference dinner party, or special contact can be made in one of the meeting rooms we have booked. We hope that the photographs of speakers or poster exhibitors in the abstract book will also help you find people you only know by name.

With its remarkable biodiversity and ecological complexity, the tropical world has always been very attractive to biologists interested in life evolution and this is reflected by the numerous conference papers dealing with fundamental research issues. The tropical world is also at the very heart of critical changes due to increasing human pressures which affect both the maintenance of natural tropical ecosystems and the development opportunities of local human populations. It is therefore also a conference objective to highlight applied research aiming at improving the management of tropical ecosystems. To enable easier communication between researchers and potential stakeholders, we have concentrated a substantial part of the more applied research within a single day (Tuesday). This day will end with an evening conference debate open to the public in order to illustrate and discuss how research can help improve tropical forest management in logging concessions so as to reconcile economic valorization and biodiversity conservation.



We are proud to report that, when writing these lines, about 380 people from 46 countries have registered for the congress. We hope that this 5-day meeting will be exciting and rewarding for all of you, we wish you an excellent conference for reconnecting biodiversity in space and time!



Olivier J. Hardy

On behalf of the Local Organizers:

Jérémy Migliore (ULB),

Yves Roisin (ULB),

Farid Dahdouh-Guebas (ULB+VUB+ARSOM/KAOW),

Karolien Van Puyvelde (VUB),

Marc Kochzius (VUB),

Nico Koedam (VUB),

Jean-Louis Doucet (ULg - GxABT),

Maurice Leponce (RBINS),

Erik Verheyen (RBINS),

Patricia Mergen (RMCA + BGM),

Hans Beeckman (RMCA),

Steven Janssens (BGM),

Philippe Goyens (ARSOM/KAOW)

**Dear friends and colleagues, dear participants of the gtö Conference 2017,**

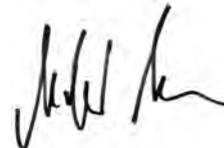
Our Society for Tropical Ecology (gtö) is becoming truly an international organization. Not only have we added the English name to the original German name “Gesellschaft für Tropenökologie”, but we also try to hold our annual meetings once in Germany and once in another European country. After Erlangen (2012) followed Vienna (2013), Freising (2014) was followed by Zürich, and after the very successful conference in Göttingen (2016) we are now here in Brussels. Consequently, our “Jahrestagung der gtö” is now called “European Conference of Tropical Ecology”. The decision by the gtö Board “to go international” is also reflected by an increasing number of international members and participants at our conferences. As the (meanwhile international) Board of gtö we try to find ways to make the gtö conferences especially attractive and financially accessible to students and young scientists and to support participants from poorer countries. The funds of the gtö are limited and the more members we have the more will we be able to do that. We are especially thankful to donors and sponsors of our conference who make it possible to organize these conferences despite our own limited resources. We also owe a big “thank you” to the local organizing committee who did a wonderful job in preparing this conference.



To judge from the number of inscriptions, posters and presentations, this will be a very big and interesting conference here in Brussels. Climate change is dominating the international environmental discussions (which is good), but the risks and threats global biodiversity is facing are still not seen sufficiently in their disastrous consequences for mankind. It's not any more a matter of threatened, possibly charismatic, species of animals and plants, it is now a matter of damaged or destroyed ecosystems and severely reduced ecosystem services. Biodiversity conservation has become a matter of human wellbeing.

As tropical ecologists and conservationists we love what we do and we should all be aware of our responsibilities. So let's have an enjoyable conference with scientifically high standards. Let's send out strong messages to the world and let's “(re)connect tropical biodiversity in space and time”.

All best wishes,



Prof. Dr. Manfred Niekisch



## SOCIETY FOR TROPICAL ECOLOGY (GESELLSCHAFT FÜR TROPENÖKOLOGIE E.V., GTÖ)

The Society for Tropical Ecology promotes and communicates new and emerging knowledge among tropical ecologists to advance the understanding of tropical ecosystems and their protection. It is currently Europe's largest scientific association in this field of research with about 500 members. The aim of the Society for Tropical Ecology, which was founded in 1987, is to further improve our understanding of all the aspects of tropical ecology. A primary means toward this scope is through the organization of annual international congresses, usually one week in February in Europe. Invited international plenary speakers contribute papers and discussions on selected themes of either outstanding universal topicality or of special relevance to up-to-date issues in tropical ecology in order to promote scientific exchange with the participants, many of which usually are students. The conferences provide an international platform for the exchange of scientific ideas and the establishment of collaborations between members and their guests. The gtö is especially dedicated to fostering junior research and equitable cooperation projects.

### *Our vision:*

Understanding biodiversity and functions of tropical ecosystems drives decision making and management on all levels.

### *Our mission:*

Promoting the conservation and rehabilitation of tropical biodiversity and ecosystems through research and its application.

More information:

<http://www.soctropecol.eu/>

## MERIAN AWARDS

In 2001 the gtö established the Merian Awards for the best contributions given by young scientists during the annual meeting. There are six Merian Awards annually, three for the best oral contributions and three for the best posters. ECOTROPICA – the society's journal – highlights these contributions by publishing the abstracts.

The gtö has selected Maria Sibylla Merian as the patron of the award to commemorate her unique work as an outstanding artist and as the first female tropical naturalist who actually travelled to the tropics in order to study their fascinating diversity, in particular insects. She was the first scientist who recognized, and documented in her artistic work, that insects go through various developmental stages. This is particularly remarkable as the general public in her time still believed that, for instance, mosquitoes and caterpillars were generated in mud by the evil.

### *Who is eligible and how to apply?*

Eligible candidates are students and PhDs who are members of the gtö and finished their dissertation less than three years ago. If you are not a member yet, just apply at the registration desk before the conference starts.

**The winners will be awarded during the closing ceremony on Friday 10<sup>th</sup> February, 11:30 – 12:30.**



# LOCAL ORGANIZERS



**Olivier J. HARDY**  
Conference Chair  
Researcher ULB - EBE



**Jérémy MIGLIORE**  
Coordinator/Secretary  
Postdoc ULB-EBE



**Heike KUHLMANN**  
Professional Conference  
Organizer - KCS



**Farid DAHDOUH-GUEBAS**  
Professor ULB/VUB - SERM



**Patricia MERGEN**  
Liaison Officer RMCA/BGM



**Karolien VAN PUYVELDE**  
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**Jean-Louis DOUCET**  
Professor ULg-Gbx - TERRA



**Maurice LEPONCE**  
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**Marc KOCHZIUS**  
Professor VUB



**Steven JANSSENS**  
Researcher BGMeise



**Erik VERHEYEN**  
Researcher RBINS



**Yves ROISIN**  
Professor ULB - EBE



**Nico KOEDAM**  
Professor VUB



**Hans BEECKMAN**  
Researcher RMCA



# INSTITUTIONS OF LOCAL ORGANIZERS



## UNIVERSITÉ LIBRE DE BRUXELLES

Since its foundation in 1834, the Université Libre de Bruxelles has been closely involved in the ongoing debate on critical thinking and freedom. Promoting free enquiry and independent reasoning, the University is firmly engaged in the defence of democratic and human values.



UNIVERSITÉ  
LIBRE  
DE BRUXELLES

In the heart of Europe, the ULB is a multicultural university with one third of students and researchers from abroad. International relations are a daily reality just like the city of Brussels itself, one of the world's most cosmopolitan cities. With 26,000 students, the ULB has 13 faculties that cover all the disciplines, closely combining academic input and research. It offers almost 40 undergraduate programs and 235 graduate programs. It also partners 20 Doctoral schools, with almost 1,600 PhD in progress.

The ULB is located on several campuses in Brussels: Solbosch, La Plaine, Erasme teaching hospital. Several research units working in the Tropics are part of the Department of Organism Biology. Their research includes genetics, ecology, biogeochemistry, behavioural ecology...

→ Website: <http://www.ulb.ac.be/>

## VRIJE UNIVERSITEIT BRUSSEL

The Vrije Universiteit Brussel is a dynamic and modern university with two parkland campuses in the Brussels Capital Region: the main campus in Etterbeek is home to seven faculties. In Jette you can find the medical campus and the University Hospital. The VUB is the only Flemish university that has incorporated the principle of 'free inquiry' in its statutes.



VRIJE  
UNIVERSITEIT  
BRUSSEL

Centrally situated in the capital of Europe, the university takes up its role as an ambassador for Flanders and Brussels, in a spirit of active pluralism and open mindness. Quality education is offered to more than 9,000 students. Add to that the almost 4,500 students of our partner, the Erasmus Hogeschool Brussels; the 400 students at the English-speaking Vesalius College; the 5,000 students at the Centre for Adult Education that shares our campus, and the more than 150 research teams working on both our campuses, and you get one of the biggest centres of knowledge in the capital of Europe.

High quality education and research are central issues. The research teams are internationally recognised in many disciplines of fundamental and applied research.

→ Website: <http://www.vub.ac.be/>



## GEMBLoux AGRO-BIO TECH – UNIVERSITÉ DE LIÈGE



Gembloux Agro-Bio Tech  
Université de Liège

Integrated at the University of Liège since 2009, Gembloux Agro-Bio Tech is a faculty of human size, open to the world and whose quality of teaching and research has been

internationally renowned for more than 150 years.

Faculty at the forefront of the sustainable development, Gembloux Agro-Bio Tech trains bioengineers. Four distinct study programs allow the students to specialize in key areas of life sciences, including forest and natural area management.

In tropical regions, the University of Liège has established numerous collaborative agreements with research and training institutions as well as with the private sector. It has also created a permanent structure in the Democratic Republic of Congo, aiming at developing research, teaching, training and expertise projects in Central Africa.

→ Website: <http://www.gembloux.ulg.ac.be/>

## BOTANIC GARDEN MEISE



**Botanic Garden  
Meise**

Older than Belgium, the earliest roots of Botanic Garden Meise can be traced to 1796. The Garden comprises 92 ha and includes a castle that dates back to the 12<sup>th</sup> century. The Garden has a large herbarium housing about 4 million specimens and containing the largest *Rosa* herbarium of the world

and important historical collections from Brazil and Central Africa. It also has a botanical library holding over 200,000 volumes, comprising publications from the 15<sup>th</sup> century to modern day. The Garden holds a collection of about 18,000 different kinds of living plants, among which several are threatened, such as the Laurent cycad (*Encephalartos laurentianus*). The Garden also houses an internationally recognised seed bank including inter alia the seeds of numerous wild bean species.

Activities of our scientists to inventory and study plant, fungal and algal diversity span the globe; from Antarctica to the rainforests of Congo. The scientific work focuses on the correct and scientific identification of plant species. On a yearly basis approximately 100,000 people explore the glasshouses and the gardens, to spread knowledge about plants and conservation.

→ Website: <http://www.botanicgarden.be/>

## ROYAL MUSEUM FOR CENTRAL AFRICA TERVUREN

The RMCA was established in 1897 and, as a multidisciplinary institution focusing on conservation, education and research. It holds the largest biodiversity collection anywhere in the world on Central Africa. Furthermore, the majority of the specimens originate from the relatively poorly studied megadiversity belt in the equatorial Africa.

RMCA is a leading multidisciplinary research institute and knowledge centre on the cultural and natural heritage in Africa, particularly in Central Africa. It develops interest and understanding for African heritage in the scientific communities and the public. The researchers carry out studies in the natural and urban environments, including historical-socio-economical aspects. Natural History manages about 10 million specimens of animals, 60,000 wood specimens, 16,000 minerals, 300,000 rocks and 21,500 fossils. The institution has about 1.2 km of archives of unique interest like the Stanley collection, 200,000 cultural objects, more than one million of photographs, 700 movies and more than 6000 hours of traditional music and voice recordings and 8000 musical instruments. Scientific staff masters ten languages; consequently, the library and reprints are unusually multilingual.

→ Website: <http://www.africamuseum.be/>



## ROYAL BELGIAN INSTITUTE OF NATURAL SCIENCES

The Royal Belgian Institute of Natural Sciences deals with most fields of natural sciences: geology, zoology, palaeontology, molecular biology, oceanography and ecosystem studies. With approximately 37 million of specimens, the collections serve as reference and research tools.

The Natural History Museum is the visible part for the public. Its permanent galleries, temporary exhibition rooms and educational workshops welcome more than 300,000 visitors each year. Its Dinosaur Gallery is the largest in Europe and exhibit a large group of Iguanodon, a dinosaur found in Bernissart, Belgium. The research institute has a long tradition of tropical exploration worldwide and possesses large collections originating from central Africa, Asia, South America and Oceania.



# DETAILED CONFERENCE PROGRAM

Talks and Posters shaded in this background color are eligible for the Merian Award



## DETAILED PROGRAM SCHEDULE

### MONDAY, 06 FEBRUARY 2017

Time	Event			
10:00	<b>START OF REGISTRATION</b> - Building D			
13:30	<b>OPENING CEREMONY</b> - Auditorium Q Maathai			
13:50	<b>PLENARY TALK 01 - Owen LEWIS - Auditorium Q Maathai</b> Unravelling the effects of insect herbivores and plant pathogens on rainforest diversity			
14:45	<b>Parallel sessions</b>			
Sessions	S01: TRAITS AND FUNCTIONS IN THE TROPICS (1/3)	S02: DRY TROPICAL WOODLANDS IN AFRICA (1/3)	S03: GENE FLOW IN THE TROPICS	S04: TROPICAL FRESHWATER MICROHABITATS
Chairs	Hans BEECKMAN, Maike DE RIDDER, Adeline FAYOLLE, Vincent MERCKX, Sofia GOMES	Manfred FINCKH, Casey RYAN, Rasmus REVERMANN	Alexandra C. LEY, Jérôme DUMINIL	Bram VANSCHOEN-WINKEL, Tom PINCEEL, Mathil VANDROMME
Room	Auditorium D03 Aké Assi	Auditorium D02 Fossey	Auditorium D07 Wilson	Auditorium D08 Clark
14:45	<b>S01-001: Anais-Pasiphaé GOREL</b> Hydraulic and wood traits of two congeneric tropical tree species in their core habitat	<b>S02-001: Priscilla SICHONE</b> Prediction of woody above-ground biomass in the Miombo Woodlands: accuracy of estimations	<b>S03-001: Jérôme DUMINIL</b> High selfing rate, limited pollen dispersal and inbreeding depression in the emblematic African rain forest tree <i>Baillonella toxisperma</i>	<b>S04-001: Annika BUSSE</b> Microfauna beta diversity in Brazilian tank bromeliads
15:00	<b>S01-002: Nina SCHICKENBERG</b> Function and morphological traits of the velamen radicum in Orchidaceae	<b>S02-002: Adia BEY</b> Participatory assessment of land use and land use change to foster sustainable management of Miombo social-ecological systems	<b>S03-002: Franck MONTHE KAMENI</b> Genes flow patterns in rainforest trees species of the genus <i>Entandrophragma</i> (Meliaceae) inferred from indirect and direct analyses	<b>S04-002: Celina Tawes BEN SAADI</b> Prey catch selectivity and pitcher infaunal community composition in two <i>Nepenthes</i> species in Peninsular Malaysia
15:15	<b>S01-003: Ariane MIRABEL</b> Relating functional and structural traits to species performance in the early stages for 15 tropical tree species	<b>S02-003: Rose PRITCHARD</b> The impact of land use intensification on provisioning services from miombo woodland in rural Zimbabwe	<b>S03-003: Alexandra C. LEY</b> Hybridization and asymmetric introgression after secondary contact in two tropical African climber species	<b>S04-003: Bram VANSCHOEN-WINKEL</b> Climatic control of diversity in freshwater microhabitats - from hydrology to biogeography



15:30	<b>S01-004: Lore VERRYCKT</b> Spatial variation of photosynthesis in tropical pristine forests: saplings vs. adults	<b>S02-004: Casey RYAN</b> Widespread degradation and boosted deforestation offset by extensive regrowth in African woodlands	<b>S03-004: Kasso DAINOU</b> Revealing unidirectional introgression in the West African contact zone of the timber genus <i>Milicia</i>	<b>S04-004: Angela ARISTIZABAL-BOTERO</b> Macroinvertebrate assemblages and its relationship with physicochemical factors in Colombian Guyana shield temporary rock pools
15:45	<b>S01-005: Lan ZHANG</b> Comparing canopy trees in tropical forest - Understanding performance from scaling architecture, allocation, physiology and anatomy to whole plants	<b>S02-005: Iain MCNICOL</b> What is the impact of protected areas on deforestation and degradation in southern African savannah woodlands?	<b>S03-005: Dennis J.R. DE RYCK</b> Genetic structure of <i>Avicennia marina</i> in the Western Indian Ocean: an unexpected genetic break	<b>S04-005: Mark Louie LOPEZ</b> Microcrustacean assemblages from groundwater-dependent ecosystems in Luzon and Mindoro Islands (Philippines): insights to tropical groundwater ecology
16:00	<b>S01-006: Grace Jopaul LOUBOTA PANZOU</b> How tree architecture varies across coexisting tropical tree species and relate to ecological strategies?	<b>S02-006: Noé HOFICO</b> Diversity and structure of Miombo woodlands in Mozambique using a range of sampling sizes	<b>S03-006: Hajaniaina RATSIMBAZAFY</b> Connectivity of Mangrove whelk in the Western Indian Ocean	<b>S04-006: Aymere AWOKE</b> Macroinvertebrate assemblages are uniquely related to microhabitats and water quality in tropical rivers of Ethiopia
16:15	<b>COFFEE BREAK AND POSTERS</b> - Building D			

16:45	<b>Parallel sessions</b>			
<b>Sessions</b>	<b>S01 CONTINUED (2/3)</b>	<b>S02 CONTINUED (2/3)</b>	<b>S05: SPECIES DELINEATION IN THE TROPICS (1/2)</b>	<b>S06: TROPICAL FOREST MODELLING</b>
<b>Chairs</b>	Hans BEECKMAN, Maike DE RIDDER, Adeline FAYOLLE, Vincent MERCKX, Sofia GOMES	Manfred FINCKH, Casey RYAN, Rasmus REVERMANN	Jean-François FLOT, Olivier J. HARDY	Louis FRANCOIS, Alain HAMBUCKERS, Marie DURY
<b>Room</b>	Auditorium D03 Aké Assi	Auditorium D02 Fossey	Auditorium D07 Wilson	Auditorium D08 Clark
16:45	<b>S01-007: Svenja KLEINSCHMIDT</b> Implications of inter- and intraspecific variation of wood density on biomass estimations in secondary forests	<b>S02-007: Rasmus REVERMANN</b> Interactions of multiple transformation pathways in the Okavango region	<b>S05-001: Olivier J. HARDY</b> Are there many cryptic plant species in the tropics? New insights from population genetics approaches applied on African forest trees	<b>S06-001: Simon SCHEITER</b> How do climate, soil and fire mediate biome patterns and diversity in South America under current and future conditions?
17:00	<b>S01-008: Marijke VAN KUIJK</b> Biomass dynamics after logging: the role of wood density	<b>S02-008: Francisco GONCALVES</b> Tree species diversity and composition of Miombo woodlands in south-central Angola, a chronosequence of forest recovery after shifting cultivation	<b>S05-002: Victor DEKLERCK</b> Species identification and separation based on chemotypes using DART-TOFMS	<b>S06-002: Nikolaos FYLLAS</b> Modeling tropical forest dynamics: from plant functional types to functional trait distributions
17:15	<b>S01-009: Benoit CASSART</b> Contrasting soil carbon turnover between monodominant <i>Gilbertiodendron dewevrei</i> and mixed-species forests is related to leaf litter traits	<b>S02-009: Valter CHISSINGUI</b> Environmental factors influencing tree species diversity in Miombo woodlands of Huila province, southwestern Angola	<b>S05-003: Felicitas GUNTER</b> Phylogeographic and phylogenetic analyses on the sand termite <i>Psammotermes allocerus</i> SILVESTRI 1908 in Namib Desert fairy circles of Southern Africa	<b>S06-003: Ervan RUTISHAUSER</b> Old growth tropical forest dynamics: gaps, succession, and long-term trends





## TUESDAY, 07 FEBRUARY 2017

08:25	<b>PLENARY TALK 02 - Noeline RAONDRY RAKOTOARISOA - Auditorium Q Maathai</b> The world network of biosphere reserves: learning places for Sustainable development			
09:15	<b>Parallel sessions</b>			
<b>Sessions</b>	S07: TROPICAL BIODIVERSITY FOR DEVELOPMENT (1/3)	S02: DRY TROPICAL WOODLANDS IN AFRICA (3/3)	S01: TRAITS AND FUNCTIONS IN THE TROPICS (3/3)	S05: SPECIES DELINEATION IN THE TROPICS (2/2)
<b>Chairs</b>	Jean HUGE, Bruno VERBIST, Luc JANSSENS DE BISTHOVEN	Manfred FINCKH, Casey RYAN, Rasmus REVERMANN	Hans BEECKMAN, Maïke DE RIDDER, Adeline FAYOLLE, Vincent MERCKX, Sofia GOMES	Jean-François FLOT, Olivier J. HARDY
<b>Room</b>	Auditorium D03 Aké Assi	Auditorium D02 Fossey	Auditorium D07 Wilson	Auditorium D08 Clark
09:15	<b>S07-001: Anne-Julie ROCHETTE</b> Capacity building for the monitoring, reporting and verification (MRV) of biodiversity and ecosystem services in Africa	<b>S02-014: Paulina ZIGELSKI</b> Trees seizing new landscapes - Evolutionary avoidance strategies of abiotic stresses allowed tropical forest tree taxa to survive in open grasslands	<b>S01-014: Leandro VAN LANGENHOVE</b> Free living N <sub>2</sub> fixation in the Imbalance-P experiment on French Guianese pristine rainforests	<b>S05-008: Jean-François FLOT</b> Haplowebs: an allele sharing-based approach to species delimitation
09:30	<b>S07-002: Erik VERHEYEN</b> Biodiversity research and monitoring related capacities in Kisangani (DRC)	<b>S02-015: David BAUMAN</b> Improving the detection of dispersal limitation in plant communities	<b>S01-015: Vincent MERCKX</b> The role of mycorrhizal specificity in plant evolution and diversification	<b>S05-009: Kasso DAINOU</b> Cryptic species diversity in the tree genus <i>Milicia</i> : an assessment based on nuclear SNPs, SSRs and a DNA sequence
09:45	<b>S07-003: Luc JANSSENS DE BISTHOVEN</b> Transfer under Nagoya Protocol of traditional knowledge to scientists in Burundi, mediated by ministries of environment and health	<b>S02-016: William APTED</b> Satellite Monitoring for Forest Management (SMFM) project	<b>S01-016: Jorinde NUYTINCK</b> Out of Africa: evolutionary history of hyper-diverse ectomycorrhizal milkcap genera (Russulales, Basidiomycota)	<b>S05-010: Catalina RAMIREZ-PORTILLA</b> Species delimitation and hybrid detection in tropical <i>Acropora</i> coral species

10:00	<b>S07-004: Marie-Lucie SUSINI</b> Using taxonomic research results to achieve a better conservation and management of biodiversity and ecosystem services	<b>S02-017: Natasha RIBEIRO</b> Miombo network of Southern Africa: a platform for collaborative research for decision-making on restoring miombo woodlands	<b>S01-017: Sofia GOMES</b> Cheating belowground interactions	<b>S05-011: Susan ROTHERFORD</b> Varying levels of interspecific plasticity confounds species delimitation in closely related eucalypts
10:15	<b>S07-005: Pieter MOONEN</b> Perceptions and management of land and resources in rural communities in the DR Congo: lessons for sustainable development		<b>S01-018: Diana GOMEZ GONZALEZ</b> Epiphytic matter and water storage dynamics in a tropical montane forest Fortuna, western Panama	<b>S05-012: Catherine REEB</b> Are cryptic <i>Riccardia</i> species really cryptic? Unraveling a puzzling thalloid liverwort genus using integrative taxonomy
10:30	<b>COFFEE BREAK AND POSTERS - Building D</b>			
11:00	<b>Parallel sessions</b>			
<b>Sessions</b>	S07 CONTINUED (2/3)	S08: SAVANNA ECOLOGY AND FUNCTIONING (1/2)	S09: THE MANGROVE BIODIVERSITY ENIGMA (1/2)	S10: FORESTS IN SPACE AND TIME (1/2)
<b>Chairs</b>	Hans BEECKMAN, Maïke DE RIDDER, Adeline FAYOLLE, Vincent MERCKX, Sofia GOMES	Julie C. ALEMAN, Laurent BREMOND, Charly FAVIER	Stefano CANNICCI, Nico KOEDAM, Farid DAHDOUH-GUEBAS	Rico FISCHER, Edna RÖDIG, Andreas HUTH
<b>Room</b>	Auditorium D03 Aké Assi	Auditorium D02 Fossey	Auditorium D07 Wilson	Auditorium D08 Clark
11:00	<b>S07-006: Katherine VANDE VELDE</b> Analysing discourses of environmental stakeholders on effective conservation of Mangrove forests in Singapore	<b>S08-001: Charly FAVIER</b> Savanna ecology in space and time	<b>S09-001: Ian HENDY</b> Terrestrial and marine consortia of wood degraders in mangrove forests are divided by a sharp tidally-defined boundary	<b>S10-001: Konstantinos PAPATHANASSIOU</b> Measuring forest structure by means of synthetic aperture radar techniques



11:15	<b>S07-007: Soraya CANDIDO</b> Biodiversity integration in development cooperation: why and how? A Delphi study to identify ways forward	<b>S08-002: Julie ALEMAN</b> Long-term forest and savanna distribution in West and Central Africa	<b>S09-002: Patrick GROOTAERT</b> Patched distribution of mangrove insects urges protection of multiple areas to maintain insect diversity	<b>S10-002: Andreas HUTH</b> Observation of global forests with L-band SAR satellites Tandem-L
11:30	<b>S07-008: Patricia MERGEN</b> Importance of UNESCO Man and Biosphere Reserves in the tropics	<b>S08-003: Judith SITTERS</b> The yin and yang of African savanna: a stoichiometric perspective of herbivore dung on ecosystem functioning	<b>S09-003: Abdulloh SAMOH</b> Diversity of Mangrove Dolichopodid flies (Diptera: Dolichopodidae) in Peninsular Thailand	<b>S10-003: Jasper VAN DONINCK</b> Mapping Amazonian biodiversity and geology from Landsat imagery and fern species inventories
11:45	<b>S07-009: Francesca LANATA</b> Responsible economic development and biodiversity conservation in Virunga National Park: the role of Botanic Garden Meise	<b>S08-004: Francesco ACCATINO</b> Spatial ecological processes allow tree-grass coexistence in savannas despite repeated fires	<b>S09-004: Columba MARTINEZ ESPINOSA</b> Crab community structure as ecological indicator of Matang Mangrove Forest in Malaysia	<b>S10-004: Marcelo NASCIMENTO</b> Plantation establishment and native species regeneration in two contrasting situations in a restinga formation in southeastern Brazil
12:00	<b>S07-010: Ute SCHMIEDEL</b> Paraecologists and parataxonomists are key for stakeholder scientist interactions	<b>S08-005: Sa LISBOA</b> Modelling the spatial variability of soil organic carbon and soil total nitrogen in Mabalane district, Mozambique	<b>S09-005: Laura MICHIE</b> Can we all just get along; understanding coexistence in Fiddler Crabs	<b>S10-005: Pedro L. SILVA DE MIRANDA</b> The importance of floristic data for biologically meaningful biomes in Lowland Tropical South America (LTSA)
12:15				<b>S10-006: Edna RÖDIG</b> Spatial heterogeneity of biomass and forest structure of the Amazon rainforest: linking a forest gap model and remote sensing
12:30	<b>LUNCH BREAK</b>			

13:30	<b>Parallel sessions</b>			
<b>Sessions</b>	<b>S07 CONTINUED (3/3)</b>	<b>S08 CONTINUED (2/2)</b>	<b>S09 CONTINUED (2/2)</b>	<b>S10 CONTINUED (2/2)</b>
<b>Chairs</b>	Hans BEECKMAN, Maike DE RIDDER, Adeline FAYOLLE, Vincent MERCKX, Sofia GOMES	Julie C. ALEMAN, Laurent BREMOND, Charly FAVIER	Stefano CANNICCI, Nico KOEDAM, Farid DAHDOUH-GUEBAS	Rico FISCHER, Edna RÖDIG, Andreas HUTH
<b>Room</b>	Auditorium D03 Aké Assi	Auditorium D02 Fossey	Auditorium D07 Wilson	Auditorium D08 Clark
13:30	<b>S07-011: Koen VANDERHAEGEN</b> Do Private Sustainability Standards walk the talk in improving economic and environmental sustainability?	<b>S08-006: Kaly OUATTARA</b> The benefit of perennial grass tufts in association with ant nest in Lamto savanna (Ivory Coast)	<b>S09-006: Sara FRATINI</b> Genetic diversity in mangrove crabs is affected by population fecundity and demographic history	<b>S10-007: Nikolai KNAPP</b> Remote sensing of tropical forest carbon fluxes: What can we learn from an individual-based model?
13:45	<b>S07-012: Africa BARRIOS TRULLOLS</b> Can mangrove silviculture in Matang Mangrove Forest Reserve be carbon-neutral?	<b>S08-007: Celine DE CALUWE</b> Biomass accumulation and patterns of natural regeneration in savannas in the Bas Congo province of the DRC	<b>S09-007: Jani SLEUTEL</b> Impact of mangrove forest management on birds: field assessment and reflections on ecological functionality	<b>S10-008: Franziska TAUBERT</b> The packing of trees in forests and its implications for remote sensing
14:00	<b>S07-013: Mark ABRAHAMS</b> Living with the enemy; crop raiders in neotropical rainforests	<b>S08-008: Amah AKODEWOU</b> torical analysis of landscape change using remote sensing techniques in Togodo Protected Area and its surrounding areas in southeastern Togo	<b>S09-008: Christina Ani SETYANINGSIH</b> A contribution to the understanding of long-term ecology and dynamics of the mangrove forests in Jambi, Sumatra (Indonesia)	<b>S10-009: Mateus DANTAS DE PAULA</b> Quantifying the effects of Forest Fragmentation on Transpiration and Total surface runoff using a forest simulation model
14:15	<b>S07-014: John NDARATHI</b> Trends in Artisanal Fish Trade in coastal Kenya (trade commodities ,challenges and organization among key stakeholders)	<b>S08-009: Anna LEßMEISTER</b> Vegetation changes in a human disturbed West African savanna over the past two decades	<b>S09-009: Nathalie TONNE</b> Coming of age the mangrove propagule, parental investment and the dual functionality towards autonomy and establishment	<b>S10-010: Chloe BROWN</b> Remote sensing investigation of how oil palm cultivation is degrading Malaysia s tropical peatland ecosystem services



14:30	<b>S07-015: Bernard RIERA</b> Xper reconnaissance base of plants and their uses for the management and conservation of protected are: Antrema, Madagascar	<b>S08-010: Simone VACCARI</b> Multi-sensor remote sensing approach to monitor pasture quality in savanna ecosystems	<b>S09-010: Molly CZACHUR</b> Tracking biodiversity benefits of a carbon offset project in mangroves of Kenya	<b>S10-011: Christine WALLIS</b> Remotely-sensed forest productivity: Performance of spectral and textural information
14:45	<b>S07-016: Jeanne Agrippine YETCHOM FONDJO</b> Effects of anthropogenic disturbances on Acridoidea species diversity and distribution in the natural ecosystem of the Coastal Region, Cameroon	<b>S08-011: Katharina STEIN</b> Thank you for Bee-ing there bee pollination increases yield and quality of cash crops in Burkina Faso, West Africa	<b>S09-011: J-Hude E. MOUDINGO</b> Invadability/ invasiveness of non-native Mangrove Palm ( <i>Nypa fruticans</i> Wurbm.) from long-term monitoring of permanent sample plots in Cameroon	<b>S10-012: Mahmoud BAYAT</b> Determination of crown canopy classes map using aerial photographs of 1955 1995 and GIS
15:00		<b>S08-012: Guillaume DELHAYE</b> Functional composition and diversity along a natural metal toxicity gradient in central Africa		<b>S10-013: Seraphine Ebenye MOKAKE</b> Impacts of selective logging on plant community structure, floristic richness and diversity in the eastern forest of Cameroon
15:15		<b>S08-013: Edouard ILUNGA WA ILUNGA</b> Ecosystem reconstruction for metalliferous plant communities during dry season: the importance of mulching for plant species regrowth		<b>S10-014: Athukorala Arachchige SUMUDU DARSHANA</b> Spatio-temporal transformation of Western Wetlands in Sri Lanka: a case study of Muthurajawela Marsh and Negombo Lagoon
15:30	<b>COFFEE BREAK</b> - Building D			

16:00	<b>POSTER SESSIONS</b> - Building D
<b>S01</b>	<b>Traits and functions in the tropics</b>
P01	<b>Marcelo NASCIMENTO</b> Foliar herbivory and leaf traits of congeneric trees of two contrasting forest formations of the Mata Atlantica biome
P02	<b>Brenner SILVA</b> Observing tree water relations and climatic variations in a mountain rainforest of SE-Ecuador
P03	<b>Elizabeth KEARSLEY</b> Rare tree species support functional diversity in resource-acquisition in central African forests
P04	<b>Yves BAWIN</b> How to crack the caffeine code? Discovering the genetic diversity behind caffeine synthesis in the genus <i>Coffea</i>
<b>S02</b>	<b>Dry tropical woodlands in Africa</b>
P01	<b>Raquel KISSANGA</b> Use of Miombo-trees for fuel and construction in Cusseque (Bié, Angola): species used, biomass estimates and impacts on vegetation
P02	<b>Amândio GOMES</b> Comparative plant functional traits among trees:shrubs and geoxylic suffrutices in Bié Plateau - Angola
P03	<b>Armel S.L. DONKPEGAN</b> Comparative phylogeography and postglacial expansion in two dry African tropical woodlands species
P04	<b>Ute SCHMIEDEL</b> Plant diversity and population dynamics in the arid Succulent Karoo of South Africa 15 years of annual monitoring
P05	<b>Casey RYAN</b> A Socio-Ecological Observatory for the Southern African Woodlands
P06	<b>Jonathan ILUNGA MULEDI</b> Permanent Plot: a novel reference tool for sustainable management of the miombo forest in Upper-Katanga
<b>S04</b>	<b>Tropical freshwater microhabitats</b>
P01	<b>Helen Yetunde OMOBOYE</b> The planktonic community and primary productivity of Owalla Reservoir, Osun State, Nigeria
P02	<b>Christine COCQUYT</b> Lotic ecosystems in the MAB Reserve of Yangambi (DR Congo): exploration of the diatom biodiversity
P03	<b>Janet HIGUTI</b> Invasive <i>Eichhornia crassipes</i> has not acted as Noah s Ark for South American ostracods (Crustacea) in the Congo River (Africa)
P04	<b>Bartosz MAREK MAKCHER</b> What affects the richness of the Odonata species? We do!
<b>S05</b>	<b>Species delineation in the tropics</b>
P01	<b>Katharina B. BUDDE</b> Hybridization and species delimitation of <i>Symphonia</i> (Clusiaceae) in Madagascar
P02	<b>Jean-François FLOT</b> A farewell to cloning: disentangling double peaks and delineating species among diploid individuals
P03	<b>Félicien TOSSO</b> Evolution in the African-Neotropical genus <i>Guibourtia</i> (Fabaceae, Caesalpinioideae), combining NGS phylogeny and morphology
P04	<b>Brandet Junior LISSAMBOU</b> Taxonomic revision of the genus <i>Greenwayodendron</i> in African tropical forests based on morphology and genetic markers



<b>S06</b>	<b>Tropical forest modelling</b>
P01	<b>Richard SMITH</b> How well do vegetation models simulate mid-Holocene Amazonia?
P02	<b>Dushyant KUMAR</b> Future vegetation pattern in biodiversity hotspots in India under changing climate
P03	<b>Marie DURY</b> Modelling past and present distributions of tropical African biomes and species using a dynamic vegetation model
P04	<b>Ulrike HILTNER</b> Simulation of resource-effective management strategies in tropical forests: development of an innovative tool for decision-making
<b>S07</b>	<b>Tropical biodiversity for development</b>
P01	<b>Charlotte COUCH</b> Tropical Important Plant Areas - a Case study from Guinea
P02	<b>Minnattallah BOUTROS</b> From Science to action - towards a science/policy interface in development cooperation
P03	<b>Minnattallah BOUTROS</b> Sangha Trinational Foundation - a case study from the Congo basin: challenges and chances of conservation trust funds
P04	<b>Christine B. SCHMITT</b> Promoting sustainable land use systems in sub-Saharan Africa through participatory research approaches and enhanced stakeholder interactions
P05	<b>Stefan KREFT</b> The MARISCO method: A Knowledge Map and Adaptive Navigation System for tropical biodiversity conservation
P06	<b>Moa MEGERSA</b> Natural coagulants obtained from seeds of <i>Moringa stenopetala</i> and tubers of <i>Maerua subcordata</i> could purify turbid water inexpensively and sustainably
P07	<b>Jean HUGE</b> Murky mangroves and catchy corals the discourses of attractiveness of coastal ecosystems
P08	<b>Tiptiwa SAMPANTAMIT</b> Contributions of traditional knowledge to food security of a small fishing community in Thailand
P09	<b>Ceiça CHIOZE</b> Evaluation between artisanal, semi-industrial and industrial linefisheries in the exploitation of fishery resources in the South Save, Mozambique
<b>S08</b>	<b>Savanna ecology and functioning</b>
P01	<b>André LINDNER</b> Vegetation structure and carbon stocks of two protected areas within the South-Sudanian savannas of Burkina Faso
P02	<b>Simon SCHEITER</b> Ecosystem management can mitigate vegetation shifts induced by climate change in West Africa
P03	<b>Julie ALEMAN</b> An index for prioritizing conservation areas in savannas of sub-Saharan Africa
P04	<b>Aires MBANZE</b> Phytosociological structure of Dambos ecosystem in the Niassa National Reserve (NNR), Northern Mozambique
P05	<b>Tatiane GOMES CALACA MENEZES</b> Effects of generalist herbivores and rainfall in a seasonally dry tropical forest in Brazil
P06	<b>David C. SIDONS</b> Influence of habitat modification by livestock on páramo bird abundance in southern Andes of Ecuador
P07	<b>Edwin ZARATE</b> Potential distribution of the Andean Condor reveals priority conservation sites in the southern Andes of Ecuador

<b>S09</b>	<b>The mangrove biodiversity enigma</b>
P01	<b>Hiroke ROY</b> A Review on the threat and vulnerability to cultural extinction of Sunderbans Mangrove forest, South Asia
P02	<b>Anne VAN ZON</b> How will salt affect the acquisition of nitrogen and phosphorus of mangrove species?
P03	<b>Laura Elisabeth AGUSTO</b> To each his own: the diversity of burrow architecture of mangrove crabs and its ecological consequences
P04	<b>Nathalie TONNE</b> The heartbeat of mangrove seedlings: dendrometry and anatomy of on-tree developing and establishing <i>Bruguiera gymnorrhiza</i> seedlings
<b>S10</b>	<b>Forests in space and time</b>
P01	<b>Monika RUWAIAMANA</b> Like a drone come true: Comparison of satellite and drone imagery for Mangrove mapping in Setiu Wetland, Malaysia
P02	<b>Viviana OTERO</b> Flying drones over mangroves: monitoring of the Matang Mangrove Forest Reserve in Peninsular Malaysia
P03	<b>Sruthi MOORTHY</b> Quantifying the impact of lianas on the vertical forest structure - A TLS approach
P04	<b>William APTED</b> Monitoring changes in rangeland and dry forest landscapes with remotely sensed data
<b>S11</b>	<b>Fragmentation genetics and biodiversity</b>
P01	<b>Dora VILLELA</b> Edge effects on the necromass and heterotrophic respiration stocks in Seasonally Dry Brazilian Atlantic Forest fragments
P02	<b>Penny GARDNER</b> Behavioural adaptations of an endangered ungulate in response to tropical forest degradation in Sabah (Malaysia, Borneo)
P03	<b>Nicole FERNANDEZ</b> Acoustic variability of a native Hawaiian thrush in a fragmented landscape
P04	<b>Inocencio Jr BUOT</b> Conserving biodiversity in fragmented forest ecosystem in the Philippines
P05	<b>Alicja WITWICKA</b> Predation rates among caterpillars in response to habitat type, leaf damage and rolling behaviour
P06	<b>Addisie GEREMEW</b> Dynamics in clonal diversity and clonal growth strategies as a response to sediment gradients in tropical <i>Cyperus papyrus</i> swamps
P07	<b>Juan Manuel AGUILAR LEON</b> Understanding anuran responses to rainforest fragmentation and oil palm agriculture in the Lower Kinabatangan Wildlife Sanctuary, Sabah, Malaysia
<b>S12</b>	<b>Large vertebrates in a changing world</b>
P01	<b>Nikki TAGG</b> Changing hunting pressures and wildlife responses and the effectiveness of secondary conservation actions in the Dja landscape, Cameroon
P02	<b>Peter GALBUSERA</b> Assessment and conservation of genetic diversity in captive and wild primate populations
P03	<b>Arthur BOOM</b> Metabarcoding: development of genetic tools for the study of the herbivore diet of <i>Pan paniscus</i>
P04	<b>Autumn CHONG</b> Intraspecific resource competition within a tropical Bird species ( <i>Ramphocelus costaricensis</i> )



<b>S13</b>	<b>Riparian ecosystems in tropical drylands</b>
P01	<b>Tibebu Alemu BEKERIE</b> Spatial pattern of riparian vegetation and diversity along human dominated highland streams south-western Ethiopia
P02	<b>Kai BEHN</b> Regeneration dynamics in floodplains: plant species guilds in the Kilombero Floodplain, Tanzania
P03	<b>Christine COCQUYT</b> Diatoms from the Congo and Zambezi basins: a guide to the genera of tropical Africa
<b>S14</b>	<b>Coral reefs at risk</b>
P01	<b>Sonia BARBA HERRERA</b> Development of a Coral Reef Resilience Index (CRRI): A management and conservation tool applicable for Caribbean coral reef ecosystems
P02	<b>Fabiola RIVERA-IRIZARRY</b> Immune and physiological response of coral with different life strategies to stress: A field-based approach
P03	<b>Friederike CLEVER</b> Local and regional differences in fish community structure on the Mesoamerican Barrier Reef
P04	<b>Qiyamah WILLIAMS</b> Wai uli coral mapping and monitoring: Integrating Western and Native Hawaiian Sciences
<b>S15</b>	<b>Food production and biodiversity conservation</b>
P01	<b>Dominic MARTIN</b> Diversity Turn in Land Use Science: Transdisciplinary research in the vanilla landscapes of NE Madagascar
P02	<b>Pieter MOONEN</b> Biodiversity and ecosystem functioning in fallow systems in the Central Congo Basin
P03	<b>Mathil VANDROMME</b> Help from above - Boosting yield and conservation value in cacao production by doing nothing?
P04	<b>Anna LEßMEISTER</b> Substitution of the most important and declining wild food species in south-east Burkina Faso
P05	<b>Hoa TRAN</b> Utilization and conservation of an indigenous-underutilized fruit tree species: <i>Xerospermum noronhianum</i> (Sapindaceae)
P06	<b>Thierry HOUHANOU</b> Quantitative ethnobotany towards conservation of food tree species of Wari Maro forest Reserve in the Sudanian zone of Benin
P07	<b>Aimé KAZIKA</b> Improved plant genetic biodiversity through the organization and promotion of agricultural shows and seed fairs
P08	<b>Sarah LUKE</b> Conservation of freshwaters in oil palm plantations
<b>S16</b>	<b>Palaeoecology of tropical ecosystems</b>
P01	<b>Fang GU</b> Late Quaternary vegetation and environment reconstruction based on pollen and dinoflagellate cysts in eastern South America
P02	<b>Kimberley HAGEMANS</b> Holocene vegetation responses to changing ENSO regimes in the southwestern Andean Cordillera, Ecuador
P03	<b>Maria Carolina GUARINELLO DE OLIVEIRA PORTES</b> 600 cal yr BP of <i>Araucaria</i> Forest and Grassland dynamics in the Serra da Bocaina National Park, Southeastern Brazil
P04	<b>Wannes HUBAU</b> Complementary imaging techniques support detailed identification of Central African charcoal

<b>S17</b>	<b>Complete Altitudinal Rainforest Transects</b>
P01	<b>Andy GRIFFITHS</b> From the Amazon to the Andes: Understanding climate adaptation along a tropical elevation gradient
P02	<b>Kerstin PIERICK</b> Variation of tree fine root architecture along a topographical gradient in an Ecuadorian tropical montane forest
P03	<b>Vincent MONTADE</b> Using modern pollen data to characterize altitudinal changes of tropical mountain rainforest in Northeast Brazil
P04	<b>Vojtech NOVOTNY</b> Altitudinal trends in the communities of geometrid moths along a complete rainforest altitudinal gradient in New Guinea
P05	<b>Petr KLIMES</b> Nutrient utilization by ants along a complete elevational rainforest gradient in Papua New Guinea
<b>S18</b>	<b>Tropical forest in a changing climate</b>
P01	<b>Francisca AKUA NUNOO</b> Fuel Wood Use and Climate Change Implication for Sustainable Development
P02	<b>Mohamed NEJI</b> De novo transcriptome sequencing and comprehensive analysis of the drought-responsive genes in <i>Erythrophleum</i> species
<b>S19</b>	<b>Seed dispersal</b>
P01	<b>Chauvelin DOUH</b> Seed bank characteristics in deep soil layers of Central African forests
P02	<b>Ludwig TRIEST</b> Western and Eastern African rift lakes and wetlands harbour different ESUs of papyrus: a dispersal mediated by elephants?
<b>S20</b>	<b>Integrative Tropical ecosystems dynamics</b>
P01	<b>Jérémy MIGLIORE</b> AFRIFORD project: Genetic and paleoecological signatures of African rainforest dynamics: pre-adapted to change?
P02	<b>Pedro L. SILVA DE MIRANDA</b> The importance of environmentally marginal habitats in the Atlantic Forest Domain of South America
P03	<b>Arne SINNESAEEL</b> Influence of bacterial leaf symbiosis on the evolution of the genus <i>Psychotria</i> (Rubiaceae)
P04	<b>Samuel VANDEN ABEELE</b> Phylogeographic study of the tropical African tree <i>Staudtia kamerunensis</i> using newly developed microsatellite markers
P05	<b>Pamela BURGER</b> Diversity estimates and population structure in global <i>Camelus dromedarius</i> populations through genome-wide ddRAD sequencing
P06	<b>Luiza F.A. DE PAULA</b> Sugar Loaf Land in South-eastern Brazil: a tropical hotspot of inselberg plant diversity
P07	<b>Inocencio Jr BUOT</b> Structure and dynamics of plant diversity in Dong Na Tard Provincial Protected Area, Lao PDR
<b>S21</b>	<b>Human-modified tropical forests</b>
P01	<b>Laurent BREMOND</b> Origin of the Guianese Dark Earths: an anthracological approach
P02	<b>Frances MULLANY</b> The immediate impact of hurricane disturbance on monitoring butterfly and ant communities in Belize, Central America
<b>S22</b>	<b>Legacy specimens, future goals</b>
P01	<b>Patricia MERGEN</b> Think Global ! What Biodiversity Information Standards can do for you !





## DETAILED PROGRAM SCHEDULE

## WEDNESDAY, 08 FEBRUARY 2017

08:25	<b>PLENARY TALK 03 - Serge PLANES - Auditorium Q Maathai</b> Revisiting population genetic approaches from individuals base genetic analysis			
09:15	<b>Parallel sessions</b>			
<b>Sessions</b>	S11: FRAGMENTATION GENETICS AND BIODIVERSITY (1/3)	S12: LARGE VERTEBRATES IN A CHANGING WORLD (1/2)	S13: RIPARIAN ECOSYSTEMS IN TROPICAL DRYLANDS	S14: CORAL REEFS AT RISK (1/2)
<b>Chairs</b>	Alice C. HUGHES, Pablo OROZCO-TERWENGEL, Ute RADESPIEL	Roseline C. BEUDELS-JAMAR, Marie-Claude HUYNEN, Fany BROTCORNE	Christine B. SCHMITT, Jan C. HABEL	Marc KOCHZIUS
<b>Room</b>	Auditorium D03 Aké Assi	Auditorium D02 Fossey	Auditorium D07 Wilson	Auditorium D08 Clark
09:15	<b>S11-001: Alice C. HUGHES</b> New approaches to understand the impacts of fragmentation on the landscape scale	<b>S12-001: Roseline C. BEUDELS-JAMAR</b> Bornean primates and forest regeneration: highlight on the proboscis monkey ( <i>Nasalis larvatus</i> )	<b>S13-001: Ashebir WOLEYOHANNES</b> Land use and land cover dynamics and landscape pattern changes in Abaya-Chamo Basin, Southern Ethiopia	<b>S14-001: Francisco J. SOTO-SANTIAGO</b> Demographic variability of two common Caribbean coral species, <i>Orbicella annularis</i> and <i>Porites astreoides</i>
09:30	<b>S11-002: Dries VAN DE LOOCK</b> Does habitat change and disturbance influence nest-site choice of an understory passerine?	<b>S12-002: Nima RAGHUNATHAN</b> Conservation in the face of climate change	<b>S13-002: Christine B. SCHMITT</b> Effects of land use pattern on riparian plant diversity in semi-arid Kitui county, Kenya	<b>S14-002: Neidibel MARTINEZ</b> Physiological impact of thermal stress in the scleractinian coral <i>Porites astreoides</i>
09:45	<b>S11-003: Laurence COUSSEAU</b> Survival in a forest fragment	<b>S12-003: Leslie WILMET</b> Is there a future for <i>Lepilemur mittermeiri</i> , an endemic and threatened lemur species of the Ampasindava peninsula, in northwest Madagascar?	<b>S13-003: Miguel ALVAREZ</b> Hydrological gradients and land uses in a sub-Saharan floodplain: the potential use of indicator plants for bio-monitoring	<b>S14-003: Fabiola RIVERA-IRIZARRY</b> Demographic dynamics of the common Demosponge <i>Ircinia felix</i>

10:00	<b>S11-004: Julieta BENITEZ-MALVIDO</b> Impact of forest fragmentation on arthropod trophic guilds on their patterns of interactions with host plants	<b>S12-004: Fany BROTCORNE</b> Reproduction control as a management strategy for local overpopulation of primates in tropical human-dominated habitats: a review	<b>S13-004: Gabriel M. MUTURI</b> Soluble <i>Prosopis</i> phenolics inhibits regeneration of <i>Acacia tortilis</i> in Turkwel Riverine Forest, Kenya	<b>S14-004: P.A. Kushlani N. DISSANAYAKE</b> Coral Reefs at Risk: Sri Lankan Context
10:15	<b>S11-005: Tatiane GOMES CALACA MENEZES</b> More abundant and widely distributed: biotic homogenization in regeneration of the Atlantic forest, Brazil	<b>S12-005: Nikki TAGG</b> Impact of changing land-use and conservation management on mammal functional diversity in southeast Cameroon	<b>S13-005: Jan Christian HABEL</b> Ecosystem health erosion along East African dryland rivers: Socio-ecological perspectives	<b>S14-005: Marc KOCHZIUS</b> Connectivity of coral reefs in the Indo-West Pacific
10:30	<b>COFFEE BREAK AND POSTERS - Building D</b>			
11:00	<b>Parallel sessions</b>			
<b>Sessions</b>	S11 CONTINUED (2/3)	S12 CONTINUED (2/2)	S15: FOOD PRODUCTION AND BIODIVERSITY CONSERVATION	S14 CONTINUED (2/2)
<b>Chairs</b>	Alice C. HUGHES, Pablo OROZCO-TERWENGEL, Ute RADESPIEL	Roseline C. BEUDELS-JAMAR, Marie-Claude HUYNEN, Fany BROTCORNE	Olivier HONNAY, Raf AERTS, Kathleen PRINZ, Katja KEHLENBECK, Jens GEBAUER	Marc KOCHZIUS
<b>Room</b>	Auditorium D03 Aké Assi	Auditorium D02 Fossey	Auditorium D07 Wilson	Auditorium D08 Clark
11:00	<b>S11-006: Etefa Guyassa DINSSA</b> Response of woody plant species diversity and tree growth in enclosure to spate irrigation from gullies	<b>S12-006: David STANTON</b> Phylogeography, population genetics and conservation of the okapi	<b>S15-001: Emma BUSH</b> Indigenous fruit tree species (IFTs) are a reliable source of nutrition and enterprise for the future in Gabon	<b>S14-006: Filip HUYGHE</b> Genetic connectivity of the Skunk Clown Fish in the Indian Ocean using two types of markers



11:15	<b>S11-007: Job ABEN</b> Evaluating realistic conservation management scenarios in an Afrotropical biodiversity hotspot using a novel, individual-based modelling platform	<b>S12-007: Chantal SHALUKOMA</b> Conservation of <i>Gorilla beringei graueri</i> and of its habitat proves also relevant to traditional medicine in Kahuzi-Biega region, DR Congo	<b>S15-002: Kathleen PRINZ</b> Genetic resources of <i>Adansonia digitata</i> L. in East Africa: prediction of persistence under changing environmental conditions and land-use	<b>S14-007: Rosa Maria VAN DER VEN</b> <i>Seriatopora hystrix</i> , a coral with short pelagic larval duration, reveals clear genetic subdivision along the East African coast
11:30	<b>S11-008: Boris DEMENOU</b> History of the fragmentation of the tropical African rain forest in the Dahomey Gap	<b>S12-008: Martin VAN OOSTERHOUT</b> Wildlife monitoring to assess impacts of human disturbance	<b>S15-003: Katja KEHLENBECK</b> Domestication of baobab ( <i>Adansonia digitata</i> L.) in Kenya: past successes and planned activities	
11:45	<b>S11-009: Jörg GANZHORN</b> Mouse lemurs in a fragmented landscape: long-term effects of fragmentation on neutral and adaptive genetic diversity of <i>Microcebus murinus</i> from the littoral forests of Madagascar	<b>S12-009: Maholy RAVALOHARIMANITRA</b> Using GIS to ameliorate the development and management plan of Andriantantely low-land forest in Brickaville, Madagascar	<b>S15-004: Kristoffer HYLANDER</b> Positive and negative effects of coffee management in SW Ethiopian landscapes	
12:00	<b>S11-010: Rosemary MOORHOUSE-GANN</b> DNA barcoding island plant communities and building food webs to assess the impact of an analogue species (the Aldabran giant tortoise)	<b>S12-010: Jorge PALMEIRIM</b> Sustainability of the harvest of tropical forest pigeons: The case of the endemic species of São Tomé (Gulf of Guinea)	<b>S15-005: Koen VANDERHAEGEN</b> Biodiversity and carbon storage co-benefits of coffee agroforestry across a gradient of increasing management intensity in the SW Ethiopian highlands	
12:15			<b>S15-006: Romaike S. MIDDENDORP</b> Can high-quality chocolate alleviate poverty and conserve biodiversity?	

12:30	<b>LUNCH BREAK</b>
13:30	<b>FREE AFTERNOON GUIDED TOURS</b> - Departure from Building D Botanic Garden Meise Royal Museum for Central Africa Tervuren Natural History Museum Brussels



**THURSDAY, 09 FEBRUARY 2017**

08:25	<b>PLENARY TALK 04 - Lydie DUPONT - Auditorium Q Maathai</b> Long-term perspective on biome changes in Africa			
09:15	<b>Parallel sessions</b>			
<b>Sessions</b>	<b>S16: PALAEO-ECOLOGY OF TROPICAL ECOSYSTEMS (1/2)</b>	<b>S17: COMPLETE ALTITUDINAL RAINFOREST TRANSECTS (1/4)</b>	<b>S11: FRAGMENTATION GENETICS AND BIODIVERSITY (3/3)</b>	<b>S18: THE TROPICAL FOREST IN A CHANGING CLIMATE (1/2)</b>
<b>Chairs</b>	Siria BIAGIONI, Katherine ROUCOUX, Hermann BEHLING, Hans BEECKMAN, Wannes HUBAU	Maurice LEPONCE, Jürgen HOMEIER, Yadvinder MALHI, Petr KLIMES, Jörg BENDIX, Vojtech NOVOTNY	Alice C. HUGHES, Pablo OROZCO-TERWENGEL, Ute RADESPIEL	Alexandra C. LEY, Katy GONDER
<b>Room</b>	Auditorium D03 Aké Assi	Auditorium D02 Fossey	Auditorium D07 Wilson	Auditorium D08 Clark
09:15	<b>S16-001: Katy ROUCOUX</b> The contribution of palaeoecology to tropical peatland science	<b>S17-001: Yadvinder MALHI</b> An elevation transect in the southern Peruvian Andes	<b>S11-011: David STANTON</b> Hook a worm to catch a man	<b>S18-001: Hilton OYAMAGUCHI</b> Thermal sensitivity of tropical amphibians and their vulnerability to climate change
09:30	<b>S16-002: Kimberley HAGEMANS</b> Holocene vegetation responses to changing ENSO regimes in the southwestern Andean Cordillera, Ecuador	<b>S17-002: Marcell PETERS</b> Biodiversity and ecosystem functioning of a tropical mountain in the Anthropocene	<b>S11-012: Jennifer BRUNKE</b> Connecting in a fragmented landscape - Dispersal and genetic structure in a tropical small mammal, the Bornean tree shrew ( <i>Tupaia longipes</i> )	<b>S18-002: Claudia HERMES</b> Climate change shifts the distribution range of an endangered parakeet: Implications for conservation
09:45	<b>S16-003: Hermann BEHLING</b> South American savanna and forest dynamics during the late Quaternary	<b>S17-003: Vincent MERCKX</b> Mount Kinabalu: a cradle of biodiversity	<b>S11-013: Penny GARDNER</b> Problematic molecular-management of a rare and wild large bovid following the destruction of tropical forests in Sabah (Malaysia, Borneo)	<b>S18-003: Eric GUILBERT</b> Ecological niche modelling in Madagascar: the response of several Insects group to global warming

10:00	<b>S16-004: Fang GU</b> Late Quaternary vegetation and environment reconstruction based on pollen and dinoflagellate cysts in eastern South America	<b>S17-004: Maurice LEPONCE</b> Our Planet Reviewed 2012 biodiversity survey along Mt Wilhelm, Papua New Guinea	<b>S11-014: Michael KRÜTZEN</b> Genomes reveal marked differences in the evolutionary history of orangutan species	<b>S18-004: Dora VILLELA</b> Do tree species from Seasonally Dry Forest differ in their sensitivity to drought and logging, how does this impact on biomass and demography?
10:15	<b>S16-005: Wannes HUBAU</b> Charcoal archives reveal holocene fire-vegetation-climate linkages in Central Africa	<b>S17-005: Hans VERBEECK</b> Cross-continental comparison of the functional composition and carbon allocation of two altitudinal forest transects in Ecuador and Rwanda	<b>S11-015: Pamela BURGER</b> Neutral and adaptive genetic diversity in Mongolian snow leopards	<b>S18-005: Simone STROBL</b> Water relations and carbon acquisition as indicators of slow climate change effects on trees in a tropical mountain forest in South Ecuador
10:30	<b>COFFEE BREAK AND POSTERS - Building D</b>			
11:00	<b>Parallel sessions</b>			
<b>Sessions</b>	<b>S16 CONTINUED (2/2)</b>	<b>S17 CONTINUED (2/4)</b>	<b>S19: SEED DISPERSAL</b>	<b>S18 CONTINUED (2/2)</b>
<b>Chairs</b>	Siria BIAGIONI, Katherine ROUCOUX, Hermann BEHLING, Hans BEECKMAN, Wannes HUBAU	Maurice LEPONCE, Jürgen HOMEIER, Yadvinder MALHI, Petr KLIMES, Jörg BENDIX, Vojtech NOVOTNY	Eckhard W. HEYMANN, Laurence CULOT	Alexandra C. LEY, Katy GONDER
<b>Room</b>	Auditorium D03 Aké Assi	Auditorium D02 Fossey	Auditorium D07 Wilson	Auditorium D08 Clark
11:00	<b>S16-006: Kartika HAPSARI</b> Anthropogenic disturbance and resilience of a tropical peatland: a message from the past	<b>S17-006: Vojtech NOVOTNY</b> Plant-invertebrate-vertebrate biodiversity and food web patterns along Mt Wilhelm and other complete altitudinal rainforest gradients	<b>S19-001: Magdalene NGEVE</b> Hidden founders or high connectivity or both? Investigating the expansion pathway of mangroves along the Cameroonian coastline	<b>S18-006: Luiza F.A. DE PAULA</b> Inselbergs in South-eastern Brazil: biodiversity encapsulated in space and time



11:15	<b>S16-007: Siria BIAGIONI</b> Prehistorical and historical human-landscape interactions at the Lindu plain and the link to climate variability of Central Sulawesi (Indonesia)	<b>S17-007: Simon SEGAR</b> The ecology of <i>Ficus</i> along the Mt Wilhelm transects: plants, pollinators and herbivores	<b>S19-002: Marta QUITIAN</b> Effects of elevation and fragmentation on interaction networks of frugivorous birds and fruiting plants in southern Ecuador	<b>S18-007: Carlos MANCHEGO</b> Distribution patterns and genomic differentiation of three valuable timber species of the mountain forests of Ecuador
11:30	<b>S16-008: Corentin BOCHATON</b> The memory of bones: How human occupations shaped the squamate diversity of Guadeloupe islands (French West-Indies) during the last 5000 years.	<b>S17-008: Conor REDMOND</b> Plant-herbivore food webs: Successional trends along an altitudinal gradient in Papua New Guinea	<b>S19-003: Franck TROLLET</b> Zoochoric trees as recruitment foci in Afrotropical forests	<b>S18-008: Alexandra C. LEY</b> Phenotypic variability along a tropical African climate gradient - the perennial forest understorey herb <i>Sarcophrynium prionogonium</i> (Marantaceae)
11:45	<b>S16-009: Lydie DUSSOL</b> Eight centuries of sustainable forest exploitation by the ancient Maya at Naachtun (Northern Guatemala, 150-950 CE)	<b>S17-009: Henry NJOVU</b> Insect herbivory along climatic and land use gradients on Mt. Kilimanjaro	<b>S19-004: Tiziana A. GELMI-CANDUSSO</b> How does territoriality behavior of seed dispersers affects spatial genetics of dispersed plants? Case study: Tamarins and <i>Leonia cymosa</i>	<b>S18-009: Myriam HEURTZ</b> Hybridization and patterns of adaptive genetic variation in tropical trees of the <i>Bertholletia</i> clade (Lecythidaceae) in French Guiana
12:00	<b>S16-010: Tom DE MIL</b> Nailing the facts: legacy of 66 years of individual tree growth in Central Africa shows differing growth rates	<b>S17-010: Friederike GEBERT</b> Mammals and dung beetles along an elevation and land use gradient on Mt Kilimanjaro	<b>S19-005: Harison ANDRIAMBELO</b> Landscape scale consequences of dispersal traits of trees in a fragmented forest ecosystem: a case study of a tropical humid forest of Madagascar	
12:15	<b>S16-011: Jan VAN DEN BULCKE</b> X-ray CT-based high-throughput increment core analysis		<b>S19-006: Eckhard W. HEYMANN</b> Long-term consistency in spatial patterns of primate seed dispersal	

12:30	<b>LUNCH BREAK</b>			
13:30	<b>Parallel sessions</b>			
<b>Sessions</b>	<b>S20: INTEGRATIVE TROPICAL ECOSYSTEMS DYNAMICS (1/3)</b>	<b>S17 CONTINUED (3/4)</b>	<b>S21: HUMAN-MODIFIED TROPICAL FORESTS (1/2)</b>	
<b>Chairs</b>	Jérémy MIGLIORE, Dario I. OJEDA ALAYON	Maurice LEPONCE, Jürgen HOMEIER, Yadvinder MALHI, Petr KLIMES, Jörg BENDIX, Vojtech NOVOTNY	Yit Arn TEH	
<b>Room</b>	Auditorium D03 Aké Assi	Auditorium D02 Fossey	Auditorium D07 Wilson	
13:30	<b>S20-001: Thomas COUVREUR</b> Why are there fewer plant species in African rain forests?	<b>S17-011: Jörg BENDIX</b> Climate variation along the eastern escarpment of the south Ecuadorian Andes	<b>S21-001: Frederik VAN DE PERRE</b> The relationship between taxonomic diversity and aboveground carbon storage is taxon-specific	
13:45	<b>S20-002: Gilles DAUBY</b> Phytogeography and phylo-diversity of Tropical African flora: insight from a mega database on the distribution of vascular plants	<b>S17-012: William FARFAN-RIOS</b> Drought effects in Amazon-to-Andean forest	<b>S21-002: Gerhard GEROLD</b> Carbon sequestration, biodiversity and social structures in Southern Amazonia	
14:00	<b>S20-003: Steven JANSSENS</b> How old is the African flora? New insights in the evolution of African biomes based on large-scale dating and diversification analyses	<b>S17-013: Elias BIZURU</b> Assessment of soil water availability in two mountains of the Volcanoes National Park in Rwanda	<b>S21-003: Maria BARROS</b> Natural regeneration after agriculture: changes in taxonomic diversity in the tropical dry forest	



14:15	<b>S20-004: Manuel DE LA ESTRELLA</b> Detarioideae, I presume? A study of the evolutionary origin of Detarioideae, a clade of ecologically dominant tropical African trees	<b>S17-014: Brenner SILVA</b> Area-wide functional indicators for changes in ecosystem water fluxes and biomass productivity in a mountain rainforest of SE-Ecuador	<b>S21-004: Jorge CUEVA</b> Tree regeneration in Tumbesian Dry Forests: effects of forest cover and livestock presence	
14:30	<b>S20-005: Dario I. OJEDA ALAYON</b> Estimating the timing of diversification and the potential role of past climate in the evolution of Anthonotha in the Guineo-Congolian region	<b>S17-015: Jürgen HOMEIER</b> Variation of tree species richness with elevation in the Andes of S Ecuador (tree diversity vs functional diversity vs phylodiversity)	<b>S21-005: Monica MORENO-BRUSH</b> Is gold mining a source of mercury exposure in bats from the Peruvian Amazon?	
14:45	<b>S20-006: Anne-Marie LEZINE</b> Lake Bambili, Cameroon: 90 000 years of montane forest history in central Africa	<b>S17-016: Pippa STONE</b> Location, location translocation: the response of Neotropical tree seedlings to simulated warming and upslope migration	<b>S21-006: Sarah LUKE</b> Managing oil palm plantations to maximise biodiversity, ecosystem functions, and yield	
15:00	<b>S20-007: François NGUETSOP</b> Past environmental and climatic changes of Central Africa from a multiproxies analysis of the Adamawa Plateau, Cameroon	<b>S17-017: Glenda MENDIETA-LEIVA</b> Topography has a non-trivial effect on vascular epiphyte diversity in Andean forests	<b>S21-007: Edgar TURNER</b> Managing for predators: the role of understory complexity in oil palm	
15:15	<b>S20-008: Alain-Didier MISSOUP</b> Biodiversity diversification patterns in african montane forests: a case study of rodents in the Cameroon Volcanic Line	<b>S17-018: Jean-Yves DUBUISSON</b> Altitudinal distribution of an emblematic hygrophilous fern family on La Réunion Island: current patterns and historical factors	<b>S21-008: Julie HINSCH</b> Nectar-rich plants as a management strategy for enhancing natural enemies of herbivorous pests in oil palm	

15:30	<b>COFFEE BREAK</b> - Building D			
16:00	<b>Parallel sessions</b>			
<b>Sessions</b>	<b>S20 CONTINUED (2/3)</b>	<b>S17 CONTINUED (4/4)</b>	<b>S21 CONTINUED (2/2)</b>	<b>S22: LEGACY SPECIMENS, FUTURE GOALS</b>
<b>Chairs</b>	Jérémy MIGLIORE, Dario I. OJEDA ALAYON	Maurice LEPONCE, Jürgen HOMEIER, Yadvinder MALHI, Petr KLIMES, Jörg BENDIX, Vojtech NOVOTNY	Yit Arn TEH	Quentin GROOM, Maarten VANHOVE, Patricia MERGEN
<b>Room</b>	Auditorium D03 Aké Assi	Auditorium D02 Fossey	Auditorium D07 Wilson	Auditorium D08 Clark
16:00	<b>S20-009: Jérémy MIGLIORE</b> Tempo of diversification in African rainforests, applying new genomic tools to phylogeography	<b>S17-019: Franca MARIAN</b> Long term decomposition processes and soil fauna community changes along an altitudinal gradient in a tropical montane rainforest in southern Ecuador	<b>S21-009: Jake L. SNADDON</b> Soil biodiversity and ecosystem processes associated with habitat complexity, soil management and replanting in oil palm plantations	<b>S22-001: Han DE KOEIJER</b> Digitalisation of historic information on ecology: Case of National Parks in DR Congo
16:15	<b>S20-010: Rosalia PINEIRO</b> Tropical tree genomics reveals fragmentation of the African rainforest during the Ice Ages	<b>S17-020: Nina FARWIG</b> Ant incidence as an indicator of environmental change and ecosystem processes	<b>S21-010: Amelia S.C. HOOD</b> The role of ants and termites in supporting ecosystem functioning in oil palm plantations in Sumatra, Indonesia	<b>S22-002: Jean HUGUE</b> Biodiversity baselines in Environmental Impact Assessments
16:30	<b>S20-011: Pablo OROZCO-TERWENGEL</b> Genetic diversity and population structure in the Malagasy Big-Headed Turtle, consequences for its conservation	<b>S17-021: Petr KLIMES</b> Contrasting the ant diversity and distribution between ground, understorey and canopy forest strata along Mt Wilhem	<b>S21-011: Frances MANNING</b> Options for reducing tropical peatland C emissions from oil palm agro-ecosystems through soil surface management practices	<b>S22-003: Maarten VANHOVE</b> Dusty Baseline: The merit of museum collections in biological invasion studies





## DETAILED PROGRAM SCHEDULE

## FRIDAY, 10 FEBRUARY 2017

08:25	<b>PLENARY TALK 05 - Helene MULLER-LANDAU - Auditorium Q Maathai</b> What determines the abundance and impact of lianas?			
09:15	<b>Parallel sessions</b>			
Sessions	S23: ECONOMIC VALUATION, CERTIFICATION, AND CONSERVATION OF TROPICAL FORESTS	S24: INCLUDING LIANAS IN VEGETATION MODELS	S25: ARTHROPOD ECOLOGY AND CONSERVATION	S20: INTEGRATIVE TROPICAL ECOSYSTEMS DYNAMICS (3/3)
	<b>Chairs</b> Barbara HAUREZ, Marion KARMANN, Sarah PRICE, Baudouin MICHEL, Doriane DESCLEE	Geertje VAN DER HEIJDEN, Hans VERBEECK, Elizabeth KEARSLEY	Yves ROISIN, Maurice LEPONCE	Jérémy MIGLIORE, Dario I. OJEDA ALAYON
	<b>Room</b> Auditorium D03 Aké Assi	Auditorium D02 Fossey	Auditorium D07 Wilson	Auditorium D08 Clark
	09:15	<b>S23-001: Marion KARMANN</b> Tropical forestry: What is the role of certification, what effects can be expected, and how to evaluate impacts?	<b>S24-001: Marco VISSER</b> Parasite-host interactions in tropical trees: lianas differentially impact population growth rates among host tree species	<b>S25-001: Elena RUDOLF</b> The conservation status and extinction risk of Malagasy Millipedes
09:30	<b>S23-002: Barbara HAUREZ</b> A look at Intact Forest Landscapes and their relevance in Central African forest policy	<b>S24-002: Elizabeth KEARSLEY</b> Impact of lianas on individual tree growth	<b>S25-002: Simon HELLEMANS</b> <i>Wolbachia</i> : a puppet master in the parthenogenesis of the Neotropical termite <i>Cavitermes tuberosus</i> ?	<b>S20-016: Peter LINDER</b> Historical development of the East African vegetation from the Late Miocene

09:45	<b>S23-003: Richard EBA'A ATYI</b> Socio-economic and conservation impacts of forest certification at local scale in central Africa	<b>S24-003: Frans BONGERS</b> The liana assemblage of a Congolian rainforest: Diversity, structure and dynamics	<b>S25-003: Erik FRANK</b> The many controlled by the few: raiding behaviour in the termite predator <i>Megaponera analis</i>	<b>S20-017: Isabel SANMARTIN</b> Integrating biogeography, paleoecology, and phylogenomics to reconstruct the evolutionary origins of the African rand flora
10:00	<b>S23-004: Doriane DESCLEE</b> Survey and diagnosis study of capital assets and livelihoods strategies of households depending on resources of the Luki Biosphere Reserve (DRC)	<b>S24-004: Isabel L. JONES</b> Increasing liana dominance may exacerbate the long-term impacts of hydropower on tree diversity and carbon storage in the tropics	<b>S25-004: Maciej BARCZYK</b> To cheat or to clean? Mutualistic relationships between ants and rattan palm in Danum Valley, Borneo	
10:15	<b>S23-005: Jean Hugues NLOM</b> Estimate the economic value of the Cameroon segment of the TRIDOM	<b>S24-005: Geertje VAN DER HEIJDEN</b> Liana impacts on carbon dynamics in tropical forests: results from a liana removal experiment	<b>S25-005: Ondrej MOTTL</b> Ant mosaics in tropical lowland forests: Take a look at a bigger scale	
10:30	<b>S23-006: Moa MEGERSA</b> Natural coagulants obtained from seeds of <i>Moringa stenopetala</i> and tubers of <i>Maerua subcordata</i> could purify turbid water inexpensively and sustainably	<b>S24-006: Manfredo DI PORCIA E BRUGNERA</b> Introducing lianas in a DGVM, methods and first results	<b>S25-006: Sara LEONHARDT</b> The smell of resins: how an Australian eucalypt attracts its bee seed disperser	





# PLENARY SESSIONS – ABSTRACTS



## PLENARY TALK 01

Monday 06<sup>th</sup> February

Plenary talk 01 - 13:50 - Auditorium Q Maathai

### UNRAVELLING THE EFFECTS OF INSECT HERBIVORES AND PLANT PATHOGENS ON RAINFOREST DIVERSITY

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Why do tropical rainforests support so many species? High plant diversity in these habitats is a particular enigma, since ecological models predict that a few competitively superior species should dominate. One leading explanation for plant species coexistence in tropical forests is the Janzen-Connell hypothesis. This suggests that density-dependent seed and seedling mortality caused by specialised pests and diseases helps to keep abundant species in check, giving rare species an advantage. Patterns of plant performance consistent with the Janzen-Connell hypothesis are widely observed in rainforest vegetation plots, but the mechanisms underlying these patterns remain poorly understood and – until recently – few studies have tested key assumptions and predictions of the hypothesis experimentally.



I will summarise and discuss recent tests of Janzen and Connell's hypothesis which provide evidence that both insects and fungi play a role in maintaining plant diversity and in structuring its composition. I will focus on experimental work assessing the specificity of plant herbivores and pathogens, their effects on plant population dynamics, and the consequences for plant community composition and species diversity.



Tuesday 07<sup>th</sup> February

Plenary talk 02 - 08:25 - Auditorium Q Maathai

## THE WORLD NETWORK OF BIOSPHERE RESERVES: LEARNING PLACES FOR SUSTAINABLE DEVELOPMENT

Noëline Raondry Rakotoarisoa<sup>1</sup>



<sup>1</sup>United Nations Educational, Scientific and Cultural Organization, Biosphere Networks & Capacity Building Section, Science Sector Focal Point for Africa, Division of Ecological and Earth Sciences, SC/EES/BNC, Paris, FR, [n.raondry-rakotoarisoa@unesco.org](mailto:n.raondry-rakotoarisoa@unesco.org)

Launched in 1971, the UNESCO Man And Biosphere (MAB) program is an intergovernmental scientific program whose objective is to better understand Human-Nature relations, especially in internationally-recognized sites: the biosphere reserves.

The communication will show how the MAB program and the World Network of Biosphere Reserves, which to date includes a network of 669 sites in 120 countries, intend to contribute to the Agenda 2030 and its Sustainable Development Objectives through its Strategy and action plan 2015-2025. Resilience of communities, ecological restoration, extractive industries... will be among the themes addressed.

Wednesday 08<sup>th</sup> February

Plenary talk 03 - 08:25 - Auditorium Q Maathai

## REVISITING POPULATION GENETIC APPROACHES FROM INDIVIDUALS BASE GENETIC ANALYSIS

Serge Planes<sup>1</sup>

<sup>1</sup>EPHE, PSL Research University, UPVD-CNRS, USR 3278 CRIOBE, Perpignan, FR, [planes@univ-perp.fr](mailto:planes@univ-perp.fr)

The development of highly variable markers has allowed the genetic discrimination of individuals within and among populations and generations. The advent of high throughput technologies means that many samples and hence many individuals can be screened. To date, individual genetic identification has been mostly used in the context of parentage analysis and started showing that demersal fish with pelagic larvae are demonstrating high level of self-recruitment. Used on larger scale, such approach is now showing that dispersal can be measured on a spatial scale sufficient to draw complete connectivity kernel and after implement the design of networks of marine reserves. The individual genetic identification from small tissue samples make also possible to track each individual through time, allowing to monitor survival and reproductive success through the life cycle and making possible to study the variability of capacity to adapt to local and changing environment. The study of the evolutionary potential of populations requires longitudinal and relatedness data with different environments to partition the contribution of genes, maternal effects and environment on fitness. Estimates of genetic heritability of fitness traits are extremely rare, especially for marine species, where inter-generational relationships are rarely known. The development of multi-generational pedigree for a marine fish population by repeatedly genotyping all individuals in a population over several years period is now possible and make possible to undertake question about heritability and local adaptation. First results demonstrate that we will have to revise some of the paradigms driving evolution of marine populations.



Thursday 09<sup>th</sup> February

Plenary talk 04 - 08:25 - Auditorium Q Maathai

## LONG-TERM PERSPECTIVE ON BIOME CHANGES IN AFRICA

Lydie Dupont<sup>1</sup>

<sup>1</sup>MARUM - Center for Marine Environmental Sciences, University of Bremen, Bremen, DE,  
ldupont@marum.de



For the study of long-term interactions between biomes and climate palaeorecords are essential. The archive of marine sediments is very suitable as it provides long well-dated continuous sequences often integrating large geographical areas, albeit at the cost of much detail. Depending on the research questions and the timescales involved such records cover thousands to millions of years. For instance, the development of the African C4 savannah lasted several million years during the Miocene while the response of biomes to global climate changes of the Pleistocene followed the pace of glacial-interglacial cycles of forty thousand and hundred thousand years.

Today, the number of analytical tools at our disposal has been considerably expanded. Microscope techniques such as pollen counting teamed up with phytolith and charcoal analysis. Chemically measuring isotopes on single compounds, in particular stable carbon and deuterium of higher plant wax, opened many new possibilities of research. Especially, the combined interpretation of chemical and microscope analysis turns out to be very fruitful studying the development of the African savanna in relation to aridity and fire.

Friday 10<sup>th</sup> February

Plenary talk 05 - 08:25 - Auditorium Q Maathai

## WHAT DETERMINES THE ABUNDANCE AND IMPACT OF LIANAS?

Helene Muller-Landau<sup>1</sup>

<sup>1</sup>Smithsonian Tropical Research Institute, Gamboa, PA, mullerh@si.edu

Lianas – woody climbing plants – are found in a majority of the world's forests, at widely varying abundances, and are critically important to determining forest carbon stores and cycling. Yet we ecologists have a surprisingly limited understanding of what determines the abundance and impact of lianas in any given forest, or variation in these among forests.

I suggest that liana abundance is regulated and limited at three distinct and interacting scales: in the proportion of trees infested with lianas; in the liana load within the crowns of individual host trees; and in the proportion of the landscape that is in a liana-dominated, low-canopy state (liana forest); and that the forest-level impact of lianas depends on all three. I argue that the proportion infested is best understood within a disease ecology framework (paralleling “proportion infested”) in terms of rates at which uninfested trees become infested, the rates at which infested trees lose lianas, and the demographic rates of infested and uninfested hosts. The biomass of lianas within a tree crown has similar parallels to pathogen load, and can be understood in terms of selection for the highest reproductive number (new hosts infested per infested host), which necessarily must balance the benefits of higher liana load and associated resource pre-emption against the cost to the parasite of negative impacts this load imposes on its host. Finally, the proportion of the landscape that is in “liana forest” doesn't fit within a disease ecology or host-parasite framework; it is as though a parasite had a free-living alternative life style that competed directly with its host.

I discuss what regulates and limits liana abundance at each of these scales in turn, and show how this framework can be applied to understand variation in the abundance and impact of lianas among tree species, liana species, and forests, and highlight the many associated unsolved questions.



# PUBLIC LECTURE



## PUBLIC LECTURE

Tuesday 07<sup>th</sup> February

Public lecture - 18:30 - Auditorium Q Maathai

### CAN INDUSTRIAL LOGGING AND NATURE CONSERVATION BE ALLIES IN CENTRAL AFRICA?

Maaïke De Ridder<sup>1</sup> - Moderator

<sup>1</sup>Royal Museum for Central Africa, Tervuren, BE, [maaike.de.ridder@africamuseum.be](mailto:maaike.de.ridder@africamuseum.be)

#### → 18:30 - 19:15 SHORT TALKS

Jean-Louis Doucet<sup>1</sup> - Logging impacts on biodiversity: a review

<sup>1</sup>Professor, Gembloux Agro-Bio Tech, University of Liège, BE, [jldoucet@ulg.ac.be](mailto:jldoucet@ulg.ac.be)

Jean-Louis Doucet has been studying central African forests since 1993. He is specialized in forest ecology, silviculture and management. In order to implement the results of his applied research activities, he has developed partnerships with FSC-certified logging companies. He is also a professor at ERAIFT (DR Congo) and USTM (Gabon).



Katharine Abernethy<sup>1</sup> - Forest Conservation strategies: protected areas, managed forests, managed species

<sup>1</sup>Associate Professor of Tropical Ecology, University of Stirling, UK and Associate Researcher, Institut de Recherche en Ecologie Tropicale, GA, [k.a.abernethy@stir.ac.uk](mailto:k.a.abernethy@stir.ac.uk)

Kate Abernethy is an ecologist living and working in Gabon, Central Africa, where she has been based since 1994. She undertakes applied research on wildlife, forest ecology and forest history to inform conservation strategies which both promote sustainable use of timber and non-timber forest products and ensure conservation of key species and ecosystems. Her work also involves teaching and training in the field in Gabon, to support future African research and conservation careers.





Paul-Emmanuel Huet<sup>1</sup> - Expectations and constraints of the private sector, an example from Congo Basin

<sup>1</sup>CSR Director, Rougier, FR, [huet@rougier.fr](mailto:huet@rougier.fr)

Paul-Emmanuel Huet is a forest engineer. After two years spent in a logging concession in Cameroon, he was General Secretary of ATIBT (International Technical Association of Tropical Timber) where he worked for six years before joining the Rougier group in 2008. He currently holds the post of CSR Director (in charge of the implementation of the social and environmental policy of the Rougier Group), Communication and Marketing.



Kasso Daïnou<sup>1</sup> - Tales of a long-standing marriage between scientific research and forest logging for the sustainable management of Cameroonian natural forests

<sup>1</sup>Responsible for the "Program of Applied Research and Silviculture", NGO Nature+, BE and Assistant professor, University of Kétou, BJ, [kdainou@ulg.ac.be](mailto:kdainou@ulg.ac.be)

Kasso Dainou is passionate by genetics and reproductive ecology of tropical rainforest tree species. He conducts most of his works in natural forest concessions and is associated to issues of biodiversity conservation despite logging. Presently he combines applied and fundamental research in silviculture and ecological genetics in order to better understand patterns of tree regeneration while offering insights for a sustainable forest management.

Richard Eba'a Atyi<sup>1</sup> - The Congo basin Forest Partnership: a platform for science-policy dialogue

<sup>1</sup>Team Leader for Central Africa, CIFOR, CM, [R.Atyi@cgiar.org](mailto:R.Atyi@cgiar.org)

Richard Eba'a Atyi is specialized in forest management and economics and he has been for more than 30 years employed by the University of Dschang in Cameroon (lectures in forest management, forest certification and forest policy), the International Tropical Timber Organization (ITTO), the Observatory for the Forests of Central Africa (OFAC), and currently for the Center for International Forestry Research (CIFOR) as Team Leader for Central Africa based in Yaoundé.

➔ 19:15 - 19:45 QUESTIONS AND DISCUSSIONS

➔ 19:45 - 19:50 CONCLUSION BY THE MODERATOR

➔ 19:50 - 20:00 PRESENTATION OF THE BELGIAN XYLARIUM

Hans Beeckman<sup>1</sup> - Presentation of the Belgian Xylarium

<sup>1</sup>Royal Museum for Central Africa, Tervuren, BE, [hans.beeckman@africamuseum.be](mailto:hans.beeckman@africamuseum.be)

Hans Beeckman graduated as forestry engineer and made his PhD on the numerical analysis of tree-ring data. He is senior scientist, curator of the Xylarium and head of the Wood Biology Service at the Royal Museum for Central Africa. Together with his research team he studies wood as a functional part of trees. This includes the analysis of cells and tissues (wood anatomy) and the growth of trees as a result of cambial activity.





# SESSION 1

## TRAITS AND FUNCTIONS IN THE TROPICS

### Chairs:

Hans BEECKMAN, hans.beeckman@africamuseum.be  
 Maaïke DE RIDDER, maaïke.de.ridder@africamuseum.be  
 Adeline FAYOLLE, adeline.fayolle@ulg.ac.be  
 Vincent MERCKX, vincent.merckx@naturalis.nl  
 Sofia GOMES, sofia.fernandesgomes@naturalis.nl

Traits are considered as a key to understand and predict the adaptation of ecosystems in the face of biodiversity loss and global changes. Since botanical information is often summarized on the level of species, there are more databases allowing analysis of interspecific variability along long gradients than intraspecific changes caused by small-scale environmental fluctuations. Currently, leaf and whole tree traits make up the vast majority of trait-oriented studies while wood traits remain less studied.

This session aims at discussing and integrating a broad number of leaf, wood and whole tree traits, reuniting ecologists, geneticists, wood biologists, modelers to discuss their work on intra- and interspecific trait differences, ontogenetic effects, effects of size and the evolution of traits through time (growth rings) in tropical forest ecosystems. Studies may range from the individual plant level up to integration within systems of higher hierarchy like species and population level. Challenges and gaps in current research as well as possible (dis)advantages of working with international databases and herbaria/xylaria can be addressed and debated.

If we look to the roots of almost all tropical plants, we can discover mutualistic interactions with fungi, known as mycorrhiza. Plants supply these root-associated fungi with carbohydrates, and in return the fungi provide their host plants with mineral nutrients and water from the soil. These interactions create complex underground networks in which plants of different species are linked by shared mycorrhizal fungi. New technologies are providing fascinating opportunities to deepen our understanding of the diversity, spatial, and temporal dynamics of these mycorrhizal fungal communities. This symposium provides also a platform to present recent advances on the taxonomy, biology, evolution, and biodiversity of mycorrhizal associations in the tropics.

## HYDRAULIC AND WOOD TRAITS OF TWO CONGENERIC TROPICAL TREE SPECIES IN THEIR CORE HABITAT

Anais-Pasiphaé Gorel<sup>1</sup>, Kathy Steppe<sup>2</sup>, Hans Beeckman<sup>3</sup>, Jean-Louis Doucet<sup>4</sup>, Adeline Fayolle<sup>1</sup>

<sup>1</sup>TERRA Forêts d'Afrique Centrale, Gembloux Agro-Bio Tech, Université de Liège, Gembloux, BE, [anais.gorel@ulg.ac.be](mailto:anais.gorel@ulg.ac.be)

<sup>2</sup>Laboratory of Plant Ecology, Department of Applied Ecology and Environmental Biology, Faculty of Bioscience Engineering, Ghent University, Ghent, BE

<sup>3</sup>Royal Museum for Central Africa (RMCA), Laboratory for Wood Biology and Xylarium, Tervuren, BE

<sup>4</sup>BIOSE unit, Gembloux Agro-Bio Tech, Université de Liège, Gembloux, BE

**Background:** For several tropical tree genera, strong niche partitioning among species has been identified across rainfall gradients. The link between hydraulic and wood anatomical traits, associated with drought tolerance, however remains to be explored, in order to identify the mechanisms shaping the range limits of tropical tree species.

**Aim:** In this study, we aimed to identify the differences in hydraulic and wood traits between two congeneric tree species with contrasting distributions in moist and wet tropical forests.

**Location:** Central African moist and wet forests.

**Methods:** In the core habitat of *Erythrophleum ivorense* (wet forest) and of *E. suaveolens* (moist), we collected branches to construct vulnerability curves and measure hydraulic capacitance, and both stem and branch wood samples to link the hydraulic traits to wood anatomy.

**Major results:** *E. suaveolens*, which is characteristic of drier forests, is clearly more resistant to cavitation than *E. ivorense*, and also possess a greater hydraulic capacitance (i.e. the capacity that species have to mitigate the impact of drought by using internally stored water). In agreement with this great drought tolerance for *E. suaveolens*, wood anatomy revealed a high number of small vessels associated with small intervessel pits, features minimizing cavitation risk but also reducing water transport.

**Main conclusions:** Drought tolerance, as indicated by both hydraulic and wood traits, strongly differed between the closely related species and explained their contrasting distribution, and affinity for moist (*E. ivorense*) and wet (*E. suaveolens*) forests. However, phenotypic plasticity in hydraulic and wood traits remained to be addressed to examine the extent of water use differences between the two species.

### Merian Award Applicant



## FUNCTION AND MORPHOLOGICAL TRAITS OF THE VELAMEN RADICUM IN ORCHIDACEAE

Nina Schickenberg<sup>1</sup>, Gerhard Zotz<sup>1,2</sup>

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<sup>2</sup>Smithsonian Tropical Research Institute, Panama, PA



Vascular epiphytes are most prevalent in humid forests in the tropics, where moisture, irradiance and available nutrients can occur in numerous combinations and temporal patchiness. One intriguing adaptation to counter the environmental challenges associated with epiphytism is the velamen radicum, a spongy and often multiseriate epidermis. Although observed in many plant families, it is most prominent in the roots of orchids. This adaptation is thought to serve several functions in aerial roots, such as acting as a boundary layer against desiccation and as a mechanism for rapid nutrient and water uptake, although these remain understudied.

Our research proposes that, in combination with intra-specific and some interspecific variation, the development of an aerial root is likely influenced by the environment but that the sponge-like velamen may not be as crucial to water and nutrient absorption as some prior research suggests. Environmental factors seem to influence root development and, to some extent, cell parameters while the velamen layers appear to be a species-specific feature. The nature of the root's micro-climate may be a better indicator for root development than large scale climate factors such as regional precipitation. In addition, epiphytic orchids do not solely depend on their velamentous roots for nutrient uptake, which inspires further investigations on not only the function but also the cost-benefit relationship of such a specialized structure.

## RELATING FUNCTIONAL AND STRUCTURAL TRAITS TO SPECIES PERFORMANCE IN THE EARLY STAGES FOR 15 TROPICAL TREE SPECIES

Ariane Mirabel<sup>1,2,3,4</sup>, Dakis-Yaoba Ouedraogo<sup>1</sup>, Hans Beeckman<sup>4</sup>, Jean-Louis Doucet<sup>1</sup>, Adeline Fayolle<sup>1</sup>

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<sup>4</sup>Laboratory of Wood Biology and Xylarium, Royal Museum of Central Africa, Tervuren, BE

The correlations between functional and structural traits and their link with species performance has been little explored for tropical trees and yielded contradictory results.

In this study, we specifically (1) tested the (de)coupling of the leaf/stem/root economic spectra already identified for tropical woody species. (2) We also examined whether the leaf/stem/root traits were correlated with biomass allocation and stem anatomy. (3) Finally, we explored the relationship between traits and performance at the seedling and saplings stages.



We selected 15 major tropical tree species, belonging to 9 families and 13 genera, and measured leaf/stem/root traits, whole plant biomass allocation (leaf/stem, and shoot/root ratio) and stem anatomy (tissue proportion, vessel density and diameter and fiber wall thickness) for ten nursery-raised seedlings. We analyzed the correlations between traits of the different organs and across tissue-to-organismal scales. We identified the different trait combinations and explored their correlation with seedlings growth in the nursery and saplings growth and survival in plantation.

We identified strong co-variations between leaf, stem, and root traits, supporting trait combination integrating the whole plant. This first trait axis was associated with species strategy of resource use (resource acquisition/conservation trade-off). Biomass allocation and structural traits tended to be correlated but orthogonal to the leaf, stem, and root traits. This second axis was associated with species hydraulic efficiency and stress resistance. We also found that traits associated with the first "acquisition-conservation" axis were good predictors of seedlings growth, but not of saplings growth and survival in plantations.

Our results suggest relationship between traits and performance, though whether this relationship are mediated by the environment or change through ontogeny remains to be explored.



## SPATIAL VARIATION OF PHOTOSYNTHESIS IN TROPICAL PRISTINE FORESTS: SAPLINGS VS. ADULTS

Lore Verryckt<sup>1</sup>, Clement Stahl<sup>2</sup>, Sabrina Coste<sup>3</sup>, David Ellsworth<sup>4</sup>, Erik Verbruggen<sup>1</sup>, Elodie Courtois<sup>1</sup>, Ifigenia Urbina<sup>5</sup>, Romà Ogaya<sup>5</sup>, Joan Llusà<sup>5</sup>, Josep Peñuelas<sup>5</sup>, Ivan Janssens<sup>1</sup>

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<sup>5</sup>CSIC, Global Ecology Unit CREAF - CEAB - UAB, Cerdanyola del Vallès, ES



Understanding what determines the spatial variation of photosynthesis is crucial for modelling canopy photosynthesis. Within canopy variation is often explained by leaf stoichiometry. Trees optimise their nitrogen allocation to maximise photosynthetic capacity under the different light conditions. The role of phosphorus in this relationship is still uncertain.

Since the tropical forests of French Guiana are very poor in soil phosphorus availability, they represent ideal case studies to assess whether or not variation in leaf phosphorus contributes to the vertical variation in photosynthesis. We carried out 840 gas exchange measurements at different height levels in the canopy of 12 plots distributed over three topographic positions. We compared gas exchange of upper canopy, lower canopy, and ground vegetation.

Here we will present how  $A_{max}$  (light-saturated photosynthesis at ambient  $CO_2$ ) and the photosynthetic parameters  $V_{cmax}$  (maximum carboxylation rate) and  $J_{max}$  (maximum electron transport rate) relate to soil nitrogen and phosphorus availability and to leaf stoichiometry.

### Merian Award Applicant

## COMPARING CANOPY TREES IN TROPICAL FOREST - UNDERSTANDING PERFORMANCE FROM SCALING ARCHITECTURE, ALLOCATION, PHYSIOLOGY AND ANATOMY TO WHOLE PLANTS

Lan Zhang<sup>1,2</sup>, Yajun Chen<sup>3</sup>, Frans Bongers<sup>1</sup>, Frank Sterck<sup>1</sup>

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<sup>3</sup>Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Yunnan, CN

An intriguing question is how large woody plants integrate the acquisition, transport, storage and loss key resources, such as carbon and water, and maintain a stable structure at the same time. Woody plants are expected to maintain optimal balances among these different functions by optimally distributing the tissues that are associated with these functions. In angiosperm species, these are vessels in the xylem for water transport, fibres for strength, phloem for the transport of carbon and parenchyma for the storage of carbon, water and other resources. Yet, in the recent literature there is a lot of attention on the functions of individual tissues, and the integrative picture of all tissues and key functions to explain tree growth is missing. Besides, balance between water transport and loss, carbon gain and fixation/storage are also important as woody plants grow up.



Therefore, our study proposed a new conceptual model that includes functions of hydraulic conductivity/safety, carbohydrate conductivity, mechanical safety and buffer zone (storage area). This is a first step to try to link all the functions and balance together to explain wood tree growth, where our first focus will be a comparison between trees and lianas. Field work was done during raining season in a tropical forest in Xishuangbanna, South-east China. A canopy crane was used to take branch samples from forest canopy. Permanent cross-sections were made to analyse tissue areas. Hydraulic conductivity, modulus of rupture and dry wood density were measured. Traits relate to photosynthesis were also measured. The conceptual model will be tested for both lianas and trees. The hypothesis is that lianas invest more in hydraulic and carbohydrate conductivity, and in storage capacity, but this comes at the cost of hydraulic and mechanical safety. Trade-offs between each function will be tested by using a wide spectrum of functional traits.



## HOW TREE ARCHITECTURE VARIES ACROSS COEXISTING TROPICAL TREE SPECIES AND RELATE TO ECOLOGICAL STRATEGIES?

Grace Jopaul Loubota Panzou<sup>1,2</sup>, Gauthier Ligot<sup>1</sup>, Jean Joël Loumeto<sup>2</sup>, Adeline Fayolle<sup>1</sup>

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### Background

Architecture refers to the overall shape of a tree and the spatial position of its components. Tree height determines the position in the forest canopy and access to light, while the amount and spatial distribution of the foliage depend on the depth and the width of the crown.

### Aim

The aim of this study is to understand how tree architecture varies across coexisting tropical tree species and relates to ecological strategies.

### Material

A total of 45 coexisting tree species (27 shade bearers, 14 non-pioneers light demanding and 4 pioneers) were sampled in the semi-deciduous forests of Northern Congo. Between 14 and 72 trees per species were sampled, leading to a total of 968 trees measured over a large range of diameter (10–162 cm). At the tree level, we measured the diameter (D in cm), height (H in m), crown radius (Cr in m) and crown depth (Cd in m). We visually estimated crown exposure index (CEI). At the species level, architectural traits (Dmax, Hmax, Crmax and Cdmax) and light requirement (CEI<sub>juv</sub>) were derived from our field measurements, and life history traits (dispersal mode, phenology and regeneration guild) and wood density were obtained from published sources.

### Methods

We investigated the height and crown allometries at the tree level using general linear mixed models on log-transformed data. Species and traits were introduced as random effects on both slope and intercept. We then used multivariate analyses to examine the relationship between architectural, functional traits (CEI<sub>juv</sub> and wood density) and life history traits.

### Results

We identified a significant variation in tree allometry between coexisting species. Based on AIC, we found that the best linear mixed model included two random parameters (intercept and slope) for H-D and Cr-D allometries, and only a random intercept for Cd-D allometry. Interspecific variation in H-D allometry was related to light requirement (CEI<sub>juv</sub>) while Cr-D and Cd-D allometries were related to dispersal mode and wood density, respectively. Multivariate analysis with 13 variables stressed that variation among ecological strategies (regeneration guilds) is continuous rather than discrete.

### Conclusions

Architectural traits strongly differentiated species and ecological strategies and might be further considered to develop trait based ecology of tropical forest trees.

### Merian Award Applicant



## IMPLICATIONS OF INTER- AND INTRASPECIFIC VARIATION OF WOOD DENSITY ON BIOMASS ESTIMATIONS IN SECONDARY FORESTS

Svenja Kleinschmidt<sup>1</sup>, Felix Kreinecker<sup>1</sup>, Peter Hietz<sup>1</sup>

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Tropical secondary forests have high carbon sequestration potential. Obtaining a reliable aboveground biomass estimate is crucial to accurately quantify carbon stocks and hence to evaluate their contribution to global carbon fluxes. Aboveground biomass is commonly determined from forest inventory data using allometric models. Wood density is one of the most important predictors of aboveground biomass and many studies use mean values obtained from international databases to quantify carbon stocks. However, many species vary significantly in their wood density along environmental gradients and within individual trees, which can lead to substantial uncertainties of local aboveground biomass estimates. To address this concern, we determined the inter- and intraspecific variation of wood density for 40 tree species in humid tropical lowland of south-western Costa Rica. Further, we compared biomass estimates derived from literature-based wood density data with those calculated by using locally measured wood density.

The study was conducted as part of a high biodiversity reforestation project next to La Gamba Biological Station. We measured branch wood density for 40 different species at the reforestation site and stem wood density in the nearby forests. Diameter and total tree height were determined at the reforestation site for about 4.500 individuals representing 154 species. First results indicate local branch wood density and local stem wood density being less significantly correlated ( $r^2 = 0.36$ ;  $p < 0.01$ ) than local stem wood density and wood density from international databases ( $r^2 = 0.66$ ;  $p < 0.001$ ). Further, we evaluated the differences in biomass estimates when using local versus literature-based wood density and branch versus stem wood density data. We suggest that more research is needed on intraspecific variation of wood density at the local scale to improve biomass estimates and the contribution of tropical secondary forests to the global carbon balance.

## BIOMASS DYNAMICS AFTER LOGGING: THE ROLE OF WOOD DENSITY

Nam Vu Thanh<sup>1</sup>, Niels Anten<sup>2</sup>, Marijke van Kuijk (speaker)<sup>3</sup>

<sup>1</sup>Vietnam Administration of Forestry, Hanoi, VN

<sup>2</sup>Wageningen University, Wageningen, NL

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Selective logging can have strong impacts on tree biomass in forests. As species with different functional traits may respond differently to disturbances, frequent logging may also impact species composition. Wood density (WD) is believed to be a key functional trait in driving growth strategies of tropical forest species. We determined changes in biomass in permanent plots in an evergreen forest in Vietnam from 2004 to 2012, a period representing the last eight years of a 30 year logging cycle. Diameter (DBH) and aboveground biomass (AGB) growth, mortality and net AGB increment were estimated at the community and species level and the latter values were correlated with species WD. At the community level, mean net AGB increment rates were  $6.47 \text{ Mg dry mass ha}^{-1} \text{ year}^{-1}$  resulting from a mean AGB growth of  $8.30 \text{ Mg ha}^{-1} \text{ year}^{-1}$ , AGB recruitment of  $0.67 \text{ Mg ha}^{-1} \text{ year}^{-1}$  and AGB losses through mortality of  $2.50 \text{ Mg ha}^{-1} \text{ year}^{-1}$ . At the species level there was a negative relationship between WD and mortality rate, and WD and DBH growth rate, but surprisingly there was a positive relationship between WD and AGB growth, and WD and net AGB increment both at the individual and population level.



In addition to studying the forest that was logged once 30 years ago, we also assessed the extent to which demographic rates were correlated with wood density at the species level in forest plots that were logged twice: the first time 30 years ago (late recovery forest), the second time in 2008-2010 (early recovery forest). Demographic rates showed significant differences between the early recovery forest (2-3 years and 4-5 years recovery forest) and the late recovery forest (30 years recovery forest), whereas we did not find differences between the early recovery forests, except for mortality rate ( $\% \text{ year}^{-1}$ ) which was higher in the 2-3 years recovery forest than the 4-5 year recovery forest. The trends we observed in the late recovery forest were not apparent in the early recovery forest. This clearly shows that logging can alter the relationship between a functional trait (such as WD) and demographic rates and indicates frequent logging could alter species composition of the forest. Our findings support the view that high wood density species contribute more to total biomass than low wood density species in tropical forests. Maintaining high wood density species increases biomass recovery and carbon sequestration after logging. Therefore, selective logging regimes should consider variation in WD between species.



## CONTRASTING SOIL CARBON TURNOVER BETWEEN MONODOMINANT *GILBERTIODENDRON DEWEVREI* AND MIXED-SPECIES FORESTS IS RELATED TO LEAF LITTER TRAITS

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In Central Africa, *Gilbertiodendron dewevrei* frequently occurs as large patches of monodominant forests (MOF) located next to higher diverse *Scorodophloeus zenkeri* forests (mixed forests, MIF). Although a series of functional traits, including leaf litter characteristics, has been shown to control monodominance in those systems, their role in regulating the rates of carbon gain and carbon loss, as well as the size and permanence of the C stocks (SOC) remains unknown.

We examined how green and litter leaf traits of dominant tree species affected SOC dynamics (stocks and fluxes) under MIF and MOF located on highly weathered sandy soils in the Yoko Reserve (DRC). In addition to estimates of aboveground and soil (forest floor plus mineral soil down to 2m depth) C stocks, we measured soil respiration and aboveground foliar litterfall during a one-year period.

Similar organic matter inputs were observed under both forest types but litterfall quality in MOF strongly differed by a set of traits related to organic matter recalcitrance. The initial decomposition rates of 8 main tree species under MIF and MOF were largely driven by the position of the species on the (green and/or litter) leaf economics spectrum. Despite similar total annual soil respiration, forest floor removal significantly reduced soil respiration only in MIF, by ca. 20%. While the combined SOC and aboveground C stocks were similar in both forests (372.33±60.97 and 350.73±83.66 Mg C ha<sup>-1</sup> in MIF and MOF, respectively), SOC stock down to 220 cm was 55 % higher under MOF compared to MIF.

The poor-quality litter of *G. dewevrei* induced limited nutrient availability under MOF, promoting SOC accumulation and decreasing soil respiration per unit soil C, but it did not limit the aboveground C storage nor the net primary productivity (as inferred from similar C litterfall inputs) compared to MIF. Our results highlight that reliable assessment of the global leaf economics spectrum should prove valuable in modelling SOC dynamics in tropical forests.

## SOIL ATTRIBUTES STRUCTURE PLANT ASSEMBLAGES ACROSS AN ATLANTIC FOREST MOSAIC

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### Aims

Community assembly persists as a key topic in ecology due to the complex variation in the relative importance of assembly forces and mechanisms across spatio-temporal scales and ecosystems. Here we address a forest-savanna vegetation mosaic in the Brazilian Atlantic forest to examine the role played by soil attributes as determinants of community assembly and organization at a landscape spatial scale.



### Methods

We examined soil and plant assemblage attributes across 23 plots of forest and savanna in a 1600-km<sup>2</sup> landscape exposed to the same climatic conditions in the Atlantic forest region of northeast Brazil. Assemblage attributes included species richness, taxonomic and functional composition (community weighted means, CWM) and functional diversity (quadratic diversity; Rao's quadratic entropy index) relative to plant leaf area, specific leaf area, leaf dry matter content, thickness and succulence.

### Important Findings

As expected, forest and savanna patches clearly differed in terms of soil and an extensive array of plant assemblage attributes with a signal of trait convergence in both vegetation types. Our results suggest that (1) savanna-forest mosaics in the Atlantic forest region represent spatially organized plant assemblages in terms of taxonomic and functional features; (2) plant assembly is influenced by deterministic processes, which seems to be driven by soil-related environmental filtering; and (3) by selecting particular plant strategies relative to resource economy, soil is responsible for the spatial organization of savanna-forest boundaries and mosaics.

### Merian Award Applicant



## SOIL MICROBIAL NUTRIENT LIMITATIONS IN TROPICAL FORESTS - A META-ANALYSIS

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Nutrient limitations exert control on ecosystem processes, which is mainly discussed for primary productivity, but it also affects microbial activity. Soil microbial processes represent crucial factors in ecosystems, mediating the cycling of carbon and nutrients in soils, but also affecting responses to environmental change. However, especially in tropical forests, which represent an important global system in the context of carbon storage, the role of soil microorganisms is poorly understood. Nutritional demands of trees growing on tropical highly-weathered soils get slowly elucidated, especially by nutrient manipulation experiments, whereas the associated microbial processes in soils are often neglected. However, recent global comparisons of microbial stoichiometry and process rates, but especially the growing amount of literature on responses of soil microorganisms to nutrient additions, provide a valuable source to address this “hidden part” of the ecosystem at this point.

We conducted an in-depth literature review of responses of microbial abundance as well as various microbial process rates in soil in response to the additions of differing nutrients in tropical forest systems. A meta-analysis comparing the effects sizes of nitrogen and phosphorus additions provides clear evidence for a primary role of phosphorus in controlling soil microbial activity, especially in tropical lowland soils, whereas in montane sites N and N/P co-limitation also gains importance. Interestingly, few studies evaluating the impact of further rock-derived elements point towards a non-Liebig system with several elements affecting the high diversity of microbial activities in soil, though more studies are needed to understand the respective significance. Also, evaluated studies comparing the relative effects of carbon versus nutrients support the hypothesis that in tropical forest soils carbon is not always the primary factor controlling microbial activity. In summary, we provide clear evidence for the important role of microbial nutrient limitations in tropical forests, especially by rock-derived elements, which is a fundamental basis for our understanding of ecosystem processes in this important biome, as well as of responses to future environmental change.

## PHYLOGENETIC STRUCTURE, ANTI-HERBIVORE TRAITS AND HABITAT SPECIALIZATION BY PLANTS IN LOWLAND AMAZONIAN FORESTS

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A growing interest in tropical forest ecology has been to investigate the relative importance of phylogenetic relatedness and trait similarity in structuring plant species assemblages across different habitats. So far, most studies have reported neutral patterns or significant phylogenetic clustering within habitats (suggesting the prevalence of trait conservatism among close-related species), but they have not included well-resolved phylogenies, accurate traits data nor a sufficient range of habitat variation in which focal species are found.



To bridge the gap, the present study uses large-scale distributional data collected in 38 0.1 ha plots in Peru that sample three widespread habitats (white-sand, terra firme and flooded forests) in geographically-replicated blocks. We focus on 39 species from the genus *Protium* (Burseraceae), an abundant taxon widely distributed over the Amazon basin and represented among the three habitat types, and for which we possess accurate phylogenetic information. We include detailed data on chemical and physical defenses, which may be of paramount importance in determining community assembly if plant coexistence is impacted by host-specific natural enemies. Phylogenetic dissimilarities with respect to spatial distance are compared between pairs of plots located within a same habitat and among different habitats, in order to test different scenarios of geographic and habitat-related phylogenetic structure. We also investigate the hypothesis that competition for enemy-free space has generated phylogenetic and traits assemblage structures in the *Protium* community, by promoting divergent anti-herbivore defenses between habitats presenting contrasted levels of environmental stresses. Our analyses will shed light on the relative importance of niche conservatism versus competitive exclusion in structuring diverse congeneric plant assemblages, providing better insights into the mechanisms maintaining species diversity in tropical forests.



## POPULATION AND COMMUNITY TRAITS ASSESSMENTS FOR SUSTAINABLE MANAGEMENT AND CONSERVATION OF *AFZELIA AFRICANA* IN BENIN

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*Afzelia africana* is an endangered tree species, widely distributed in West Africa. In Benin, it is found in all climatic zones along a latitudinal gradient. As a multipurpose species, the tree is threatened especially by human impact. However, deep knowledge of genetic resources is missing but is required to guide its sustainable management and conservation. Several research approaches have been developed recently to investigate the variation of populations and community traits in association with disturbance degrees, and to model ecological niches.

We will present a summary of findings to identify knowledge gaps and future challenges for research on *A. africana*. Among structural population traits, regeneration density, basal area and mean height differed significantly among climatic zones with the Guinean zone holding the highest values. Human disturbance effects on structural population traits were dependent on climatic zones with a significant negative effect in Guinean zone. Woody species composition of *A. africana* habitats is similar in Sudanian and Sudano-Guinean zones but distinct in Guinean and Sahelo-Sudanian zones. Environmental variables such as precipitation, temperature and altitude explain most variation observed in population and community traits along climatic zones. Ecological niche modeling showed that the effectiveness of protected area network conserving current suitable habitats of *A. africana* depends on climatic zones as well with the lowest effectiveness in the Guinean zone. Regarding these findings, research focused on morphological traits, genetic diversity, and population structure, and gene flow analyses are ongoing to cope with efficient management and conservation strategies of *A. africana*.

## FREE LIVING N<sub>2</sub> FIXATION IN THE IMBALANCE-P EXPERIMENT ON FRENCH GUIANESE PRISTINE RAINFORESTS.

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Free living nitrogen fixation is often thought to be an important contributor to high nitrogen availabilities in tropical ecosystems. However, our knowledge of controls over free living nitrogen fixation remains poor.

We set up a fully factorial nitrogen and phosphorus addition experiment at two forest sites and along a topographical gradient. Free living nitrogen fixation in soil and leaf litter layer was measured using two techniques: the Acetylene Reduction Assay and 15N<sub>2</sub> labelling. Along with fixation we measured available nitrogen, phosphorus and molybdenum.

Results indicate very low N<sub>2</sub> fixation rates that correlate positively with soil phosphorus availability. Activity was greatest in the wet season and higher in litter than in soil. Compared to other tropical studies measuring free living nitrogen fixation, our rates were very low, likely attributable to the extremely low soil phosphorus availability on the Guiana Shield.



## THE ROLE OF MYCORRHIZAL SPECIFICITY IN PLANT EVOLUTION AND DIVERSIFICATION

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The arbuscular mycorrhizal symbiosis between the majority of land plants and fungi of the phylum Glomeromycota, arguably the most widespread mutualism on earth, is generally characterized by low specificity. In plant clades where the mutualism has shifted to parasitism (mycoheterotrophy) mycorrhizal specificity is often increased, in some cases to extreme levels. However, the evolutionary trajectories leading to this mycorrhizal specificity and the consequences for plant diversification remain largely unclear.

We traced the interaction between several tropical mycoheterotrophic genera and their arbuscular mycorrhizal mycorrhizal fungi (Glomeromycota) in the context of evolutionary time and the biogeographic history of the plants. In different plant lineages we observe different levels of specificity. When mycorrhizal specificity is high it can persist over considerable evolutionary time and allow for rapid diversification and wide range extensions. However, mycorrhizal fidelity is not exclusive. Mycoheterotrophic plant lineages can shift to distant narrow lineages of AM fungi, providing new opportunities for range extensions and co-existence with other mycoheterotrophs. We hypothesize that the possibility for host shifts contributes to the evolutionary stability and success of highly specific cheaters of diffuse mutualisms.

## OUT OF AFRICA: EVOLUTIONARY HISTORY OF HYPER-DIVERSE ECTOMYCORRHIZAL MILKCAP GENERA (RUSSULALES, BASIDIOMYCOTA)

Jorinde Nuytinck<sup>1</sup>, Eske De Crop<sup>2</sup>, Jan Hackel<sup>3</sup>, Melanie Roy<sup>3</sup>, Steven Janssens<sup>4</sup>, Kobeke Van de Putte<sup>2</sup>, Terry Henkel<sup>5</sup>, Annemieke Verbeke<sup>2</sup>

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Ectomycorrhizal fungi, obligate symbionts of many trees and other plants, exhibit a biogeographic pattern counter to the established latitudinal diversity gradient of most macroflora and fauna, but the evolutionary basis for this pattern has not often been explicitly tested. Many ectomycorrhizal fungi display disjunct distribution patterns that might be explained by vicariance or long-distance dispersal events. The hyper-diverse ectomycorrhizal milkcap genera *Lactarius* and *Lactifluus* (Russulaceae) display such disjunct distributions and especially *Lactifluus* is characterised by many evolutionary divergent lineages in sub-Saharan Africa.

We reconstructed the evolutionary history of the genus *Lactifluus* and tested whether it originated in the Afrotropics. We carried out an extensive global sampling and assembled a dataset of 1306 *Lactifluus* collections. Species delimitation was performed using the GMYC method in R. Divergence times were estimated in BEAST, using a secondary calibration procedure on a dataset containing species from several Basidiomycota orders. Biogeographical ranges were inferred using BioGeoBEARS in R.

Species delimitation resulted in 369–461 possible *Lactifluus* species, of which the majority are Asian and African species. Our dating analysis estimates the origin of the Russulaceae in the early Cretaceous and its major genera, *Lactifluus*, *Lactarius* and *Russula*, originated near the mid-Cenozoic. Biogeographical analyses indicate an Afrotropical origin for *Lactifluus* to be most likely, with multiple on-land migrations and long-distance dispersal events to other continents.



## CHEATING BELOWGROUND INTERACTIONS

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More than 80% of land plants obtain their vital resources through arbuscular mycorrhizal fungi. Generally, mycorrhizal fungi facilitate the uptake of water and soil minerals from the soil to the plants in exchange of photosynthetically fixed carbon from the plants to the fungal partner. However, in specific cases the carbon flux is inverted from the fungus to the plant, and the interaction is mycoheterotrophic. Hence, these plants become cheaters in the mycorrhizal system, obtaining their carbon ultimately from green surrounding plants through the belowground mycorrhizal network.

Host specificity is a hallmark of antagonistic systems, and in general, mycoheterotrophic interactions involve narrower lineages of fungal hosts than mutualistic interactions. Thus, the fungal diversity available for mycoheterotrophic plants is restricted. This implies that host diversity and overlap among mycoheterotrophic plants may have important consequences for their coexistence. Yet, little is known about these host patterns.

In this study, we shed light on mycoheterotrophic interactions patterns. We used high-throughput DNA sequencing data to investigate the interactions between arbuscular mycorrhizal fungi and mycoheterotrophic plants. We detected no phylogenetic signal on the number of fungal host nor on the shared fungal hosts among these plants. Instead, we found that the phylogenetic diversity of fungal hosts associated with any given group of mycoheterotrophic plants increases proportionally with their overlap in fungal hosts. Our findings suggest that mycoheterotrophic interactions are more strongly modulated by ecological than by evolutionary processes.

## EPIPHYTIC MATTER AND WATER STORAGE DYNAMICS IN A TROPICAL MONTANE FOREST FORTUNA, WESTERN PANAMA

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Tropical montane forests are characterized by substantial epiphyte loads. One of the important ecological roles of epiphytes in these forest systems is the impact on forest hydrology. Notably, the diversity and abundance of epiphytes respond more strongly to the reliable availability of water than any other life form. This role of epiphytes is expected to be strongly affected by global change, but baseline data to document the status quo and possible changes are rare.



In a tropical lower montane cloud forest, we weighed and estimated the water storage capacity of all the epiphytic matter from 22 tree trunks varying in DBH and 28 canopy branches.

We extrapolate our data to the 1-ha plot level from a nearby plot. The resulting estimate of the total epiphytic matter and its stand water storage was c. 23,000 kg ha<sup>-1</sup> and c. 31,000 l ha<sup>-1</sup>, respectively. Water content capacity was the highest for bryophytes with 734 % of dry weight.



# SESSION 2

## DRY TROPICAL WOODLANDS IN AFRICA

### Chairs:

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The Miombo belt of dry tropical woodlands is regarded as one of the most intact of the major terrestrial biomes. However, current studies identify the region as a hot spot of deforestation and forest degradation. At the same time, in the Global Biodiversity Outlook Miombo woodlands are considered as one of the global tipping points in the Earth System as summer rainfall and humidity are transported from the Congo rainforest zone via the Miombo belt towards the southern arid savannas. Nevertheless, over the last decades the region has received much less scientific attention than tropical rain forests.

Therefore, we would like to bring together researchers working on ecological baseline assessments, land use change, human use of woodland resources, species diversity, vegetation patterns and communities, forest structure and biomass, and plant-animal interactions in the Miombo belt. We especially encourage contributions that a) link ecological field studies to remote sensing or modelling approaches b) investigate processes and drivers of change or develop scenarios on future land uses c) study changes in social-ecological systems and their impact on provision of Ecosystem Services Studies from comparable African ecosystems such as the wet Guinea savannas are also welcome.

## PREDICTION OF WOODY ABOVE-GROUND BIOMASS IN THE MIOMBO WOODLANDS: ACCURACY OF ESTIMATIONS

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Allometric assessments of the tree biomass are a key tool for assessing the level of degradation of woodland vegetation and deforestation worldwide. Data on structural characteristics of vegetation is required for making precise estimation of carbon storage and biomass energy values globally and regionally such as in southern Africa.

In this study, we employed three allometric models to estimate above-ground biomass (AGB) at grain scale, one developed for dry subtropical forests worldwide (Brown et al. 1989) and two models developed particularly for the Miombo Woodlands (Chidumayo 1997; Ryan et al. 2011) in order to assess the impact of land-use intensities on AGB. The following research questions were addressed: How do the regional models for estimation of AGB in Miombo Woodlands compare to a global model for dry subtropical forests? How does the AGB relate to the land-use intensities of the study sites in Western Zambia?

At each of the three study sites with high (Luampa), medium (Dongwe) and low (Kafue National Park) land-use intensity, respectively, a Biodiversity Observatory of 1 km<sup>2</sup> was set up. The three Observatories form part of the SASSCAL research portfolio (sasscal.org) and complement the 37 Observatories that already exist in southern Africa. Within 20 randomly selected hectare cells per Observatory, two nested plots of 100 m<sup>2</sup> and 1000 m<sup>2</sup> were sampled. Species inventories, abundance per species, tree height and diameter at breast height were analysed for tree density and AGB. The comparison of the AGB estimations resulting from the three different algorithms revealed that the means of the AGB were significantly different from each other ( $p < 0.00001$ ). The post-hoc analysis (Neymenyi test) revealed that the global model differed from the two regional models. All three equations for AGB showed that the higher land-use intensity site had a lower woody biomass than the low intensity site. AGB was negatively associated with species diversity.



## PARTICIPATORY ASSESSMENT OF LAND USE AND LAND USE CHANGE TO FOSTER SUSTAINABLE MANAGEMENT OF MIOMBO SOCIAL-ECOLOGICAL SYSTEMS

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The miombo ecoregions span more than 2.6 million km<sup>2</sup> and support the livelihoods of over 100 million people in Eastern and Southern Africa. However, the sustainability of activities such as agriculture and the extraction of wood products, as well as the ability of miombo woodlands to provide other ecosystem services and goods such as carbon sequestration and biodiversity over the long term, are poorly understood. Timely and accurate information on land use composition, land use change, land degradation and restoration is needed to understand anthropogenic impacts on miombo ecoregions and to foster sustainable management of these social-ecological systems. Studies thus far have either used ground-based data that provide high levels of detail, but are not easily scalable to the ecoregion level, or medium-to-coarse resolution remote sensing approaches that provide large-scale results but lack the granularity to assess the small-scale land use conversions and land degradation activities.

Here, we present preliminary findings from the recent FAO Global Assessment of Land Use and Land Use Change on land use composition in 2015 and land use change over the past 15 years in miombo ecoregions. The results describe the major land use categories, as well as tree canopy cover percentage, tree density per hectare and level of fire and infrastructural disturbances. The rates and patterns of deforestation, agricultural expansion and other land use changes in miombo ecoregions are compared with those for the broader Southern Africa region. The FAO Global LULUC Assessment is the first of its kind, leveraging free and open source software, Google technology, freely accessible archives of very high-resolution satellite imagery and a participatory GIS approach. More than 500 individuals from 34 institutions assessed 500,000 sites globally. The full dataset, including the data for the 45,000 sites in Southern Africa, will be made publically available in 2017.

### Merian Award Applicant

## THE IMPACT OF LAND USE INTENSIFICATION ON PROVISIONING SERVICES FROM MIOMBO WOODLAND IN RURAL ZIMBABWE

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Miombo woodlands are key to livelihoods in much of southern Africa, making it critical to understand how changing land use patterns will impact the ecosystem services used by households. However, understanding has been limited by poor inclusion of the ecological knowledge held by rural communities in assessments of woodland change. Here we examine links between land use intensity (LUI) and availability of tree-based provisioning ecosystem services around Wedza Mountain, Zimbabwe, by combining a socioecological LUI measure with woodland surveys and a questionnaire survey scoring trees in a range of use categories.

We find that the potential for woodlands to provide most provisioning services decreased as LUI increased. In the firewood and construction categories this decrease was driven by declining stocking density rather than establishment of less valued species, as the species present in high LUI areas still scored highly with local respondents. Provision of construction material and firewood was more robust to LUI than other services because loss of species characteristic of mature woodland was partially compensated by increased abundance of more disturbance tolerant species which provide the same service, such as declining dominance of *Brachystegia* species being counteracted by higher abundance of *Combretum molle*. Wild food was the provisioning service most impacted by LUI, with woodland in high land use intensity areas having significantly lower abundance of the fruit trees perceived as most valuable by local households. We also find that local ecological knowledge is evolving in response to novel species, with both deliberately introduced trees and 'harmful' invasives such *Lantana camara* reported to have diverse use values. Our results show the value of including local plant use data in forest change analyses, and suggest that local ecological knowledge can increase livelihood resilience in the face of environmental change.



## WIDESPREAD DEGRADATION AND BOOSTED DEFORESTATION OFFSET BY EXTENSIVE REGROWTH IN AFRICAN WOODLANDS

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Deforestation and forest degradation alter the resources available to rural communities, and can contribute to climate change. In African woodlands, the rates and locations of degradation are unknown and deforestation and subsequent regrowth rates are uncertain. This leads to a lack of knowledge of the impacts of such land cover changes on livelihoods and the carbon cycle, and confuses analyses of the causes of these changes and appropriate policy responses. In the miombo and mopane woodlands that dominate southern Africa, the (presumed) drivers of degradation are abundant, but no regional assessment of degradation rates and associated carbon emissions exists, and current understanding rests upon 'received wisdom'.

We address this with the first sub-continental assessment of the rates and locations of degradation, deforestation and (re)growth. We use radar imagery to construct 25 m resolution maps of carbon stocks for the years 2007-10, and derive estimates of the area affected by degradation, deforestation and (re)growth and the associated carbon stock changes. We find that degradation affected 13% of the study region over the three years, 3.5 times the area deforested. Deforestation rates (3.7%/yr) are double previous estimates, partly due to a more realistic definition of "forest loss" more suited to the practices of small-scale agriculturalists in the region. Most of the woodland increased in biomass, particularly in low biomass areas, leading to no net change in woody carbon stocks over the study period. Carbon losses from degradation exceed deforestation substantially (0.24 vs 0.08 PgC), which is not reflected in current climate mitigation policy or practice. The location of degradation hotspots suggests that trans-boundary flows of timber and woodfuel are important causes. The widespread increase in biomass probably reflects the response of the woodlands to past disturbance and illustrates their resilience; it may also indicate that elevated atmospheric CO<sub>2</sub> is increasing tree growth rates.

## WHAT IS THE IMPACT OF PROTECTED AREAS ON DEFORESTATION AND DEGRADATION IN SOUTHERN AFRICAN SAVANNAH WOODLANDS?

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Seasonally dry tropical forests and savanna woodlands are the dominant vegetation types in Southern Africa, covering over 4 million km<sup>2</sup> across some of the world's poorest countries. They underpin the livelihoods of 150 M people, many of whom rely heavily on the agricultural land, woodfuels, construction materials and timber the woodlands provide. Rising populations are increasing this demand resulting in widespread deforestation and degradation (see McNicol, Ryan and Mitchard, this session). The establishment of protected areas (PAs) remains the foremost strategy in mitigating against extensive forest loss globally. A necessary precursor to any future expansion is a comprehensive, evidence-based assessment of the performance of the current conservation estate to help inform where future protected areas should be located and how they should be managed.



To this end, we used radar data to map aboveground woody carbon stocks and quantify deforestation and degradation across the southern African savanna woodlands for the period 2007 – 2010. Matching techniques are used to assess whether protected areas (PAs) are effective at avoiding these disturbance relative to the counterfactual scenario of no protection. The effectiveness of PAs in avoiding degradation has never been assessed before. PAs effectiveness was highly variable with National Parks appearing to be the most successful PA type in reducing biomass losses compared to similar unprotected areas. Forest reserves, which encompassed the majority of the PAs analysed, were slightly less effective, with less than half showing a reduction in woodland loss, and a quarter doing no better in terms of avoided land cover change than similar unprotected lands. Around a third of PAs within all major reserve types showed significantly greater rates of deforestation and degradation. The presentation will go on to examine the factors that underline this spatial variation in protected areas effectiveness.



## DIVERSITY AND STRUCTURE OF MIOMBO WOODLANDS IN MOZAMBIQUE USING A RANGE OF SAMPLING SIZES

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Forest assessments are essential to understand the tree population structure and diversity status of forests and to provide information for biodiversity recovery planning. Unfortunately, the majority of Miombo woodlands in Mozambique lack of inventory data, and consequently are often insufficient for management.

This study aimed to assess the species richness, diversity and structure of Miombo woodlands using a range of sampling sizes in Mocuba district, Mozambique. Plant inventory was carried out in 128 systematically selected sample plots in 71.6 ha, which was divided into eight treatments, i.e., T1: 0.1 ha; T2: 0.25 ha; T3: 0.375 ha; T4: 0.5 ha; T5: 0.625 ha; T6: 0.75 ha; T7: 0.875 ha; T8: 1.0 ha, with 16 repetitions. All stems  $\geq 10$  cm diameter at breast height were measured and the species name recorded to evaluate the floristic composition, richness of tree species, diversity and diameter distribution.

A total of 36,535 individuals were recorded, belonging to 124 species of 83 genera and representing 31 botanical families. The most important species was *Brachystegia spiciformis* Benth. and the richest botanical family was Fabaceae. The forest showed an average of  $517 \pm 85$  trees/ha, and high species diversity and evenness. Analysis of covariance showed that the intercepts and slopes of the exponential function for diameter distribution were not significantly different for the eight treatments. Compared with the entire composite forest, inventory means were accurately estimated and size class distributions were well represented for plots  $\leq 0.25$  ha, for selecting an efficient sampling design suited to forest characteristics and the inventory's purpose.

### Merian Award Applicant

## INTERACTIONS OF MULTIPLE TRANSFORMATION PATHWAYS IN THE OKAVANGO REGION

Rasmus Revermann<sup>1</sup>, Manfred Finckh<sup>1</sup>, Achim Röder<sup>2</sup>, Marion Stellmes<sup>2</sup>, Anne Schneibel<sup>2</sup>, Francisco Maiato Gonçalves<sup>3</sup>, Michael Pröpper<sup>4</sup>, Fernanda Lages<sup>3</sup>, Norbert Jürgens<sup>1</sup>

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The Okavango Basin is one of the last remaining intact river basins in Africa. The Okavango has its origin in the Miombo woodlands of the Angolan Central Plateau and terminates in the endorheic Okavango Delta in the semi-arid Kalahari in Botswana. The region is a biodiversity hub of global importance and provides key ecosystem services ranging from food and freshwater for adjacent settlements to timber, charcoal and agricultural crops for the urban centres. However, the social-ecological systems of the Basin are subject to rapid transformations.

We will present an overview on current transformation dynamics in the Okavango Basin, their pathways, drivers and mutual interactions. The analyses allow pinpointing intervention points for sustainable land management which are relevant for similar settings in the larger Miombo belt. A vegetation survey documented the so far unknown plant diversity of the headwaters and as such provides baseline data for future conservation efforts. Based on time series of remote sensing data we detected accelerating deforestation of the forest ecosystems in the headwaters, caused by expanding smallholder agriculture and new infrastructure axes that open corridors for resource exploitation. Socio-economic studies revealed societal changes like urbanisation and the globalization of desires that increasingly fuel dynamics of natural resource commodification. Inadequate land management practices, especially with regard to fire handling, act as trigger mechanisms that stabilize man made land cover changes and prevent forest recovery.

The existing governance frameworks seem not to respond sufficiently to the identified transformation processes, due to a lack of coordination between private, customary and statutory policy makers. The deficiencies of sustainable resource governance within the complex networks of actors across scales are especially critical with regard to global public goods.



## TREE SPECIES DIVERSITY AND COMPOSITION OF MIOMBO WOODLANDS IN SOUTH-CENTRAL ANGOLA, A CHRONOSEQUENCE OF FOREST RECOVERY AFTER SHIFTING CULTIVATION

Francisco M.P. Goncalves<sup>1,2</sup>, Rasmus Revermann<sup>2</sup>, Amândio Luís Gomes<sup>2,3</sup>, Marcos P. M. Aidar<sup>4</sup>, Manfred Finckh<sup>2</sup>, Norbert Juergens<sup>2</sup>

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The study was carried out in the Cusseque area of the Municipality of Chitembo in south-central Angola, which is dominated by typical Miombo woodlands comprising tree species of the genera *Brachystegia*, *Julbernardia* and *Cryptosepalum*. Our objectives were to analyze the regeneration of floristic diversity, species composition and stand structure of Miombo woodlands after shifting cultivation.

A total of 40 vegetation plots of 1000 m<sup>2</sup> were surveyed corresponding to mature forest and three regeneration stages of different age. The analyses were based on plot inventories of all trees with a dbh  $\geq$  5 cm. A total of 51 woody species from 38 genera and 19 families were recorded. The dominant family was Fabaceae, with the sub-family Caesalpinioideae being very abundant. Shannon diversity and evenness were highest in mature forest and young fallows, mature forests showed also the highest species richness. The Principal Coordinates Analysis (PCoA) showed that the intermediate regeneration stages shared many species, but had only few species in common with young fallows. Mature forests clearly formed a distinct group. This study shows potential pathways of forest recovery in terms of regeneration after agricultural abandonment. Thus, it may help in future forest management and planning to reduce the demand for land and old-growth forest transformation.

### Merian Award Applicant

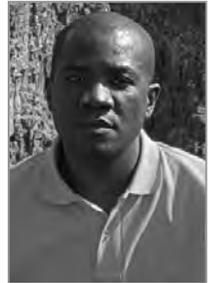
## ENVIRONMENTAL FACTORS INFLUENCING TREE SPECIES DIVERSITY IN MIOMBO WOODLANDS OF HUÍLA PROVINCE, SOUTHWESTERN ANGOLA

Valter Chissingui<sup>1</sup>, Francisco Gonçalves<sup>1</sup>, Jose Tchamba<sup>1</sup>, Jose Luis<sup>1</sup>, Marina Rafael<sup>1</sup>, Fernanda Lages<sup>1</sup>, Rasmus Revermann<sup>2</sup>

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The study was carried out in the municipalities of Cuvango, Jamba, Quilengues and Gambos in the Huíla province, southwestern Angola. The northern and eastern parts of the study area constitute the western fringes of the Miombo belt dominated by tree species of the genera *Brachystegia*, *Julbernardia* and *Cryptosepalum*. The southwestern part of the study zone is covered by Mopane Woodlands dominated by *Baikiaea*, *Mopane* and *Croton*.



Our objectives were to analyze the influence of environmental factors like topography, climate factors and soil types on tree species diversity. A total of 90 vegetation plots of 1000 m<sup>2</sup> were surveyed and the analyses were based on plot inventories of all trees with dbh  $\geq$  20 cm.

One hundred and seventy four woody species were recorded in the plots. We used multivariate statistics to test the relationships between environmental factors (independent variables) and species diversity (dependent variable). The results showed strong differences of Shannon diversity and Evenness between forest types. Shannon diversity varied between > 3.5 and 0.9, Evenness between > 0.9 and 0.3. In general terms, Miombo plots showed considerably higher diversity than the drier woodland types in the southwest. Soil type and annual precipitation were the factors that showed the strongest effects on diversity indices in the area.



## IMPACT OF FIRE ON TROPICAL DRY FORESTS IN SOUTH-CENTRAL AFRICA

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Fire is an important driver of forest degradation in the tropical dry forests of Africa, leading to diminished ecosystem services for the local communities. Forest degradation is however difficult to measure as it often entails repeated measurements over a long period of time.

This study assesses forest degradation at the edge of the Miombo Ecoregion in south-central Africa, at the border between Namibia and Angola, by comparing a forest inventory just before and after a fire, but mainly by extracting information of single forest inventories. The following methods were used: (1) an analysis of the fire damage that trees have accumulated over time, (2) a comparison of stem density, basal area and fire damage just before and after a dry season fire in 2015, and (3) a study of forest structure in function of fire frequencies during the two decades before the forest inventory was performed. Forest inventory data collected over the last 10 years were used. Fire frequency data were derived from Landsat images and the MODIS burned area product.

The results show that almost half of all trees recorded showed fire damage, varying from mild to serious. The diameter at breast height (DBH) class of 25 to 30 cm had the highest proportion of trees with fire damage. The effect of the 2015 fire on forest composition was limited to an increase in fire damage class. The mean and maximum DBH and the basal area of larger trees decreased with fire frequency in the more protected state forest. However, these trends were less obvious in community forests and on other communal land where logging affects the occurrence of larger trees. The study shows that although one fire does not have a large effect on forest composition, it is the accumulation of damage caused by recurring fires in the late dry season that results in the early mortality of the larger trees and finally to forest degradation. Forest managers need to limit fire frequencies to sustain a timber industry and maximise carbon sequestration.

## WOODY SPECIES COMPOSITION OF AFRICAN SAVANNAS AND DRY FORESTS

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### Background

Though savannas dominate the terrestrial tropics, harvest a substantial species diversity and are considered as a major resource for developing countries, there is however little information available on their floristics and biogeography, specifically in Africa.

### Aim

In this study we aimed to identify large-scale variation in woody species composition across tropical African savannas and dry forests, and determined the underlying environmental and historical factors.

### Methods

We report multivariate analysis of more than 200 samples describing the woody species composition of savanna vegetation across Africa. The samples extend from 18° N to 26° S and from 17° W to 48° E including 30 countries. The data were collated from published books and papers, the authors' personal data and a few websites.

### Main results

Correspondence analysis showed a clear differentiation in woody species composition in the north and west (Sudanian Region) from those in the east and south (Zambezian Region). The floristic transition between the two groups was in north eastern Africa (Uganda, Kenya, Ethiopia and Somalia) where the barrier of the equatorial forest zone does not intervene. Within each group, there was a strong floristic gradient related to annual rainfall.

### Conclusion

We examined the relationship between environment (climate, altitude, geology, soils) and the floristic groups to highlight possible determining influences. We propose a pan-African classification that might assist in the development of management and conservation policies.



## LAND USE AND ENVIRONMENTAL GRADIENTS DRIVE TURNOVER OF BIRD SPECIES IN MIOMBO ECOSYSTEMS

Janika Wendefeuer<sup>1</sup>, Friederike Richter<sup>1</sup>, Jens Oldeland<sup>1</sup>, Rasmus Revermann<sup>1</sup>, Manfred Finckh<sup>1</sup>

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The Okavango is one of Southern Africa's most emblematic river systems. On its way from the headwaters in the Angolan highlands to the Delta in Botswana the River follows an environmental gradient from dense Miombo Forests over *Baikiaea-Burkea* woodlands towards the Mopane and Thorn-bush Savannas in northern Botswana.

While a lot of ecological research has been done in the wetlands of the Okavango Delta, little is known about the woodland ecosystems of the Basin. Due to the long lasting civil war almost no research has been carried out in Angola for decades. With accelerating infrastructure development and landscape transformation over the last years, the lack of data regarding state and value of these ecosystems is concerning.

In order to assess the bird diversity as an indicator for the conservational value of these ecosystems, we studied bird communities of intact and degraded forests and woodlands at three research sites of the TFO-Project: Cusseque (Bie Province, central Angola), Caiundo (Cuando Cubango Province, South-eastern Angola) and Seronga (Ngamiland, Botswana). We aimed especially at (1) analysing the bird species turnover between Miombo forests, *Baikiaea-Burkea* woodlands and Mopane woodlands, (2) assessing the impact of forest fragmentation and degradation on bird communities within each research site. Therefore, we used an unsupervised classification to stratify for structural vegetation types and randomly placed ten points in each habitat type in order to conduct standardised bird point counts.

Highest species diversity was found in the Miombo forests. The biggest species overlap was detected between Miombo forests and *Baikiaea-Burkea* woodlands, the smallest overlap between Miombo forests and Mopane woodlands. These results show the strong environmental gradient along the Okavango. All three research core sites are subjected to land use changes. Within each core site we observed that the disturbance of habitats facilitated higher species diversity. This study thus supports the intermediate disturbance hypothesis for bird diversity in Miombo-ecosystems. However, the intact vegetation units host bird species that depend on near natural close-canopy structures. The gathered data can help for conservational action plans for these unique ecosystems.

## HUMAN AND WILDLIFE DISTURBANCE AFFECT VEGETATION STRUCTURE AND AVIAN DIVERSITY IN MOPANE WOODLANDS

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Landuse change is considered as a major threat to biodiversity. As biodiversity underpins ecosystem functioning and services, there is a growing interest in understanding its response to landuse change. The mopane is one of the important woodland ecosystems in the southern Africa. But, the biodiversity of these woodlands has received little attention. Many global level meta-analysis studies predict considerable losses of biodiversity, but do not have substantial representation from the mopane landscapes. Used to anthropogenic (logging and fire) and ecological (herbivory) disturbances, the biodiversity in these woodlands may be more resilient and follow different trajectories than expected from these studies. To add mopane context to the global biodiversity-landuse knowledge, the present study examines relationships between human and wildlife disturbance, woodland structure and diversity of birds.

Using the proportion of impacted stems as an indicator, we showed that human disturbance is linked to decrease in mean DBH and increase in densities of smaller stems (<10cm DBH) while wildlife disturbance is associated with higher mean DBH and lower stand densities. Both disturbances affected the presence of avian species differently. The wildlife disturbed areas contained equal number of species "losers" and "winners" and are related to the turnover of avian communities while human disturbed areas had more "losers" and showed evidence of nestedness. The analysis of functional traits revealed that there is no significant effect on functional richness, although functional evenness decreased in human disturbance. Functional composition differed significantly in response to both disturbances. On examining the traits individually, we found that the diet specialists and habitat generalists of smaller body size are more likely to occur in human disturbed woodlands while habitat and forage specialists, and species of bigger body size occur more commonly in wildlife affected woodlands.

Our findings indicate that the disturbance by humans and wildlife may lead to changes in structural composition of the mopane woodland and this may cause slow decrease in bird species richness and changes in species composition. The functional richness may not be affected although there may be transformation in functional composition.

**Merian Award Applicant**



## TREES SEIZING NEW LANDSCAPES - EVOLUTIONARY AVOIDANCE STRATEGIES OF ABIOTIC STRESSES ALLOWED TROPICAL FOREST TREE TAXA TO SURVIVE IN OPEN GRASSLANDS

Paulina Zigelski<sup>1</sup>, Barbara Rudolph<sup>1</sup>, Fernanda Lages<sup>2</sup>, Norbert Jürgens<sup>1</sup>, Manfred Finckh<sup>1</sup>

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The western part of today's Miombo region was strongly affected by the climatic changes at the Pliocene-Pleistocene boundary. Precipitation seasonality increased strongly, leading to the emergence of pronounced wet and dry seasons. Evergreen closed canopy forests disintegrated into a mosaic of open lands and dry forests.

In this changing environment tree species had to adapt. Options were either to retreat north into more humid regions, to specialize to humid extrazonal sites, or to go extinct. Yet the spreading grasslands, still mostly devoid of woody species, offered new evolutionary niches.

However, environmental conditions in the open plains were adverse as nocturnal frosts and episodic fires in the dry season would be fatal for many woody taxa from tropical families. But evading thermic stress by hiding vital parts underground allowed many taxa from different families to colonize these new tropical grassland environments. They maintained their woody character and translocated most of their biomass underground, as so called geoxylic suffrutices. As result of this evolutionary strategy, we find today many cases of suffrutex species in these grasslands which are closely related to tree species within the neighboring forests.

We selected one of these tree-suffrutex species pairs, the *Syzygium guineense* complex, to study the evolutionary steps out of the forest. By genotyping *Syzygium* populations from northern Namibia up to northern central Angola via haplotype and microsatellite analyses, we are able to trace back their adaptation steps.

Today's *Syzygium guineense* complex is the result of multiple evolutionary pathways which follow the above mentioned options. Thus, we assessed for the different phenotypic and genetic clusters which ecological factors have been the driving forces that led to their evolution. The answer is a complex interplay of environment and genetics as evolutionary adaptations have been facilitated by *Syzygium*'s polyploidy and phenotypic plasticity.

## IMPROVING THE DETECTION OF DISPERSAL LIMITATION IN PLANT COMMUNITIES

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Understanding the ecological processes structuring living communities is a central issue of community ecology and conservation biology. Accurate insights of community dynamics rely on a relevant characterisation of the abiotic environment, an explicit consideration of space, and the integration of dispersal limitation (DL). DL is a central process of species coexistence in tropical forests, and was shown to bias estimations of abiotic effects on species if not explicitly considered. Variation partitioning (VP), a spatially explicit method, allows decomposing the community composition variability into pure and covarying fractions of the environment and spatial components, thus assessing the relative contributions of environmental determinism and neutral processes to species distribution. However, the method still lacks a solid background for interpreting the fraction exclusively related to the spatial component, generally interpreted as resulting from DL or unmeasured abiotic parameters.

In this study, a novel method mixing the VP to null models of a cluster Poisson process was developed in order to explicitly account for DL in VP. We used tree community data of a 10-ha miombo forest (DRC) characterised by 32 soil parameters. Out of 24 studied species, 58% displayed significant soil-species associations ( $R^2$  ranging from 2 to 49%). Spatial structures were detected for half of the species, among which nine displayed a significant pure spatial fraction. This fraction was explained at 0 to 100% by DL, depending on species. Additionally, combining VP to null models revealed that the risk of wrongly detecting an environmental signal increased with the mean number of individuals within clusters (up to 12% depending on species). The study highlights (1) a highly variable role of DL in explaining the pure spatial fraction of variation, and (2) the necessity of integrating DL characteristics of species when using VP in order to avoid overestimating the environmental effect.

**Merian Award Applicant**



## SATELLITE MONITORING FOR FOREST MANAGEMENT (SMFM) PROJECT

William Apted<sup>1</sup>, Simone Vaccari<sup>1</sup>, Casey Ryan<sup>2</sup>

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Tropical dry forests are subject to some of the highest rates of deforestation and degradation. These ecosystems are particularly at risk due to their fragility and the high demand for forest goods/services required to support the livelihoods of large numbers of the world's poorest. Despite this, tropical dry forests are among the least studied ecosystems due to their lower economic value compared to moist forests. However, tropical dry forests cover some 2.7 million km<sup>2</sup> in Africa alone, and represent globally important carbon storage.

Forest degradation (FD) is a more significant cause of biomass/carbon loss than deforestation in many dry forest ecosystems. However, FD occurs at small-scale and at sub-canopy level, and its quantification from space is therefore challenging. As a result, FD is often under-reported, which is critical to quantify the economic, social and environmental value of the forest.

The World Bank (WB) developed the **Satellite Monitoring for Forest Management (SMFM)** project to develop satellite EO methods and global knowledge to address challenges related to monitoring changes in tropical dry forest ecosystems. The European Space Agency (ESA) is a key project partner & technical advisor, providing support in the form of data, tools, and technical support, with particular focus on Sentinel-1&2 data. LTS International Ltd. (LTS), in partnership with the University of Edinburgh, has been selected to carry out this work, targeted in Mozambique, Zambia and a third, yet unknown, country.

The first aim is to improve **global knowledge and capabilities** for FD assessment and monitoring dry forest areas by building upon and working with existing international programs. Secondly, the SMFM project will support selected countries to develop their EO capacity. It will develop and test new/improved methods to process and analyse satellite datasets, including assessments of processing methods through practical implementation in the selected partner countries.

## MIOMBO NETWORK OF SOUTHERN AFRICA: A PLATFORM FOR COLLABORATIVE RESEARCH FOR DECISION-MAKING ON RESTORING MIOMBO WOODLANDS

Natasha Ribeiro<sup>1</sup>

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The miombo woodlands cover 2.7 million km<sup>2</sup> across seven countries (DRC, Angola, Zambia, Malawi, Zimbabwe, Tanzania and Mozambique) in southern Africa. The socio-ecological relationships established in miombo are unique and are key to sustain the ecosystem and livelihoods in the region. Maintaining these relationships is a challenge in the current context of accelerated human population growth coupled with economic development, which impose rapid land cover changes in miombo.



The Miombo Network (MN) is the oldest regional network in southern Africa that fosters collaborative efforts in land cover monitoring and management in the miombo woodlands of southern Africa. The Network's goal is to achieve effective and appropriate management policies and practices in the region through the use of field-based approaches, remote sensing and other geospatial information technology. The role of the MN is to provide science-based evidence for decision making in the region. This communication presents the results from the last MN meeting held in July 2016 in Maputo, Mozambique. The meeting congregated more than 90 people from academia, private, government, non-government sectors in the region and abroad.

The outputs of the meeting clearly indicate the need to leverage high quality and harmonized research in the region to better understand the socio-ecological relationships and restore the ecosystem. In general it was agreed that some socio-ecological processes are relatively well known such as the impacts of shifting cultivation, fires, selective logging and charcoal production. However, some gaps were identified namely: understanding of the current levels of degradation, resiliency of the woodlands after disturbances and appropriated restoration models for miombo. It is recognized that the MN has a major role in producing high quality knowledge and informing management actions and practices. Some flagships projects identified are: (i) analysis of the legal framework within the miombo region in order to define common issues among countries; and (ii) develop a restoration strategy for the region, which includes geospatial analysis of miombo degradation, identification of restoration models and priorities per country and land cover type and identification of implementation strategies.



# SESSION 3

## GENE FLOW IN THE TROPICS

Chairs:

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Gene flow is a major influencing factor of species population dynamics and evolution. In addition to morphological and ecological data, characterizing gene flow provides important information on species' genetic diversity, spatial demographic dynamics, and inter-specific permeability (hybridisation). This information is thus necessary to understand a species' evolutionary history and estimate its current conservation status, which in turn allows deducing its future evolution and implementing management strategies.

In this symposium we welcome contributions focusing on intra- and inter-specific gene flow in tropical species and its implications on species history, integrity and survival.

S03-001 - GENE FLOW IN THE TROPICS

### HIGH SELFING RATE, LIMITED POLLEN DISPERSAL AND INBREEDING DEPRESSION IN THE EMBLEMATIC AFRICAN RAIN FOREST TREE *BAILLONELLA TOXISPERMA*

Jérôme Duminil<sup>1,2,3</sup>, David Mendene Abessolo<sup>2,4</sup>, Dyana Ndiade Bourobou<sup>5</sup>, Jean-Louis Doucet<sup>6</sup>, Judy Loo<sup>7</sup>, Olivier J. Hardy<sup>3</sup>

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Mating system and gene flow are major influencing factors of species population dynamics and evolution. These factors are often not characterized in tropical tree species, yet they constitute basic information that must be considered to implement sustainable management practices. In particular, as logging implies a reduction of the density of congeneric mates, the connectivity through pollination between individuals has to be well characterized (selfing versus outcrossing rates, distances between mates).

We conducted a genetic-based analysis (using 10 nuclear microsatellites) to determine the mating system and gene flow characteristics of an emblematic timber tree species from lowland rain forests of the Congo Basin, *Baillonella toxisperma* (Sapotaceae). The species, which is frequently exploited for its wood and for a number of non-timber forest products, naturally occurs at low densities (ca. 0.01-0.1 individuals/ha). It is supposedly an entomophilous species whose seeds are probably dispersed by mammals.

We have shown that the species presents a mixed-mating system (about 20 to 40% of selfing depending on analysis method). However, the comparison of inbreeding parameters among cohorts suggests that inbred individuals die between seedling and mature tree stages. The mean pollen dispersal distance was relatively low for such a low-density population species (estimated to be 690 or 777 meters depending on analysis method) and, together with a low mean number of pollen donors ( $NEP = 2.76$ ), it suggests a pattern of nearest-neighbour mating where allo-pollen could be a limiting factor. However, *B. toxisperma* presents a relatively weak genetic structure ( $S_p$  statistic = 0.0095) indicative of long gene dispersal distance ( $sg = 3$  to 5 km according to the assumed effective population density). Overall, this would indicate that gene flow occurs mainly by extensive seed dispersal in this species. These results suggest that mammals and local populations involved in the dispersal of the species play a key role by lowering biparental inbreeding effects. Sustainable population management might require assisted regeneration using unrelated planting material.



## GENES FLOW PATTERNS IN RAINFOREST TREES SPECIES OF THE GENUS *ENTANDROPHRAGMA* (MELIACEAE) INFERRED FROM INDIRECT AND DIRECT ANALYSES

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### Background

Understanding patterns of gene flow of rainforest species is a key requirement for implementing species management and conservation in light of global changes. Pollen and seed dispersal are key processes affecting the demographic and evolutionary dynamics of plant species. Limiting gene flow can lead to reduced effective population sizes which, in turn, can cause serious inbreeding depression in plant species, especially in trees. We studied through direct and indirect genetic analyse the mating

system, the extent of pollen and seed dispersal for insect-pollinated and wind-dispersed timber species in two species of the African genus *Entandrophragma* (Meliaceae).

### Method

For the two species, *E. cylindricum* and *E. utile*, we sampled and genotyped (using nuclear microsatellite markers), adult trees, seeds and saplings, in 400-ha and 900-ha study plot respectively and along four forest trails extending outward the plot in a natural forest from East Cameroon.

### Result

*Entandrophragma cylindricum* is mainly outcrossed ( $t = 0.925$ ) and seeds from the same fruit are usually pollinated by the same father (correlated paternity,  $rp = 0.77$ ). An average of 4.76 effective pollen donors (Nep) per seed tree contributes to the pollination. Seed dispersal was as extensive as pollen dispersal: mean dispersal distance in the study plot approached 600 m. Gene's dispersal in *E. utile* was highly efficient and immigration rates from outside the plot was high for both pollen and seeds in two species.

### Discussion & Conclusion

Extensive pollen- and seed-mediated gene flow is further supported by the weak fine-scale spatial genetic structure (Sp statistic = 0.0058), corresponding to gene dispersal distances ( $\sigma_g$ ) reaching c. 1500 m in *E. cylindricum*. In *E. utile*, effective genes dispersal distance can be explain by the lower density. Generally, the average distance of gene dispersal increased with decreasing density.

## HYBRIDIZATION AND ASYMMETRIC INTROGRESSION AFTER SECONDARY CONTACT IN TWO TROPICAL AFRICAN CLIMBER SPECIES

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Interspecific hybridization is frequently observed between closely related plant species with overlapping distribution ranges, especially in zones of secondary contact after isolation in different refugia. Although well studied in temperate regions, interspecific hybridization is little documented in tropical regions while it may be frequent in high species diversity areas. To bridge this gap, we investigate hybridization in two closely related climber species from the genus *Haumania* (*Haumania danckelmaniana* and *H. liebrechtsiana*) originating from Gabon/Cameroon and the Democratic Republic of Congo, respectively, and co-occurring in Northern Gabon. The aim of this study was to genetically quantify and qualify the degree of hybridization between these species in their area of distributional overlap by including for the first time morphological intermediates.



We investigated 265 individuals from nine sites (seven sites containing both species) by genotyping seven microsatellites and sequencing one chloroplastic region (*trnC-petN<sub>1</sub>r*). Bayesian clustering analysis and simulated genotypes allowed the assignation of sampled genotypes to one or the other species or their intermediates (first generation hybrid or backcrosses). We found 13% and 41% of intermediates based on morphological versus genetic data, respectively, indicating only a partial congruence. There was an equal amount of backcrosses to both parental species (15%). However, a comparison at local scale of microsatellites and cpDNA sequence data revealed a unidirectional introgression from *H. liebrechtsiana* into *H. danckelmaniana*. At the scale of the nine sites, genetic differentiation was much lower among *H. liebrechtsiana* than among *H. danckelmaniana* populations.

These results are in line with the previously proposed phylogeographic scenario for the genus *Haumania* and the theoretical expectation of chloroplast capture when an expanding species (here *H. liebrechtsiana*) invades the range of a local species (here *H. danckelmaniana*). As the forest flora of Central Africa has undergone repeated cycles of fragmentation and expansion following past climate changes, we expect that similar scenarios of hybridization after secondary contact may be common.



## REVEALING UNIDIRECTIONAL INTROGRESSION IN THE WEST AFRICAN CONTACT ZONE OF THE TIMBER GENUS *MILICIA*

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DNA-based techniques are particularly appropriate to assess interspecific hybridization patterns in long-living plant taxa such as tropical tree species. As different types of markers may reveal various patterns, the combination of several methodologies and types of markers is highly recommended for such a purpose. We used different analytical tools (the haploweb approach based on the identification of fields for recombination, and algorithms that are able to separate purebreds from hybrids) and three types of genetic markers (nuclear SSRs, SNPs and a gene region) to revisit hybridization patterns in the African timber tree genus *Milicia*.

Samples were collected in the natural range of *M. regia* and *M. excelsa* in West Africa. Based on simulated genotypes containing purebreds and hybrids, and the real datasets, the results from the SNPs were more consistent than those from the SSRs: outputs from the different Bayesian programs significantly differed with the SSRs whereas they were perfectly congruent with the SNPs. A proportion of 12.4% hybrids was detected in the samples of SNP genotypes. A haploweb derived from a haplotype network constructed on the gene sequence *At103* confirmed the existence of interspecific hybrids. There was also a clear evidence of advanced generations of hybrids (backcrossed individuals) but only towards *M. regia*. Although more investigation is required for understanding mechanisms of this asymmetric introgression, this introgression would be due to a delay in flowering time between species as well as between sexes, combined with a maternal inheritance of flowering time. Although the substantial proportion of interspecific hybrids and introgressed samples may question the existence of two distinct species of *Milicia* in West Africa, other findings and observations (the delay in species specific flowering phenology, introgression in only one direction) tend to reject the assumption of a unique species at this time.

## GENETIC STRUCTURE OF *AVICENNIA MARINA* IN THE WESTERN INDIAN OCEAN: AN UNEXPECTED GENETIC BREAK

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The need for an improved understanding of the genetic structure and explanatory processes has been raised recently for mangroves, which constitute a very characteristic intertidal vegetation along tropical and subtropical coastlines worldwide and are among the most carbon-rich tropical forests. Despite their importance in coastal protection, and the wide variety of socio-economical services they provide, loss and fragmentation due to excessive exploitation and development have reduced global mangrove area with nearly 20% between 1980 and 2005 and the trend has not been halted.

Our study, which we will present and discuss in our conference presentation, aims at linking mangrove history and ocean surface circulation patterns to the genetic composition of the mangrove *Avicennia marina*, a major constituent of the mangrove forests in the Western Indian Ocean (WIO). Therefore, we selected 31 mangrove sites (1128 individuals) along the East African coastline and among islands in the WIO for genetic analysis with 8 nuclear microsatellite and 2 chloroplast sequences. This provides an unprecedented opportunity to better understand patterns of connectivity throughout this region.

The WIO was deliberately chosen because of the complex Ocean surface current patterns (e.g. large Ocean currents and Eddies) in this region and the lack of a large biogeographical genetic study on *Avicennia marina* (but also mangroves in general) as well as the reported ecological and socio-economical importance of mangroves and the long-term survival of mangroves that is being threatened through human encroachment in this region.

Teaser: One unexpected result is the clear genetic break between the Seychelles plus East-Madagascar populations and all other populations for both the microsatellite and chloroplast markers. This genetic break, together with the extremely high observed inbreeding levels in the main Seychelles populations on Mahé and Curieuse islands and no or very little gene flow between other regions suggest that these island populations have a different history.

The wide range of *Avicennia marina*, including many remote oceanic islands, indeed suggests a very high dispersal potential and hence reduction of marked genetic structure amongst populations. The complex oceanic current systems in the past as well as present, particularly in the WIO region, may be an explanation for the peculiar features of the genetic structure in the range of this mangrove tree species.





# SESSION 4

## TROPICAL FRESHWATER MICROHABITATS

### Chairs:

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When asked about freshwater in the tropics, most people think about flooding rivers, large wetlands, lagoons and oxbow lakes. However, few would think about aquatic microhabitats that can hold water permanently or periodically. Isolated rocks and mountains such as tepuis can contain cracks and depressions that house unique endemics. Temporary wetlands can house special groups freshwater organisms adapted to survive drought in situ. In terms of micro-arthropods, few habitats are more diverse than the semi aquatic habitats of moss patches. There is also an abundance of freshwater and associated diversity present in the canopy of tropical forests in water filled tree holes and plants such as pitcher plants and bromeliads. These habitats are widespread and can be very abundant, both inside pristine forests as well as on the outskirts of human settlements and even in city centers. More and more researchers are focusing on these understudied systems trying to understand their value for biodiversity conservation, their suitability as model systems in ecology and evolutionary biology, their contribution to ecosystem services as well as the potential dangers associated with disease vectors developing inside.

In this session we provide a platform for researchers that study different aspects of these ecosystems to meet and share novel insights about the functioning of these ecosystems, their broader importance for society and likely responses to changes in climatic conditions.

## MICROFAUNA BETA DIVERSITY IN BRAZILIAN TANK BROMELIADS

Annika Busse<sup>1</sup>, Pablo A. P. Antiqueira<sup>2</sup>, Alexandre Neutzling<sup>2</sup>, Anna M. Wolf<sup>3</sup>, Gustavo Q. Romero<sup>2</sup>, Jana S. Petermann<sup>1</sup>

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Freshwater microhabitats such as phytotelms (i.e. plant-held waters) are increasingly used for answering ecological questions because they provide excellent study systems with comparatively easy access, low complexity and high replicability. Tropical tank bromeliads are an excellent example of this habitat as they can occur in high densities and contain a considerable amount of water. Complex multitrophic food webs develop between the bromeliad leaf axils, which have been shown to be based on light availability and nutrients from leaf litter. Depending on the location of the bromeliad with respect to forest canopy cover, light and nutrient availability can vary considerably. This may influence the species survival and abundances and thus may lead to differences in community composition on a relatively small spatial scale.

We collected microfauna samples from 78 bromeliads along a canopy cover gradient in one site in Brazil and examined the differences in community composition and beta diversity with respect to changing environmental factors including pH, oxygen concentration and temperature fluctuations.

Our results show that microfauna community composition changes along the canopy cover gradient and that daily temperature fluctuations are a crucial factor. These changes are the result of species loss instead of species replacement along the gradient.

This deepening of our understanding of patterns in beta diversity helps us to improve conservation strategies and to preserve diversity more efficiently.



## PREY CATCH SELECTIVITY AND PITCHER INFAUNAL COMMUNITY COMPOSITION IN TWO NEPENTHES SPECIES IN PENINSULAR MALAYSIA

Celina Tawes Ben Saadi<sup>1</sup>, Jamilah Mohd. Salim/Halim<sup>1</sup>, Bram Vanschoenwinkel<sup>1</sup>

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Pitcher plants of the genus *Nepenthes* are iconic organisms that capture the fascination of many. Lack of nutrients in poor soils has ensured that these plants started to digest animals that get trapped in water bodies contained in their leaves. Much work has been done describing the prey content of different pitcher plant species and different pitcher types within species. However, these studies were mainly field surveys and lab experiments rather than manipulative experiments in the field that combine realism with control.

Manipulating position of pitchers via transplants in combination with artificial pitchers can help us to answer why different pitcher types of different species catch different prey. In addition, virtually all studies have focused on the prey composition rather than on the aquatic animals that manage to live inside the pitchers without getting digested. Finally, the selectivity of pitchers to catch different types of prey should be assessed by contrasting prey composition with the relative abundances of potential prey in the environment.

The study area was located in Jambu Bongkok, Peninsular Malaysia. In general, the main goal was to study the attraction of prey and infauna in pitcher plants by disentangling the relative importance of pitcher traits and pitcher position (ground or aerial level) in explaining prey catch and infaunal aquatic invertebrate community. We did this for two species -*Nepenthes gracilis* and *N. rafflesiana*. The former has similar pitchers that only differ in position while the latter has morphologically dissimilar pitchers located at different positions.

Our results showed that *Nepenthes* pitchers use attraction cues to selectively attract prey and infaunal organisms and are therefore not merely passive traps. We confirmed that *N. rafflesiana* aerial pitchers were the most conspicuous for winged prey. Position was only found to influence winged prey catch in ground pitchers. In addition, the habitat dimension *i.e.* pitcher size and volume, and nutrient source *i.e.* trapped prey, were found to explain infaunal community structure.

## CLIMATIC CONTROL OF DIVERSITY IN FRESHWATER MICROHABITATS - FROM HYDROLOGY TO BIOGEOGRAPHY

Bram Vanschoenwinkel<sup>1</sup>, Tom Pinceel<sup>2</sup>, Luc Brendonck<sup>2</sup>, Falko Buschke<sup>3</sup>

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Correlations between climate and diversity have been commonly reported in ecological and biogeographical literature since the second half of the 19<sup>th</sup> century. While patterns are easy enough to find, pinpointing the underlying mechanisms remains challenging until this very day. In aquatic habitats, climate has a number of direct and indirect effects on biota predominantly mediated by temperature and precipitation. In smaller aquatic habitats water level fluctuations and regular drying are one of the most stringent selective filters that modulate the composition of communities.



Here I will show how reconstructions of hydrology can help to understand patterns of species coexistence in small aquatic habitats and help to parameterize demographic models to better predict the effects of climate change on biota. I will use examples from field studies in subtropical African and Australian rock pool clusters and Neotropical tank bromeliads to illustrate how hydrology can emerge as a dominant driver of both local intra-metacommunity and regional inter-metacommunity variation in species distributions. Finally, I will present some ideas and preliminary results on how we can reconstruct future hydrologies under different climate change scenarios and model species responses.



## MACROINVERTEBRATE ASSEMBLAGES AND ITS RELATIONSHIP WITH PHYSICOCHEMICAL FACTORS IN COLOMBIAN GUYANA SHIELD TEMPORARY ROCK POOLS

Ángela Aristizábal-Botero<sup>1</sup>, Juan Carlos Quijano-Tristancho<sup>1</sup>, Manuel R Astudillo-Aldana<sup>2</sup>, Rodolfo Novelo-Gutiérrez<sup>2</sup>, Emilio Realpe<sup>1</sup>

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This study constitutes the first report of macroinvertebrates diversity in temporary rock pools of Colombian Guyana Shield, and presents an analysis about the relationship between physical and chemical characteristics of water with habitat characteristics of macroinvertebrates. We attempt to identify the main abiotic factors that influence composition and abundance of assemblages in two rocks (*Karikari* and *Cerro Morrocoy*) using a general linear model and cluster analysis. These rocks are separated by eight kilometers of savanna and small areas of gallery forest within the *Bojonawi* Natural Reserve. The study areas were visited at the end of the rainy season where we collected samples that allowed us to estimate the composition of communities and the relative abundance of major taxonomic groups of macroinvertebrates present in these pools: Diptera, Hemiptera, Diplostraca, Nematoda, Coleoptera, Anomopoda and Odonata. The effective number of species  $D$  and the Shannon exponential  $1D$  of diversity will be calculated to analyze  $\alpha$  and  $\beta$ -diversities in the study area. Moreover, we are testing the sampling efficiency using species accumulation curves; and finally we will explore the relationship of genera abundance with the physical and chemical characteristics of water variables performing a canonical correspondence analysis, verified with a Monte Carlo permutation test.

## MICROCRUSTACEAN ASSEMBLAGES FROM GROUNDWATER-DEPENDENT ECOSYSTEMS IN LUZON AND MINDORO ISLANDS (PHILIPPINES): INSIGHTS TO TROPICAL GROUNDWATER ECOLOGY

Mark Louie Lopez<sup>1</sup>, Francis Magbanua<sup>1</sup>, Augustus Mamaril<sup>1</sup>, Rey Donne Papa<sup>1</sup>

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In the Philippines, the ecology of microcrustaceans from ground waters and its dependent ecosystems remain poorly understood, yet knowledge of this group is important to know patterns in groundwater biodiversity to develop sound conservation policies. In this study, microcrustaceans were studied by collecting samples from 102 groundwater-dependent ecosystems, including 51 artesian wells, 23 caves, 14 springs, and 14 piped groundwater pumps during the dry (Nov 2014-April 2015) and wet seasons (May-October 2015).



Results indicate the presence of 21 species from Cladocera and Copepoda including 2 stygobiotic and 19 non-stygobiotic taxa. Significant differences in microcrustacean assemblages were noted among types of groundwater-dependent ecosystem ( $P < 0.05$ ), while there are no significant variations observed between seasons ( $P > 0.05$ ). Furthermore, PCA analysis revealed that sampling sites are highly characterized by altitude, specific conductivity, and total water hardness. Microcrustacean assemblages in sampled sites are highly dominated by the influence of temperature, dissolved oxygen, and altitude. Results revealed low species richness in sampled sites within the region supporting existing notion that temperate groundwater-dependent ecosystems were more diverse and faunal composition in terms of ecological groups is extremely different in tropical and temperate setting.





# SESSION 5

## SPECIES DELINEATION IN THE TROPICS

Chairs:

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Olivier J. HARDY, ohardy@ulb.ac.be

Most tropical ecosystems are characterized by a huge biodiversity that is presently endangered in many countries, hence the need for rapid, accurate and effective ways to document the biodiversity of tropical environments. Besides, proper species delimitation is a prerequisite to population genetic or ecological studies of tropical organisms, and failure to identify true species boundaries due to confounding factors such as phenotypic plasticity, morphological convergence, morphological stasis or interspecific hybridization can wreak havoc on otherwise exquisitely well-designed projects.

This session welcomes morphology-based as well as DNA-based studies aimed at overcoming these problems; species delineation studies integrating several sources of information (ecology, genetics, morphology, physiology...) are especially encouraged.

## ARE THERE MANY CRYPTIC PLANT SPECIES IN THE TROPICS? NEW INSIGHTS FROM POPULATION GENETICS APPROACHES APPLIED ON AFRICAN FOREST TREES

Olivier J. Hardy<sup>1</sup>, Kasso Daïnou<sup>1,2</sup>, Armel Donkpegan<sup>1,3</sup>, Jérôme Duminil<sup>1,4</sup>, Eben-Ezer Ewedjé<sup>1,5</sup>, Davy Ulrich Ikabanga<sup>1,6</sup>, Brandet-Junior Lissambou<sup>1,6</sup>, Rosalía Piñeiro<sup>1,7</sup>

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Tropical forests are renowned for hosting a remarkable diversity but the estimation of their species richness depends on the species concept used for their delimitation. Plant taxonomy is essentially based on morphological characters and the outcome of species delimitation can vary according to the 'splitter' versus 'lumper' tendency of taxonomists. Moreover, speciation may sometimes occur without significant morphological changes, leading to the occurrence of cryptic species. Hence, species richness can be underestimated by the occurrence of cryptic species or overestimated by taxonomical oversplitting.



Phylogenetic approaches are increasingly used to help decipher species delimitation. However, reciprocal monophyly at gene trees requires that the number of generations since speciation largely exceeds the effective population sizes of the sister species. Alternatively, population genetics methods allow to assess reproductive isolation, which is at the basis of the 'biological species concept'.

Using the latter species concept, we relied on large-scale genotyping using nuclear microsatellite markers to evaluate species delimitation in several African tree taxa (e.g. *Azelia*, *Carapa*, *Erythrophleum*, *Greenwayodendron*, *Lophira*, *Milicia*, *Santiria*). To this end, we considered that distinct species can be recognized when well differentiated genetic clusters occur in sympatry.

Main results: (i) We found no case of oversplitting: even when phenotypically very similar, species distinguished by taxonomists formed distinct genetic clusters, although some genetic introgression was occasionally detected. (ii) By contrast, we found several examples of taxonomical species made of several sympatric genetic clusters, indicating that cryptic species are not uncommon. (iii) Interestingly, a re-examination of morphological



traits associated to each genetic cluster can reveal diagnostic characters. Hence, taxonomy can greatly benefit from population genetics approaches to resolve species complexes, although the biological species concept has also its own limitations. (iv) In some cases, large-scale genotyping showed that the documented geographical distributions of species were erroneous due to the confusion between similar species in parts of their ranges. (v) Finally, we found that markers from the chloroplast genome were not always reliable to distinguish closely related species, limiting the usefulness of plastid-based DNA barcodes

## SPECIES IDENTIFICATION AND SEPARATION BASED ON CHEMOTYPES USING DART-TOFMS

Victor Deklerck<sup>1</sup>, Hans Beeckman<sup>2</sup>, Maaïke De Ridder<sup>2</sup>, Pamela J. McClure<sup>3</sup>, Nils Bourland<sup>2</sup>, Jan Van den Bulcke<sup>1</sup>, Joris Van Acker<sup>1</sup>, Edgard O. Espinoza<sup>3</sup>

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Species identification of traded timber is one of the main challenges faced in combating illegal logging. Correct identification of CITES species is key to enforce legal timber trade and to encourage sustainable forestry. A number of techniques are therefore being used by customs for wood identification. For example, wood anatomy and DNA-analyses are but two of commonly employed methods.



Wood anatomy is, however, often insufficient to distinguish on the species level. DNA-analyses are not straightforward to perform, a.o. because of degraded or ancient DNA. However, metabolites are largely under genetic control, hence analysing metabolites may provide a cheap and easy way to identify species. More specifically, Direct Analysis in Real Time (DART) Time-Of-Flight Mass Spectrometer (TOFMS) uses metabolites for wood identification and chemotyping of timber species. This technique can assist in identifying and separating the African timber species *Pericopsis elata* (Harms) Meeuwen from its timber lookalikes.

In DART-TOFMS analysis, heartwood slivers are positioned in a stream of heated helium gas produced by the ion source, resulting in the emission of compounds (ions) from the wood. This allows chemical fingerprinting based on metabolites of the species. A species-distinction can be made based on the intensity of different ions using Kernel Discriminant Analysis or decision trees (Random Forest algorithm). We show that species within one genus from different continents can share a very similar chemical fingerprint but are still distinguishable based on small variations in ion-intensity. DART-TOFMS can be used to identify and distinguish several look-a-like species, thus helping to safeguard the biodiversity in tropical ecosystems by assisting customs to identify illegal logged species.



## PHYLOGEOGRAPHIC AND PHYLOGENETIC ANALYSES ON THE SAND TERMITE *PSAMMOTERMES ALLOCERUS SILVESTRI* 1908 IN NAMIB DESERT FAIRY CIRCLES OF SOUTHERN AFRICA

Felicitas Gunter<sup>1</sup>, Barbara Rudolph<sup>1</sup>, Norbert Jürgens<sup>1</sup>

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At the eastern margin of the Namib Desert several hotspots of fairy circles occur along a corridor from north to south within an isohyet of 50 to 200 mm. The fairy circles are generated and maintained by the sand termite (*Psammotermes allocerus*). The sand termite forages on grasses primarily within the bare patch later also in the matrix vegetation. However, *Psammotermes allocerus* also occurs in more humid regions east of the fairy circle hotspots.

Hitherto, the biology of *P. allocerus* was understudied especially with regard to its reproductive system, colony structure and foraging behavior.

We investigated the taxonomic position of fairy circle termites and non-fairy circle termites within the Isoptera by sequencing the two mitochondrial genes COII and CYB and performing geometric morphometric analyses.

Furthermore, we studied the genetic similarity of termites within clusters of neighbouring fairy circles within and between several hotspots using amplified fragment length analysis.

Our data suggest that the former species *P. allocerus* should be regarded as a species aggregate containing several genetically and morphologically delineated taxa. The origin and position of *P. allocerus* within the phylogenetic tree, the results of the haplotype analyses as well as the genetic structure and diversity within and between *P. allocerus* populations will be presented and discussed in detail.

### Merian Award Applicant

## POPULATION HISTORY AND SPECIES DELIMITATION OF THE ENDEMIC GENUS *LOPHIRA* FROM TROPICAL AFRICA

Eben-Ezer B.K. Ewédjè<sup>1,2</sup>, Guillaume Koffi<sup>1,3</sup>, Adrien Staquet<sup>1</sup>, Rosalia Piñeiro<sup>1,4,5</sup>, Kasso Dainou<sup>1,6</sup>, Achille B Biwolé<sup>6</sup>, Jean-Louis Doucet<sup>6</sup>, Olivier J. Hardy<sup>1</sup>

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Species is an essential concept in all biological disciplines, mostly for understanding of biodiversity and evolution. However, defining species boundaries objectively and consistently remains a challenge, especially for widespread plants occurring across forest-savanna ecotone. Whether past forest fragmentation and ecological gradients are the two main drivers of genetic differentiation of African tropical forest species, their respective roles remain unclear. In this study, multilocus genotypic data were used to determine species boundaries and introgression levels in the widespread tree genus *Lophira* (Ochnaceae), which includes two related species adapted to contrasted habitats in the Guineo-Congolian domain where rainforests and savannas are close together from Western to Central Africa. A total of 790 individuals from 11 populations of both species were genotyped for genetic analyses (diversity, correlation of gene pools divergence with taxonomic delimitation, differentiation and spatial genetic structure, and introgression in their contact zone), using ten polymorphic nuclear loci.



Trees exhibited a high level of genetic diversity ( $A = 8.05$ ,  $H_e = 0.51$  for *L. alata* and  $A = 7.85$ ,  $H_e = 0.45$  for *L. lanceolata*). *Lophira* spp. displayed substantial differentiation among *L. lanceolata* and *L. alata* consistently with taxonomic delimitation ( $F_{ST} = 0.38$  and  $R_{ST} = 0.48$ ) with a phylogeographic signal ( $R_{ST}$  significantly larger than  $F_{ST}$ ,  $p = 0.02$ ), although they can occasionally hybridize but without leaving clear evidence of introgression. While a single gene pool was detected within *L. lanceolata* throughout its Sudanian savanna distribution, *L. alata* displayed two deeply differentiated gene pools ( $F_{ST} = 0.33$  and  $R_{ST} = 0.47$ ) supporting historical events of past forest fragmentation. The significant phylogeographic signal between both clusters from which one was endemic to Western Gabon, suggested the occurrence of a cryptic species within this taxon.



## SPECIES DELIMITATION IN THE AFRICAN TREES OF THE GENUS *Khaya* - WHEN GENETIC MARKERS HELP TAXONOMY

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The sustainable management and conservation of biodiversity require reliable species delimitation. However, in tropical forests, species delimitation is a recurrent problem. This is the case in the African trees of the genus *Khaya* (African mahogany, Meliaceae), whose delimitation varied widely since the publication of the first species. Currently, the online database of the Conservatory and Botanical Garden of the city of Geneva (CJBG) retains only five species, considering *Khaya nyasica* and *K. anthotheca* as synonyms while Styles & White (1991) recognize them as distinct species. We are thus far from a stable taxonomy of the genus. In particular, *K. anthotheca* sensu lato might contain several species morphologically very similar.

By combining a classical herbarium-based taxonomic study with the genotyping of hundreds of samples using nuclear and cytoplasmic genetic markers (SNPs), we propose a taxonomic revision of the genus *Khaya*. Nuclear SNPs allowed us to distinguish genetic groups matching well the currently recognized *Khaya* species, except that at least four genetic groups, sometimes found in sympatry, could also be recognized within *K. anthotheca* sensu lato. These groups were also supported by subtle diagnostic morphological characters, so that we argue that they should be considered as distinct species. These results are particularly important in view of the logging pressure because some of these near-cryptic species could be endangered by overexploitation of African mahoganies.

## SPECIES AND SPECIATION IN LAKE TANGANYIKA: AN OSTRACOD PERSPECTIVE

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Most lakes on the planet are very young and there are only about a dozen truly ancient lakes lying in active rift valleys. The rift widens and deepens at a faster rate than the rate of sedimentation, and thus lakes can become old and deep. Because of their high biodiversity and large number of endemics, ancient lakes are natural laboratories for evolutionary research. Lake Tanganyika in the East African rift valley is 9-12 Myr old and c 1.5 km deep.



Ostracods, small bivalved crustaceans, form a significant part of the endemic, benthic fauna in ancient lakes. Up to 95% of ostracods are endemic to Lake Tanganyika. One of the major ostracod radiations in Lake Tanganyika is the Cyprideis flock, which currently holds ca. 25 endemic morphospecies in 6 genera. Here, we show from phylogenetic reconstructions that this species flock is polyphyletic, probably owing to multiple invasions and independent radiations. We estimate the age of the Cyprideis flock to be c. 15 myr, older than the lake itself. This ostracod species flock thus must have been able to survive drastic changes in lake level and salinity during the entire history of Lake Tanganyika.

Endemic ostracod diversity of Lake Tanganyika is probably even higher than previously thought, owing to the existence of cryptic species. We present a genetic study of two closely related endemic *Romecytheridea* species from different populations in the southern part of Lake Tanganyika, testing for the existence of cryptic species and the factors that could further increase biodiversity in ancient lakes.



## SURVEY OF *DALBERGIA* SPS. IN VIETNAM FOR IDENTIFYING *D. OLIVERI* FROM A COMPLEX SPECIES FOR CONSERVATION

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Vietnamese *Dalbergia oliveri* or Cẩm Lai Bông (vernacular name) is native to Vietnam and found in dense tropical evergreen or semi-deciduous forest. The species is a quite valuable timber in SE Asia and in the Indochina region. It is currently listed in the IUCN Red List (A1cd) and meets the criteria for CITES category II B since it is at risk of extinction due to illegal logging and deforestation. However, the identification of this species remains problematic until now, hindering its conservation. The aim of this study was therefore to apply morphology-based and DNA-based methods to try to overcome this problem.

We completed a taxonomic revision of the *D. oliveri* species complex. Morphological analyses and sequences of ITS region and *matK* gene are used to describe a newly revised taxon (commonly known as the Cẩm Lai) and redefine *D. oliveri*. The morphological and molecular data indicate that *D. oliveri* is distributed on the provinces of Ninh Thuan (NT), Binh Thuan (BT), Lam Dong (LD) and Dong Nai (DN, Bien Hoa). The newly revised species is endemic to Vietnam and restricted to the central mountains of Kontum (KT), Gia Lai (GL), and Dak Lak (DL).

Our data demonstrate that there is no support for the separation of *D. oliveri*, *D. mammosa* (Cẩm Lai Vú) and *D. bariensis* (Cẩm Lai Bà Rịa).

Genetic data based on 28 microsatellite markers (in 8 multiplex-sets) also indicate that *D. bariensis* is part of the *D. oliveri* species group and does not bring any support to the distinction between *D. mammosa* and *D. oliveri*. A diagnostic key for *Dalbergia* with a description of a new-revised species is presented.

## HAPLOWEBS: AN ALLELE SHARING-BASED APPROACH TO SPECIES DELIMITATION

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A prerequisite to studying the biodiversity and functioning of tropical ecosystems is to delineate species boundaries, thereby partitioning the set of organisms inhabiting each ecosystem into discrete species entities. Because the morphology of tropical species can be highly plastic in response to their environment, molecular delimitation approaches based on DNA sequencing have become the methods of choice in such studies, either alone or in conjunction with morphological and/or ecological data.



A great diversity of molecular approaches to species delimitation have been proposed that are either based on genetic distances, on phylogenetic trees or on allele sharing. Here I present a graphical, allele sharing-based approach called “haplowebs”, and illustrate its monolocus as well as multilocus implementations using examples of tropical animals (corals, primates) and plants (tropical forest trees).



## CRYPTIC SPECIES DIVERSITY IN THE TREE GENUS *MILICIA*: AN ASSESSMENT BASED ON NUCLEAR SNPS, SSRS AND A DNA SEQUENCE

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Scientists face challenges when delimiting species in closely related plant taxa: morphological differences do not always reflect genetic boundaries, whereas plastid sequences are highly used for this purpose but are not appropriate when paralogy exists in the complex of taxa. Here we revisited species delimitation in the African genus *Milicia*, currently divided into *M. regia* (West Africa) and *M. excelsa* (from West to East Africa). We genotyped SNP and SSR loci and sequenced a nuclear gene, *At103*, in individuals collected across the range of *Milicia*.

West African *M. regia*, West African and East African *M. excelsa* samples constituted three distinct genetic clusters according to SNPs and SSRs. In Central Africa, two genetic clusters were consistently inferred by both types of markers. Curiously, some Central African samples grouped in three populations exhibited leaf traits of *M. regia* and were assigned to the West African *M. regia* cluster based on SNPs whereas SSRs considered them as a distinct cluster. SSR results were confirmed by the nuclear sequence region which revealed three distinct 'Fields For Recombination' corresponding to (i) West African *M. regia*, (ii) Central African samples with leaf traits of *M. regia*, and (iii) all *M. excelsa* samples.

Our genetic data clearly indicated that three species of *Milicia* should be recognized although further morphological characterization is required for the new taxon. SSRs were reliable for population genetic structure in *Milicia* whereas outputs from the SNP loci were impacted by ascertainment bias. Implications in terms of sampling strategy are also discussed. In terms of forest management, finding cryptic species is particularly relevant to protect rare cryptic taxa from overexploitation of their morphologically close relatives.

## SPECIES DELIMITATION AND HYBRID DETECTION IN TROPICAL *ACROPORA* CORAL SPECIES

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The issues of species delineation and hybrid detection are tightly linked. To explore the interplay between these two problems, we performed a molecular analysis of two *Acropora* coral species, *Acropora florida* and *Acropora intermedia*, which have been found to interbreed and yield apparently fertile hybrids in the Pacific Ocean.

DNA sequences were acquired from a set of 17 individuals, including putative hybrids, at two independent nuclear loci and analysed using haplowebs to find out whether *A. florida* and *A. intermedia* share a common gene pool or in the contrary remain genetically distinct despite interbreeding.



## VARYING LEVELS OF INTERSPECIFIC PLASTICITY CONFOUNDS SPECIES DELIMITATION IN CLOSELY RELATED EUCALYPTS

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Delineating species boundaries is critical to the discovery of life and is of immense importance for a reliable reference of biological information. The success of conservation efforts requires a clear understanding of species boundaries. However many organisms display a high degree of variation in morphology and functional traits across a range of environments and climatic gradients (i.e. phenotypic plasticity). While phenotypic plasticity is an important means through which organisms cope with environmental variability, it can be problematic when identifying and describing species.

We focus on a group of closely related eucalypts known as the green ashes. The green ashes have historically been a taxonomically challenging group. They include the tallest flowering plant in the world (*Eucalyptus regnans*) and a rare mallee less than 1 m in height (*E. cunninghamii*). We used phylogenetic and population genetic analyses based on Diversity Arrays Technology (DArT) to reconstruct the evolutionary history of the species relations. A glasshouse experiment was then conducted to examine plasticity to resource availability in green ash seedlings. Twelve species were selected from different habitats and growth forms. Seedlings were exposed to high and low nutrient and water availability in a factorial experiment.

We found significant differences in seedling growth and leaf functional traits across species, growth forms and substrates in response to changes in resource availability. The results suggest that many of the parameters used to identify species in the green ashes (e.g. leaf width) are highly plastic. Other functional traits (e.g. leaf specific leaf area) were not as variable between treatments for the majority of species. Differences in leaf-level phenotypic plasticity was significant between species, however this was not correlated with phylogeny. Overall, our results provide important insights for species delimitation in *Eucalyptus*; these have implications for the management of the many rare and localised taxa within the green ash group.

## ARE CRYPTIC *RICCARDIA* SPECIES REALLY CRYPTIC? UNRAVELING A PUZZLING THALLOID LIVERWORT GENUS USING INTEGRATIVE TAXONOMY

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Taxonomic issues in describing and understanding biodiversity patterns culminate as organisms decrease in size and morphological complexity. Species delimitation methods based on molecular divergence have therefore been increasingly employed in taxa with reduced morphologies. However, application of these methods often results in the identification of cryptic species that are not formally recognized due to the lack of morphological characters to identify them, and hence overwhelm the systematic literature.

Here, we present an example of how the combination of species delimitation analyses and thorough morphometrical investigation can shed light on African species of the liverwort genus *Riccardia*, one of the most taxonomically challenging cases. From the multilocus genotyping of a representative number of specimens representing the morphological diversity of the group in Africa and an analysis of congruence between three species delimitation techniques, namely distance-based (ABGD), tree-based (GMYC) and allele sharing-based (haploweb), fourteen species were recognized. Using discriminant analysis, we then determined whether morphometrical data from the formalized description of branched thalloid shapes using the software "Leafsnake" specially developed for this study significantly improves our ability to assign specimens to the right species as compared to traditional morphological traits. At the end of this process, twelve species of African *Riccardia* were retained. A new monospecific genus, *Afroriccardia* is proposed for the species *A. comosa*. A global phylogeny of *Riccardia* shows that African species are scattered in several clades and confirms the monophyly of the cosmopolitan and puzzling *Riccardia longispica* – *Riccardia amazonica* group.



# SESSION 6

## TROPICAL FOREST MODELLING

### Chairs:

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Tropical forests are among the terrestrial ecosystems exhibiting the highest diversity of plant species on Earth. This diversity is threatened by anthropic activities that lead to the fragmentation of the forest landscape and to the overexploitation of forest products and services. Moreover, the response of tropical forests to climate change is not currently well understood, but may lead to further degradation of these ecosystems, in their functioning, structure and diversity. The maintenance of forest diversity is critically dependent on the existing interactions between plants and animals, through key processes, such as seed dispersal by birds or mammals, pollination by insects or other animals, grazing by herbivores, etc. Hence, any alteration of the animal community may strongly impact the composition of the flora, and vice versa. Disturbances by fires or extreme meteorological events are also important processes that might alter forest growth dynamics and diversity.

In this session, we welcome contributions assessing the changes in tropical forest species distribution and diversity through time, from the past (Pleistocene, Holocene) to the future, particularly with the use of models (such as, but not exclusively, niche-based models, gap models and dynamic vegetation models). Studies comparing model results with palaeodata are particularly encouraged, as well as model projections for the future under various climate and/or land use change scenarios. Contributions testing ecological processes recently implemented into models, evaluating new methods to quantify change in forest dynamics and animal-plant interactions, or analysing the limits of modelling to describe the future of biodiversity will be also much appreciated.

## HOW DO CLIMATE, SOIL AND FIRE MEDIATE BIOME PATTERNS AND DIVERSITY IN SOUTH AMERICA UNDER CURRENT AND FUTURE CONDITIONS?

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Elucidating the drivers of broad vegetation formations improves understanding of Earth system functioning. The biome, defined primarily by the dominance of a particular growth strategy, is commonly used to group vegetation into similar units. Process-based dynamic global vegetation models (DGVMs) are powerful tools to simulate vegetation patterns, yet, projections of the spatial distribution or presence of the South American savanna and forest biomes are often uncertain. Evidence suggests that fire plays a significant role in mediating biome boundaries, however, fire alone does not appear to be sufficient to predict these boundaries.

We use a novel vegetation model, the aDGVM2, to test the hypothesis that soil depth and fire interactions affect the probability of savanna emergence and plant communities. The aDGVM2 has been specifically designed to allow plant trait strategies, constrained by trade-offs between traits, evolve based on the abiotic and biotic conditions where the resulting community suites are emergent properties of model dynamics. Furthermore, plant hydrology is represented with an implementation of the cohesion-tension theory, which allows us to explore in more detail the role of hydraulic factors in controlling biome distributions and plant traits.

We show that, across much of South America, the biome state is non-deterministic, that interactions between soil depth, fire and precipitation affect the probability of a given biome state, the emergent traits of plant communities, and plant diversity relationships. We further show that the model can simulate biome patterns in good agreement to contemporary biome maps and that future climates may shift vegetation towards more wood dominance. Our results add support to the idea of non-deterministic vegetation states and highlight the importance of considering the influence of soils and fire on vegetation dynamics.



## MODELING TROPICAL FOREST DYNAMICS: FROM PLANT FUNCTIONAL TYPES TO FUNCTIONAL TRAIT DISTRIBUTIONS

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Understanding forest dynamics and their response to global change is a key question in the Tropical Ecology research agenda. Vegetation dynamics models have been extensively used to integrate ecological theory with field measurements, aiming to realistically simulate tropical forest dynamics. Tropical forest are characterised by their great species diversity and plant functional types have been repeatedly used to represent alternative functional strategies in vegetation dynamics models. The next generation of vegetation dynamics models replaces the traditional use of plant functional types with distributions of some key functional traits to better represent diversity of plant form and function.

In this talk we present recent developments in modelling tropical forest dynamics that pay special attention to realistically represent their functional diversity. We initially discuss how objective definitions of plant functional types can be used in vegetation dynamics models. We then describe how observed distributions of some key functional traits can be integrated with basic ecophysiological and ecological theory to provide accurate simulations of forest productivity along geographic and elevation gradients in the Amazon.

## OLD GROWTH TROPICAL FOREST DYNAMICS: GAPS, SUCCESSION, AND LONG-TERM TRENDS

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The response of tropical forests to ongoing climate and atmospheric changes is critical to future global carbon budgets, but remains highly uncertain. A critical question is whether increasing atmospheric CO<sub>2</sub> and temperature are stimulating forest dynamics, and if so, to what extent. Some recent studies have detected enhanced forest productivity and increased biomass in old-growth forests, consistent with a fertilization hypothesis. Attribution of such increases to global change is complicated by spatial and temporal variability in biomass associated with the gap-dynamic cycle. Old-growth forests can hence be viewed as mosaics of many small patches, with most showing small increases in biomass, and a few showing larger decreases. Hence, temporal variation in disturbances can confound detection of long-term directional change.



Using 30 years (1985-2015) of forest inventories at Barro Colorado Island (BCI), Panama, we investigate the local gap-dynamic cycle within subplots of varying sizes (0.04 to 1 ha). We seek to test whether there is evidence for shifts in this gap dynamics over time - for example, have the rates of biomass accumulation in initially low-biomass patches (recent gaps), their self-thinning mortality, and/or species compositional change sped up or slowed down over the last three decades? We quantified shifts in species composition by first assigning shade-tolerance scores to each tree species, and then averaging scores across individuals in a given patch and time, to assign compositional position and quantify changes in it over 5-year census intervals.



## HABITAT SUITABILITY MODELLING OF SPIKED PEPPER (*PIPER ADUNCUM L.*) IN MINDANAO, PHILIPPINES

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Invasive Alien species is the biggest threat to biodiversity next to habitat destruction. This study provides insights in identifying suitable areas for *Piper aduncum* in Mindanao using a novel modelling method known as Maxent. Two models were generated: Full Model which is based on the 25 environmental variables and Final Model which is based on the final set of variables kept after series of variable reduction method. The relative predictive performance of the two models were evaluated using Receiver Operating characteristic (ROC)-Area under curve (AUC).

Results showed that the Final Model performed best with AUC score of 0.825 compared to the Full model (AUC=0.749). The predicted suitable habitat of *Piper aduncum* was heavily influenced by these top five predictors: Soil type, Mean Temperature of Warmest Quarter, Mean Diurnal Range, Maximum Temperature of Warmest Month and Seasonality of Precipitation. We also assess the suitable area coverage in relation to administrative boundaries and protected areas in the study area. Overall, this study will contribute to natural resource managers especially in setting priority areas for current management of the species and in predicting its potential spread in the future.

## SIMULATING PLANT-ANIMAL INTERACTIONS IN A VEGETATION MODEL: A SENSITIVITY ANALYSIS

Fabio Berzaghi<sup>1</sup>, Hans Verbeeck<sup>2</sup>, Carlo Trotta<sup>1</sup>, François Bretagnolle<sup>3</sup>, Marco Marchetti<sup>4</sup>, Giuseppe Scarascia-Mugnozza<sup>1</sup>

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Herbivores in tropical forests directly and indirectly impact forest structure, function, and carbon cycling through browsing, seed dispersal, folivory, and nutrient cycling. For example, it has been shown that taxa at the extreme end of the taxonomic range (large vertebrates and invertebrates) can both directly impact above ground biomass. Some of the most studied processes that involve plant-animal interactions include seed dispersal by large vertebrates and folivory by invertebrates. However studying these processes over large spatio-temporal scales can be challenging in field-studies.



Vegetation models offer a tool to study some of these plant-animal interactions from a different perspective and evaluate their effects on forest dynamics at larger scales. Vegetation models implicitly include the role of animals but can we use processes and parameters already in vegetation models as a proxy to explicitly implement plant-animal interactions? Here we present one possible application of a vegetation model, Ecosystem Demography 2, to study changes in seed dispersal patterns. We perform a sensitivity analysis on the seed dispersal parameter in ED<sub>2</sub> and evaluate if such parameter can be used as a proxy to simulate the presence/absence of seed dispersers in a relatively undisturbed tropical forest in the Democratic Republic of Congo.





# SESSION 7

## TROPICAL BIODIVERSITY FOR DEVELOPMENT

### Chairs:

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Tropical ecology and biodiversity research contribute to a better understanding of precious ecosystems. But how can science contribute to better management of and policies for ecosystem conservation? The need for integrating knowledge involving stakeholders with diverse backgrounds is increasingly recognized. What approaches have been successful in the past and have a larger potential to generate increased development while preserving biodiversity. What role can development aid play to trigger, improve or sustain current efforts? What value can be generated for local and global stakeholders in order to preserve or even increase local biodiversity. What have been successes and failures of participative processes, multi-stakeholder engagement and development programs? Examples presented can come from development projects that included the uptake of local biodiversity knowledge and/or led to increased biodiversity awareness of different stakeholders, as well as from biodiversity research projects that applied participative methodologies to involve various development- stakeholders. A key interaction involves the relationship between scientists and policy-makers. As the acknowledgement of the importance of their interactions progresses, insight in methods allowing these interactions to yield useful output is highly needed.

### The objectives of the session are:

- To provide an overview of methods that facilitates scientist-stakeholder interactions, based on practical experiences in biodiversity conservation,
- To discuss methodological effectiveness in a context of scientist-stakeholders interactions,
- To present examples of successful research - policy linkages and to make suggestions for future research.

## CAPACITY BUILDING FOR THE MONITORING, REPORTING AND VERIFICATION (MRV) OF BIODIVERSITY AND ECOSYSTEM SERVICES IN AFRICA

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With the adoption of the Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets in the framework of the Convention on Biological Diversity, countries will have to formulate biodiversity indicators and gather data that will feed these.

The CEBioS programme is carrying out capacity building for partners of the Belgian development cooperation in the field of biodiversity conservation and sustainable management linked to poverty eradication. It is hosted and implemented at the Royal Belgian Institute of Natural Sciences (RBINS). Improving the knowledge on Measurement, Reporting and Verification (MRV) of biodiversity, ecosystem services and related policy choices is one of its principal objectives.

To that end, calls are launched annually since 2015 in order to provide funding and guidance to our partner countries. Two calls were launched so far, with two different approaches. The first one mainly aims at setting national indicators for the follow-up of their National Biodiversity Strategies. Selected projects were carried out in Benin, Burundi and the DR Congo. The second call focuses on the DR Congo and targets the follow-up of biodiversity at regional level. The themes of the latter are charcoal, bushmeat and fisheries.

Our presentation will introduce the partnerships established to conduct the projects. They consist of a collaboration between a political authority (CBD National Focal Point, Ministry of Environment, regional biodiversity antenna...) and a research centre or university. This enables to improve the science-policy interface and to make scientific data usable for biodiversity policy.

We will address capacity building needs to establish indicators, follow-up processes and the methodology used to promote the Science-Policy interface.

A workshop on exchange of best practices and lessons learnt revealed that especially ground truthing, economic valuation of biodiversity, and the application of modern technologies in biodiversity monitoring were missing capacities in the global South. Also, efforts are needed to avoid that indicators remain a theoretical concept. The outputs of our closing workshop in Cotonou for the dissemination of results among managers and policy makers in the field of biodiversity will be presented.



## BIODIVERSITY RESEARCH AND MONITORING RELATED CAPACITIES IN KISANGANI (DRC)

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Worldwide millions of people rely on forests for food, medicine, energy and income. Many indigenous groups depend almost entirely on them. Increasing economic activity may result in a rapid and chaotic development, with the destruction of natural resources and biodiversity as a consequence. The notion of ecosystem services is gradually incorporated in the economic equation.

The forests in the DR Congo account for approximately 50% of the rain forests on the African continent, whereas the Congo River represents 25 % of the renewable water in Africa. From a global perspective, the main importance of the Congo basin is its uniquely rich biodiversity and its climate-relevant functions. However, these forests also represent an important resource for the country's economic development. Knowledge on the region's ecosystem can thus become a powerful tool for regional development and sustainable usage of its natural resources.

In 2010 the Belgian government has favorably responded to a appeal by Congolese authorities to empower the Congolese scientific community - and hence the Congolese society as a whole - to address biodiversity related issues. The Congo2010 Initiative set up several actions to increase local capacity to tackle issues of deforestation, climate change and the sustainable exploitation of environmental and biological resources.

The development of the "Centre de surveillance de la biodiversité" (CSB) at the Université de Kisangani, a key-deliverable of the Congo2010 Initiative, increased the reliability of monitoring and control of the impact on forest biodiversity by logging, agriculture and fishing practices, bush fires, mining activities and bush meat hunting.

We will describe selected biodiversity projects on taxonomy, ecosystem studies, research and monitoring techniques executed by the CSB that each in a different way contribute to a better knowledge of the biodiversity in the Congo basin, including the reinforcement of local expertise and the valorization of biological resources through sustainable exploitation. Arguably, these projects contribute to the empowerment of the Congolese scientific community, and the Congolese society as a whole.

## TRANSFER UNDER NAGOYA PROTOCOL OF TRADITIONAL KNOWLEDGE TO SCIENTISTS IN BURUNDI, MEDIATED BY MINISTRIES OF ENVIRONMENT AND HEALTH

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The 'Office Burundais pour la protection de la nature' (OBPE), supported by CEBioS (Royal Belgian Institute for Natural Sciences, Belgian cooperation), has developed a negotiation process under the Protocol of Nagoya (NP) between traditional healers and the academic world, in order to promote access and the fair and equal benefit sharing of genetic resources. Protection and valorisation of traditional knowledge are means to combat e.g. bio-piracy. These negotiations, with a memorandum of understanding, offer a framework of cooperation, facilitating the transfer of traditional knowledge from traditional healers to scientists in exchange of valorisation of that knowledge at several levels: (1) research on the active therapeutic components of medicinal plants, (2) development of patents for products derived from these plants, (3) development of pharmacological production processes and value chains. The advantages for the traditional healers were perceived as (1) endorsement by science for medicinal plants, hence confirming the therapeutic value of these plants, (2) pecuniary interests in the form of benefit sharing of patents, processing, production and marketing processes. It is pioneering work under the NP and handles a delicate exchange of knowledge and advantages. Several interests converge, e.g. therapeutic properties of plants and their application to the population, also including a magical unexplained component not tackled by science, as well as the sustainable collection of medicinal plants in e.g. protected areas under the management of OBPE. The self-organisation capacities of traditional healers is also an important success factor in this national process. Any transaction of knowledge about medicinal plants will occur under the umbrella of the national traditional healers' association, and the vice-chancellor of the university. A steering group will control the process, in order to avoid individual transactions that could jeopardize mutualisation and reciprocity effects. The MoU is the start of a learning-by-doing process where all parties are expected to converge in a win-win situation when handling concrete cases for the benefit of the environment, the preservation of traditional knowledge, the sustainable development and the health of local communities.



## USING TAXONOMIC RESEARCH RESULTS TO ACHIEVE A BETTER CONSERVATION AND MANAGEMENT OF BIODIVERSITY AND ECOSYSTEM SERVICES

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In 2001, the Royal Belgian Institute of Natural Sciences (RBINS) was appointed National Focal Point (NFP) to the Global Taxonomy Initiative (GTI). The GTI is a cross-cutting issue addressed by the Convention on Biological Diversity (CBD) ratified by 196 parties.

The aim of the GTI is to reduce the so-called taxonomic impediment that hinders the implementation of the CBD, especially in developing countries. Indeed inadequate taxonomic information and infrastructure, coupled with poor taxonomic expertise, hinders stakeholders' ability to make informed decisions about conservation and sustainable use of biodiversity and ecosystem services.

The Belgian GTI NFP, funded by the Belgian Development Cooperation as part of the CEBioS programme, offers competitive short term grants for young taxonomists from developing countries (mainly in Africa) to come to Belgium in order to access natural history collections and expertise, and to improve their taxonomic and curatorial skills.

Since 2004, after 14 external calls for proposals, more than 180 scientists have benefited from GTI grants and generated hundreds of tangible outcomes such as Masters graduations, Ph.D. completions, lecturer positions, career progressions or scientific publications in peer reviewed journals.

However, the translation of these outcome towards conservation and sustainable use of biodiversity and ecosystem services remains a continuous challenge. In order to tackle this important issue, new capacity building initiatives are developed within the GTI programme: GTI grantees not only, as usually, have to write a scientific report after each training, but they were invited in June 2016 to participate in a workshop in Benin in order to produce public awareness material, such as short articles, policy briefs and posters on their research and main results. This was accompanied by short video interviews to raise awareness on the importance of their work to help protect biodiversity and ecosystem services in their respective countries. Finally, they were invited to write small projects (<2 k€) to raise awareness among selected stakeholders over a period of 6 months.

Our presentation will introduce our main achievements in supporting our partners to better communicate on their work. We will discuss the pros and cons of this approach and the steps to come.

## PERCEPTIONS AND MANAGEMENT OF LAND AND RESOURCES IN RURAL COMMUNITIES IN THE DR CONGO: LESSONS FOR SUSTAINABLE DEVELOPMENT

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Given its vast forest area and rising deforestation rates, the Democratic Republic of Congo is a key country in the international REDD+ program, which aims to reduce emissions from deforestation and forest degradation. Population growth, rural poverty and a strong reliance on shifting cultivation and artisanal resource extraction as livelihood strategies have been identified as the main drivers of deforestation and forest degradation in the core forest regions of the country. Subsequently, the national REDD+ strategy strongly focuses on agricultural intensification and introduction of alternative income generating resources. Despite official engagement and considerable donor investments, there are increasing concerns on the possibility to realize REDD+ objectives in the country. One reason for this is that local stakeholders are rarely consulted, which seriously threatens the identification of locally acceptable and sustainable REDD+ programs.

This study thus documents perceptions and aspirations in rural communities on four key REDD+ themes: (i) state, use and management of natural resources, (ii) transition of the agricultural system, (iii) land and carbon rights and (iv) deforestation drivers. By linking the results to forest cover, population density and the state of the natural resource base in the study villages, we tested the hypothesis that the forest transition theory of Mather and the agricultural intensification theory of Boserup can predict the type of locally appropriate REDD+ interventions.

Results indicate that under increasing population densities current adaptive strategies result in a further backward shift of the forest frontier and a degradation of the natural resource base, among which bushmeat. In sites where old-growth forest is still abundant the perception that forest is an inexhaustible reserve and the adherence to traditional, labor efficient and risk averse practices restrain sustained interest in intensified production systems. In sites with limited forest cover the improvement of access to credit and inputs and technical assistance are needed to increase adoption of intensified production systems. In all communities, investments in awareness building of sustainable resource management, strong local stakeholder engagement and recognition of customary rights were identified as indispensable conditions for local REDD+ support. Given the existing within community heterogeneity in land rights and deforestation responsibilities negotiating equitable REDD+ policies will require substantial transaction costs. We further report on a promising approach for awareness building, in which community representatives visited other, more degraded, villages.



## ANALYSING DISCOURSES OF ENVIRONMENTAL STAKEHOLDERS ON EFFECTIVE CONSERVATION OF MANGROVE FORESTS IN SINGAPORE

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In Southeast Asia, the **highly biodiverse and highly valuable** (e.g. in terms of ecosystem services) **mangrove forest cover has shown a rapid decline** in recent decades. We considered the case of Singapore, which contains merely 6.59 km<sup>2</sup> from the once extensive mangrove cover, causing a strong decline of its biodiversity heritage.

This research acknowledges the importance of **analysing discourses** (shared ways of perceiving and representing the world) on conservation actions. Based on the theoretical framework of **Social Constructionism** (including discourse analysis methodologies) Jorgensen M. and Phillips L.J. stated in 2002: *“Within a specific worldview, some social actions become natural, others unthinkable”*. Thus, the **presence of certain discourses in a social-ecological system can have a direct effect on conservation actions**, because these actions are judged in relation to the discourse we support.

Using the inductive **Q methodology to analyse discourses** on effective mangrove conservation we: (i) delineated and described discourses of environmental stakeholders and actors of mangroves in Singapore, (ii) extracted generalizations (i.e. knowledge and representations shared by all discourses) as a basis for management recommendations and (iii) developed hypotheses explaining the differences between discourses.

Based on the differences between discourses, we **hypothesize** that the level of specific interest in mangroves has a significant influence on the way we perceive effectiveness of the current mangrove conservation state and approach. **Generalizations** include among others the view that Singapore does not lack space or funding to conserve the remaining mangrove cover. Rather, conserving the last mangroves of Singapore comes down to better (informed) top-down prioritization of funding and land-use, more consultation of citizens when it comes to decision making (bottom-up) and more responsibility and account of their own actions for citizens and private companies.

## BIODIVERSITY INTEGRATION IN DEVELOPMENT COOPERATION: WHY AND HOW? A DELPHI STUDY TO IDENTIFY WAYS FORWARD

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The importance of tropical biodiversity for development is now firmly established, and has been translated into the popular concept of ‘ecosystem services’. Scientific studies and policy framework (such as the Sustainable Development Goals) emphasize the linkages between biodiversity and poverty reduction. However, the practical integration of biodiversity concerns and actions into development cooperation is still a challenge. We collected data among development experts using the Delphi method, in which experts are asked to fill out an iterative questionnaire, based on anonymized feedback from the other participating experts. The findings revealed consensus regarding the suitability and potential effectiveness of development cooperation interventions as a vehicle for biodiversity integration in the southern partner countries. A range of preconditions for effectiveness were identified, such as the need for an integration of biodiversity across all levels of decision-making, i.e. treating biodiversity a cross-cutting issue. Effective ‘entry points’ were identified: these range from national budgets and national development strategies, to the project identification and implementation stages, in particular in the agriculture, energy and education sectors. The respondents considered the following tools as effective: payment for ecosystem services, capacity building, impact assessments, regulation and legislation, local stakeholder participation and empowerment of indigenous people. There is however no blueprint on how to integrate biodiversity in development cooperation: the ideal combination of biodiversity perspectives, suitable tools and effective entry points is highly context-dependent. Through the strong focus of the surveyed experts on human well-being – the main reason to integrate biodiversity in development cooperation- in the modalities, the less visible and tangible aspects of biodiversity seem to be given a lower importance. In order to overcome the reductionist, narrowly utilitarian perspective on biodiversity in development cooperation, a more holistic ‘nature and humans’ view is probably more suitable to anchor biodiversity firmly in development thinking and acting, as it goes beyond the substitutable, marketable view on biodiversity. We conclude this contribution by identifying research tracks for the future.

**Merian Award Applicant**



## IMPORTANCE OF UNESCO MAN AND BIOSPHERE RESERVES IN THE TROPICS

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The UNESCO's Man and the Biosphere Program (MAB), with 669 reserves in 120 countries, including 16 transboundary sites, is an Intergovernmental Scientific Program to establish a scientific basis to improve relationships between people and their environments. Biosphere Reserves (BR) have three zones where scientists, NGOs, local communities work together:

- the core is mainly for long-term conservation and research,
- the buffer zone is for activities like environmental education, monitoring eco-tourism and research,
- the transition zone allows sustainable activities (agriculture, settlements).

The concept of BRs is interesting to model sustainable development and to monitor ecosystem responses to global changes. Well-known as sensitive areas are the tropical forest of which several are already classified as BRs. Recognizing the importance of these ecosystems across the world, in 2009, a Memorandum of Cooperation representing, Brazil, Indonesia and DR Congo was signed to address mainly capacity building, however the agreements of the exchange of scientific information and joint trans-continental publications remained too limited.

The MAB-NET project (for Man and Biosphere Reserves Network), financed by the Belgian Science Policy Office (BELSPO) aims at improving the intercontinental exchange of knowledge on the management of the BRs reserves. It addresses aspects like scientific research, data and information management, policy making, conservation, legal issues and public engagement. The project will with two missions on site evaluate and compare the management of the MAB reserves of the Amazonas in Brazil (near Manaus) and in the MAB reserve of Luki in D.R. Congo. In its assessment the positioning and collaboration with site monitoring networks such as the GEO-BON (Group for Earth Observation-Biodiversity Observation networks) and ILTER (International Long Term Ecological Research) will be taken into account.

Since 2004 the Royal Museum for Central Africa developed many interdisciplinary projects in the Luki reserve, together with the Botanic Garden Meise, the ERAIFT and the universities of Ghent and Liège/Gembloux. In this talk the MAB-NET project will be presented, demonstrating how it fits in the new UNESCO MAB Strategy and Lima Action Plan (2016-2015) and how it will contribute to enhance conservation and sustainable development in tropical areas.



## RESPONSIBLE ECONOMIC DEVELOPMENT AND BIODIVERSITY CONSERVATION IN VIRUNGA NATIONAL PARK: THE ROLE OF BOTANIC GARDEN MEISE (BGM)

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Virunga National Park (1925) is Africa's first national park and a UNESCO designated World Heritage site since 1979. It is a biodiversity hotspot and home to the world's critically endangered mountain gorillas. ICCN, Institut Congolais pour la Conservation de la Nature and the Virunga foundation formed the Virunga Alliance to improve conservation measures of this park endangered by several threats (poaching, deforestation and possible oil extraction). The Alliance acts in peacekeeping and prosperity increase through the responsible economic development of natural resources for four million people who live within a day's walk of the park's borders. A crucial step to fight poverty and novel employment generation is the proper supply of electricity in rural regions, made possible *via* the construction of a 13 megawatts hydroelectric plant in Matebe - Rutshuru (North Kivu), which offers sustainable energy alternatives and lowers the pressure on the local natural resources.

BGM plays a major role in this endeavour, by taking on the challenge to make the hydroelectric plant blend in within its surrounding natural environment. The site was landscaped thanks to tremendous effort in planting, wherever possible, with indigenous plants. To overcome the lack of local trees and shrubs fit for ornamental purposes, nurseries were established on site to produce seedlings and propagate locally threatened species. In total 7 ha of bushlands were reshaped showcasing different ecosystems, which are used also for education and public engagement. The 'Jardin écologique de Matebe' was born with the objectives to promote environmental education and communication towards schools, the civil society, the policy makers and the media in North Kivu, in particular to underline the Park's role in preserving this unique hotspot of Africa's biodiversity. Furthermore, revenue generating activities for the local populations are planned with the launch of a horticultural program to support the production of plants and edible mushrooms and will contribute to build stronger economies, achieve goals for development and sustainability, improving the quality of life for families and communities. BGM activities in environmental education and enhancement of livelihood will greatly contribute to the reduction of pressures on the Park and to ICCN's efforts in nature conservation.

## PARAECOLOGISTS AND PARATAXONOMISTS ARE KEY FOR STAKEHOLDER - SCIENTIST INTERACTIONS

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Paraecologists or parataxonomists are resident professionals with local knowledge who lack formal academic training, being largely trained on-the-job, in one or more fields of ecological and taxonomic science. They contribute to scientific research and local capacity development and enhance communication between local and scientific communities. In contrast to citizen scientists who contribute to biodiversity assessment or monitoring on a voluntary, non-committal basis, paraecologists and parataxonomists are employed and are full members of a research team.



Organisations in different parts of the world (e.g., Costa Rica, India, Papua New Guinea, Thailand, and southern Africa) involve paraecologists or parataxonomists for supporting the work-intensive assessment and monitoring of the high biodiversity in resource-poor countries. Through special training courses and training on the job, paraecologists and parataxonomists gain special skills and knowledge in their field of work and have sound understanding of the objectives, methods and findings of the respective scientific research projects. As local residents, paraecologists and parataxonomists are intimate with the study area and its biota as well as with the languages, culture, and land-use practices of local residents and stakeholders. In their dual role as members of the local stakeholder communities and of the research teams, paraecologists and parataxonomists can play a key role in facilitating the interaction and exchange between the two.

Based on many years of first-hand experiences with paraecologist and parataxonomist programmes in different parts of the world, we will explain when and through which processes paraecologists and parataxonomists can enhance the interaction between scientist and various stakeholders groups and discuss how projects can strengthen capacity development, environmental awareness, and stakeholder involvement in biodiverse regions while also producing sound science.



## DO PRIVATE SUSTAINABILITY STANDARDS WALK THE TALK IN IMPROVING ECONOMIC AND ENVIRONMENTAL SUSTAINABILITY?

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A wide variety of private sustainability standards is spreading in global agri-food sectors, each with their own promises on improving the sustainability of food production and trade. Organic certification is promoted as eco-friendly. Fair-trade claims to provide farmers with a better deal that allows them to improve their lives and to offer consumers a powerful way to reduce poverty through their everyday shopping. Rainforest Alliance claims to ensure the long-term economic health of forest communities through protecting ecosystems, safeguarding the well-being of local communities and improving productivity, and so on. But do they walk the talk?

In this study, we analyze the environmental, economic and social implications of a double Fair-trade – Organic (FT-Org) and a triple Utz – Rainforest Alliance – 4C (Utz-RA-4C) smallholder coffee certification scheme in the Mt. Elgon region in Eastern Uganda. We use household- and plot-level socio-economic data from a quantitative survey among 596 farm-households producing coffee on 1,202 plots in combination with plot-level inventory data of a matched sub-sample of 74 coffee plots on tree- and invertebrate-biodiversity and carbon storage.

We found that Utz-RA-4C increases coffee yields, labour productivity and coffee incomes but creates little ecological benefits on coffee plots while FT-Org results in higher biodiversity and carbon storage but reduces yield, labour productivity and coffee incomes (despite higher farm-gate prices). Results show that standards which focus most on farmers' income have the lowest impact on those incomes and that standards which focus most on environmental issues create the least ecological benefits. Invertebrates of the leaf litter layer proved to be valuable indicators of management-induced changes in plot biodiversity. Their study also led to the discovery of new species for science.

## CAN MANGROVE SILVICULTURE IN MATANG MANGROVE FOREST RESERVE BE CARBON-NEUTRAL?

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There is a growing interest in mangrove forests because of the variety of ecosystem functions, goods and services they provide (e.g. buffer against coastal erosion, habitat for fish and shellfish, timber and non-timber forest products). Mangroves are the most carbon-rich forests in the world and have a high economic potential yet they are facing increasing anthropogenic threats.



Matang Mangrove Forest Reserve (hereafter referred to as MMFR) is located on the northwest coast of Peninsular Malaysia (State of Perak at 04°45'N, 100°35'E) and covers approximately 40000 ha along 52 km of coastline. A large part of the area is covered by *Rhizophora apiculata*, which is the most important mangrove species in terms of commercial timber in the Asia - Pacific region. This reserve is under silviculture management by the Perak State Forestry Department since 1902. More than 30000 ha are exploited for charcoal (in 30 year cycles) and pole production (in 20 year cycles) for national and international trade. After harvesting, the area is replanted with *Rhizophora apiculata* and *R. mucronata* seedlings.

This management process in Matang involves a series of exploitation activities that emit carbon, whereas other natural processes result in carbon sequestration.

The objective of this study is to calculate the emission of carbon produced by the exploitation activities as well as calculating the carbon sequestered by MMFR mangroves (through a meta-analysis of vegetation growth data). The final result will indicate whether or not the carbon release is outbalanced by carbon sequestration. Preliminary results will be presented, including the relative importance of various management activities with regard to carbon emissions, and the method & findings for calculating carbon sequestration by the mangrove forest.

With this project we aim to enhance the understanding of the potential of mangrove forests as key systems in effective climate change mitigation.



## LIVING WITH THE ENEMY; CROP RAIDERS IN NEOTROPICAL RAINFORESTS

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Tropical smallholders; amongst the world's monetarily poorest people, are exhorted to preserve their megadiverse surroundings and bear significant costs. Damage to staple crops by wildlife (crop raiding) strains precarious livelihoods. Our study quantifies crop raiding damage to *M. esculenta* in the Medio-Jurua region of Brazilian Amazonia, implicates its protagonists and explains its prevalence.

In 48 communities, 133 camera trap deployments were made in diverse landcover classes and 152 interviews focused on livelihood, diet, agriculture and crop raiding. Respondents were asked about up to four of their roçados (agricultural fields). Data analysis included the extraction of landscape variables, and generalised linear mixed effects hurdle models and ordinations.

Across 238 roçados, mean reported loss to crop raiders was 7.73% ±1.01. The most frequently reported crop raiders were amongst the most detected by camera traps, especially in disturbed habitats and were reportedly commonly hunted species. Community size and proximity to undisturbed habitat negatively influence the likelihood of a roçado being raided. Community size and proximity to city negatively influence the amount of manioc raided. A higher biomass of crop raiders was detected in disturbed habitats and associated with smaller communities. Responses to crop raiding were split roughly equally between lethal and nonlethal methods. Interviewees reported that losses to crop raiders would be 70.64% ± 3.35 in the absence of crop protection.

Crop raiding losses are a significant cost of living with high biodiversity. Modest mean losses hide occasional devastation. Agriculture is the most important livelihood activity and farmers invest substantially in protecting their fields to prevent tenfold losses. Opportunities to hunt crop raiders offer little compensation as hunting is a less important livelihood activity than farming, hunted meat is a smaller proportion of the diet than fish and the most hunted species are not necessarily the worst crop raiders.

## TRENDS IN ARTISANAL FISH TRADE IN COASTAL KENYA (TRADE COMMODITIES, CHALLENGES, AND ORGANIZATION AMONG KEY STAKEHOLDERS)

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Artisanal fisheries provide direct employment to several tens of millions and indirect employment to more tens of millions all over the world. Kenyan coastal communities have for long depended on fishing and related activities for their livelihood. Due to its longevity of existence and development, the small scale industry is itself a hive of activities- from fishing to marketing the final fish products. As such, the industry is surrounded by a unique organization and challenges between and among the fishermen, buyers, government and other stakeholders such as NGOs. There are vital links between the fishermen and small scale traders which shape the fish trade dynamics.



Small scale fish buyers act as an important link between the fishermen and the market. Moreover, although the trade is described as tradition and artisanal by various literatures, it is clearly evident that the markets are dominated by dynamism, competition and demand for new fish products. This study will attempt to further understand the organization and challenges of the fish trade, at least within the small scale fishermen and buyers, by setting the following general objectives:

- (01) To identify the challenges and intra-group organization among the fishermen and traders in the context of acquiring the fish and accessing suitable markets / products.
  - (02) To identify ways in which traders influence fishermen practices - by selection of fish and provision of capital.
  - (03) To get an estimate of fish landings weight and composition.
- Structured questionnaires, informal interviews, observations, weight measurements were used in collecting data.

Primary results to be presented will include a chain showing roles of key players in the fish trade and trends in the trade in the last 10 years. In addition fish composition at landing and in the market and an estimate of value of fish at each trading level will be shown. Challenges listed among the stakeholders will be listed and categorized based on their cause i.e. social or ecological. With this project we aim to enhance the understanding of the artisanal fish trade as key systems in supporting livelihoods. We also seek identify interventions at the different trade levels that can make the trade more viable and sustainable.



## XPÉR RECONNAISSANCE BASE OF PLANTS AND THEIR USES FOR THE MANAGEMENT AND CONSERVATION OF PROTECTED AREA: ANTREMA, MADAGASCAR

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High species diversity and a high rate of endemism in plant species is found in Madagascar (12 000 vascular plant species, more than 90% endemic). Therefore, efforts of the Malagasy government are increasing the number of protected areas of biological interest, in order to implement the ratification of international treaties.

Our field study is located in the new protected area (NAP) of Antrema, northwest of Madagascar, submitted to limited sampling. Changes in the structure of the formations results from human activities, mostly farmers who benefit from resources provided by the forest. This forest displays a matrix of wooded savanna and mangroves, with a high biodiversity. This special site of Antrema is significant due to many sacred places, where traditional regard to environmental protection is devoted.

This allows to measure the positive impact of people in maintaining biodiversity, related to their perceptions. The conservation of these areas and species request tools in order to identify species and their uses. The analysis of the collected samples provided a precise identification, and resulted in a sound data base (Xper 2 and 3) with appropriate identification. An interactive multicriteria data base has been completed and is of interest for scientists as well as for tourists, as the information concerns the species and their uses.

## EFFECTS OF ANTHROPOGENIC DISTURBANCES ON ACRIDOIDEA SPECIES DIVERSITY AND DISTRIBUTION IN THE NATURAL ECOSYSTEM OF THE COASTAL REGION, CAMEROON

Jeanne Agrippine Yetchom Fondjo<sup>1</sup>, Sévilor Kekeunou<sup>1,2</sup>, Alain Didier Missou<sup>1,3</sup>, Martin Kene<sup>1,3</sup>

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Acridoidea have been identified as important bio-indicators for assessing biodiversity and monitoring ecosystem responses to anthropogenic disturbances. This study was carried out within nine sites in the natural ecosystem of the Coastal region of Cameroon between August 2015 to August 2016. These sites were distributed among three vegetation types based on degree of human disturbances including three farmlands, three herbaceous fallows and three forests. Grasshoppers were collected monthly, using sweep nets for a period of 30 minutes in each vegetation type. They were further identified using identification keys.



A total of 2615 individuals of 47 Acridoidea species were collected. Forty seven Acridoidea species, belonging to three families (Acrididae Pyrgomorphidae and Eumastacidae) and ten subfamilies were recorded. Family Acrididae was represented by 39 species, constituting about 82.97% of Acridoidea collected. *Oxyacantops spissus* and *Penichrotes sp.* were widely distributed as they occurred in all the habitats, whereas *Oxyacantops imperator* and *Oxya sp.* were only present in fallow habitat. Two species, *Eyprepocnemis plorans* (13.31%) and *Coryphosima stenoptera* (12.24%) were the most dominant of the total of individuals collected during the study period. The species like *Chrotogonus senegalensis*, *Gastrimargus africanus*, *Heteracris sp.*, *Pyrgomorpha cognata* and *Rutidoderes squarrous* occurred exclusively in farmland. Whereas *Oxya sp.*, *Oxyacantops imperator* and *Oxyacantops sp.* were exclusively present in fallow habitat. Eight species occurred exclusively in the forest. In general, the relative abundance was higher in the farmland (45.71%) and fallow (42.62%) than in forest (11.67%). Two species (*Eyprepocnemis plorans* and *Spathosternum pygmaeum*) were constant during the study period. No significant variation was observed between farmland and fallow as well as between fallow and forest. The Acridoidea community was similar between vegetation of similar level of degradation and less similar between farmland and forest. The species richness, abundance and diversity, increased when vegetation age decreased. In the coastal region of Cameroon, Acridoidea community's composition and abundance finally appear to be positively affected by anthropogenic disturbances.



# SESSION 8

## SAVANNA ECOLOGY AND FUNCTIONING

### Chairs:

Julie C. ALEMAN [julie.aleman@yale.edu](mailto:julie.aleman@yale.edu)

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Tropical savannas are characterized by the coexistence of a continuous grass layer and discontinuous tree cover. Although they dominate the terrestrial tropics, harvest a substantial species diversity and are considered as a major resource for developing countries, they remain underrepresented in scientific literature and conservation concerns as compared to tropical forests. Moreover, the structure (tree/grass biomass and relative proportion), and functional and specific composition of savannas are highly variable across their distribution area and their determinants are still a matter of debate. They result from complex interaction between environmental trait filtering, species interaction mechanisms (competition or facilitation for soils resources or mediated by fire and herbivory), the intensity of which are dependent on climate, soil and level of human intervention. Climate, and particularly rainfall, has long been considered as the primary driver of savanna structure at broad scale, with disturbances (fire and herbivores) and soil variables as secondary ones. But ecological theories contradict each other regarding how tree cover varies with these potential drivers. Indeed, some studies suggest that climate constrains maximum tree cover, but tree cover varies substantially below that maximum due to top down factors. However, other studies have supported the hypothesis that there is a climatic trend in mean tree cover. The potential sources of these discrepancies are related to both spatial and temporal scales of observations, and a lack of integration of the recent advances in different disciplines of savanna ecology. In the current context of global change, bridging these different findings and advances are urgently needed to estimate savannas range of resilience and to adapt human practices.

The aim of this session is thus to bring together contributors from different horizons, field and theoretical ecologists, investigating savanna ecology at small and large temporal and spatial scales, with the scope of vegetation or human ecology. We thus invite contributions from fields spanning ecology, modeling, and experimental work, as well as paleoecology and GIS, to help bringing new insights into the dynamics and functioning of savannas over space and time.

## SAVANNA ECOLOGY IN SPACE AND TIME

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Savanna structure, functional and specific compositions are highly variable across their distribution area and their determinants are still a matter of debate. They result from complex interaction between environmental trait filtering, species interaction mechanisms (competition or facilitation for soils resources or mediated by fire and herbivory), the intensity of which are dependent on climate, soil and level of human intervention.

Despite recent major advances in different disciplines of savanna ecology, a integrative view of savannas is yet to arise. As an introduction to the session, we will present the interest of integrating spatial and temporal scales and bridging disciplines in order to reach a unifying view of savannas.



## LONG-TERM FOREST AND SAVANNA DISTRIBUTION IN WEST AND CENTRAL AFRICA

Julie Aleman<sup>1</sup>, Carla Staver<sup>1</sup>

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Tropical forest and savanna biomes sustain many ecosystem services, and are strategic both economically and ecologically. In the context of ongoing anthropogenic global change, forecasting how these two biomes will respond represents a burning issue. Nevertheless, the ecological processes that drive forest and savanna distribution at large scale remain elusive, hindering the production of reliable prediction and adapted management plan. Long-term reconstruction using bio-proxies (e.g. pollen) from lake sediments make it possible to understand the relationships between climate, anthropogenic impacts and vegetation.

Here we used pollen data from lakes sediments extracted from the African Pollen Database, since the beginning of the Holocene and for West and Central Africa. At each site, we classified pollen taxa in Plant Functional Types (PFTs). We then used the biomization procedure to assign PFTs to forest or savanna biomes, every 1000 years. We also used the modern analogue technique to reconstruct past tree cover at each site and also every 1000 years. The preliminary results show major changes in biomes arrangement and structure during the Holocene. The next step will be to obtain a spatially explicit map of forest and savanna distribution every 1000 years. For this purpose, we will use a statistical model linking biome occurrence (at each paleosite) with simulated annual rainfall (HadCM3, every 1000 years).

## THE YIN AND YANG OF AFRICAN SAVANNA: A STOICHIOMETRIC PERSPECTIVE OF HERBIVORE DUNG ON ECOSYSTEM FUNCTIONING

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African savannas support the highest abundance and diversity of ungulate herbivores, which are believed to play a prominent role in maintaining the co-existence of the woody and herbaceous parts of the vegetation. The influence of these herbivores on the structure of savanna vegetation through forage consumption has been extensively studied, while their influence through more indirect pathways, such as through their dung, has been underrepresented



Here we show that the variation in nutrient stoichiometry (e.g., nitrogen to phosphorus ratios) of herbivore dung can be largely ascribed to the herbivore's diet (i.e., browsers versus grazers). We then propose that this variation in nutrient stoichiometry is likely large enough to affect competitive interactions among grasses and trees, and argue that the pathway of nutrient return through herbivore dung could play an important role in maintaining the tree-grass balance in savanna ecosystems.



## SPATIAL ECOLOGICAL PROCESSES ALLOW TREE-GRASS COEXISTENCE IN SAVANNAS DESPITE REPEATED FIRES

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Repeated fires could prevent tree encroachment in the grass stratum of savannas. However, there are some ecological mechanisms that allow invasion of trees in moist grasslands and eventually, when trees reach high density, prevent fire spread. To better understand the interplay between fire and tree encroachment, we developed a spatially explicit individual-based model representing the interactions between grass, fire spread and trees. We considered three different sets of tree life history traits characterizing three types of trees, namely *resprouters*, *resisters*, and *avoiders*. *Resprouters* are able to resprout after their aboveground biomass is burned, *resisters* can resist fire due to a thick bark developed in early age, *avoiders* are very fire vulnerable but tend to grow fast.

The results of the model show that these three strategies allow tree invasion in the grass stratum despite repeated fire. *Resprouters* form a population of gullivers (alive trees whose aboveground biomass is burned) persisting repeated fires, *resisters* could grow slowly from year to year despite fires, and *avoiders* form clusters where fire cannot spread. The three simulated tree strategies demonstrated that, in savannas, spatial interactions between trees, grass and fire spread are able to allow tree invasion into the grassland stratum despite repeated fires, and allow tree-grass co-existence in savannas for a transient period, before the complete canopy closure. We remark that the inclusion of space in the model is fundamental in achieving our results, and spatial interactions in savannas are among the mechanisms allowing tree-grass coexistence.

## MODELLING THE SPATIAL VARIABILITY OF SOIL ORGANIC CARBON AND SOIL TOTAL NITROGEN IN MABALANE DISTRICT, MOZAMBIQUE

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Soil Organic Carbon (SOC), Soil Total Nitrogen (STN) and vegetation carbon stocks are crucial to understand the ability of forests to contribute to climate change mitigation and resilience. This study aimed to evaluate the relationship between woodland degradation, SOC and STN in the Mozambican southern dry district of Mabalane. The methods included field survey, regression models and geo-statistics to estimate the spatial patterns of SOC and STN at depths of 5 cm and 30 cm. Generalised linear models with a step-wise variables selection were used to test the relationship between SOC, STN and the environmental variables.

The stock of averages SOC and STN were relatively low: (SOC<sub>5cm</sub> = 4.35 Mg ha<sup>-1</sup>, SOC<sub>30cm</sub> = 18.01 Mg ha<sup>-1</sup>, TN<sub>5cm</sub> = 0.49 Mg ha<sup>-1</sup>, TN<sub>30cm</sub> = 2.19 Mg ha<sup>-1</sup>). The woodland type and soil type had no significant effect on SOC and STN. Intensity of charcoal production, litter biomass, tree species richness, and silt and sand content had a significant effect. The stock of STN and SOC showed high spatial variability, and over 80% of this variation was explained by litter biomass and intensity of charcoal production.



## THE BENEFIT OF PERENNIAL GRASS TUFTS IN ASSOCIATION WITH ANT NEST IN LAMTO SAVANNA (CÔTE D'IVOIRE)

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**Introduction:** The grass layer in Lamto savanna is known to be among the most productive over the world despite the low agronomic value of the soil. Recent observations on association between grasses and ant nest raise the question of possible contribution of biotic interactions to the success of grass in Lamto savanna. This study aims at characterising the association in order to understand its contribution to promote high primary production in Lamto savanna.

*Andropogon schirens*, *Hyparrhenia diplandra* and *Loudetia simplex* have been chosen in Lamto savanna to investigate (1) the rate of association with ants, (2) the growth rate and biomass production in the presence and absence of ant nest (3) the diversity and composition of ant community associated to grass.

**Methods and results:** Three study sites have been chosen and each one is subdivided in two experimental plots of 2500 m<sup>2</sup>. Digging method has been used to collect ant nest. After ants identification, *Hyparrhenia diplandra* (site 1 = 55,849%; site 2 = 37,209% and site 3 = 55,303%; with an occupancy rate of 49,454%) is much better colonized by ants nesting under grass tufts. Student test is used to see significant differences between the means of tufts with and without ant nest. *Hyparrhenia diplandra* with ant nest growing rapidly than these without ant nest. The dry biomass quantified show that *Hyparrhenia diplandra* (1,782g/m<sup>2</sup> with; 0,795g/m<sup>2</sup> without ant nest) have a best amount with ant nest (3) peuplement setting are assess with EstimateS software 8.0.

**Conclusion:** This study through the increase in *Hyparrhenia diplandra* biomass when associated with ant nest, allowed understanding that ants affect the soil parameters by the mechanism of bioturbation. The high biomass of this species with ant nest support that ant increase effectively the availability of nutrients in their nest with consequently a positive impact on savanna ecosystem health.

## BIOMASS ACCUMULATION AND PATTERNS OF NATURAL REGENERATION IN SAVANNAS IN THE BAS CONGO PROVINCE OF THE DRC

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WWF is working in buffer areas around the Luki Biosphere Reserve in the Democratic Republic of Congo, on the natural regeneration of savanna (NRS) by preventing annual fires. Groups of local communities for forest conservation are established thanks to decade long experience on community based conservation in the region. A degraded savanna area of 88 ha was demarcated near the Manzonzi village in 2005.

By 2015, the savanna had evolved to a mosaic of different types of secondary forest. Typical forest expansion pioneer species as *Macaranga spinosa* and forest species as *Anthocleista vogelii* are becoming more important and typical savanna species as *Hymenocardia acida* are losing ground. The NRS offers hunting possibilities, since the local communities have observed a slow return of birds and smaller mammals. The absence of fire enables the soil to slowly develop again and to restore the soil's fertility, which offers possibilities for agriculture. The communities based conservation groups and WWF is working on a sustainable way of managing these new patches of forest.



## HISTORICAL ANALYSIS OF LANDSCAPE CHANGE USING REMOTE SENSING TECHNIQUES IN TOGODO PROTECTED AREA AND ITS SURROUNDING AREAS IN SOUTHEASTERN TOGO

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Landscapes of the Togodo Protected Area (TPA) in southeastern Togo and its periphery have been under increasing modifications for decades. As for the dry savannah and forest ecosystems in West Africa, one of the main factors of this transformation in land cover/use is the expansion of agricultural systems to meet the demand for food from a growing population. For their own subsistence and to improve their livelihoods, local people develop food crops (maize, cassava, yams), cash crops (e.g. cotton) and also oil palm plantations. The Togodo Protected Area is a crucial habitat for many threatened animals such as the red-bellied monkey (*Cercopithecus erythrogaster*), vulnerable and endangered species, endemic in southern Togo and Benin. However, human disturbance, in addition to directly threaten biodiversity, promote the establishment and development of invasive plants.

Analyzing the historical changes in the landscape is a necessary first step to understand not only the forces driving land use and land cover change in the TPA, but also the effects of the historical legacy on the plants invasion success. This information can then be used to identify practices, understand drivers and then design management interventions and policies, as part of an integrated landscape approach. The savanna and dry forest ecosystems of the TPA were analyzed using Landsat images archives from 1990 to 2016. An object-oriented classification was conducted throughout the TPA and its surrounding areas to help understanding the landscape structure, composition and historical legacy.

The landscape of the area has been gradually shaped by human activities. The rate and extent of changes seem to be related to socio-political crises. Within this study, we were able to establish a first result on landscape change that will serve as the foundation for future work in developing a landscape approach in the TPA.

## VEGETATION CHANGES IN A HUMAN DISTURBED WEST AFRICAN SAVANNA OVER THE PAST TWO DECADES

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Savanna ecosystems provide important ecosystem services for local human populations in West Africa e.g. by providing timber and non-timber forest products (NTFPs). Thus, biodiversity matters for livelihoods in West African savannas. However, increasing human populations and land use intensification lead to increasing degradation of savanna ecosystems.



To assess and understand savanna vegetation changes under the impact of land-use, our study focused on the changing species composition and plant species diversity in communal areas of the Sudanian vegetation zone in south-eastern Burkina Faso. We conducted vegetation re-samplings of relevés of the early 1990 on fallows of different age and in uncultivated pasturing zones. We analysed species composition changes using non-metric multidimensional scaling (NMDS) and indicator species analysis (IndVal). Above, changes in species richness, evenness and structure were investigated.

Overall, we found more pronounced changes in the herb than in the woody vegetation layer. In the herb layer, major changes were found on younger fallows. Moreover, a general ruderalization was detected, indicating a homogenization of the herbaceous vegetation. Species richness increased in the herb layer, whereas it stayed almost stable in the woody layer, where some species decreased in frequency or abundance. Thus, vegetation changes under land-use impact differed widely between vegetation layers.



## MULTI-SENSOR REMOTE SENSING APPROACH TO MONITOR PASTURE QUALITY IN SAVANNA ECOSYSTEMS

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Tropical savannas are characterised by a hot tropical climate with little annual rainfall, causing an arid and dry ecosystem in which vegetation growth and spread is diverse and complex, comprised of a mixture of bare soil, grassland, shrubland and sparse woodland. The *Prosopis* species is a major invasive species globally and is considered a threat to African savannas, particularly in livestock grazing areas. Although *Prosopis* may offer other potential uses for flour from its seed pods, charcoal and firewood production, it competes with other species for resources and is largely inedible to grazing animals. African countries, particularly in the Horn of Africa are advocating for its eradication. Unless control of the spread of this invasive, including reliable monitoring and mapping, are developed soon, it could cause issues on a national scale that will take many years to rectify.

To monitor the spread of *Prosopis*, LTS International developed a semi-automated tool to produce remotely sensed recordings of vegetation cover in remote savanna ecosystems. The Rangeland Vegetation NDVI (RaVeN) tool combines optical satellite imagery (Landsat and MODIS), to assess vegetation reflectance using Normalised Difference Vegetation Index (NDVI), and radar satellite imagery (Sentinel-1), to map vegetation three-dimensional structure, and makes it possible to approximate differences between vegetation types within the ecosystem. This allows mapping vegetation cover and areas of productive grassland in savanna ecosystems with an innovative multi-sensor fusion approach.

LTS has applied the RaVeN tool within the BRACED\* programme, implementing participatory rangeland management in the region of Afar, Ethiopia, between 2015 and 2017. The tool is currently used and ground-truthed by the programme to monitor the effect of the project interventions on the ecosystem, addressing livestock grazing concerns and impact of the spread of *Prosopis* within target areas.

\* <https://goo.gl/sZjvwm>

## THANK YOU FOR BEE-ING THERE - BEE POLLINATION INCREASES YIELD AND QUALITY OF CASH CROPS IN BURKINA FASO, WEST AFRICA

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Insect pollination constitutes an ecosystem service of global importance, providing significant economic benefits to human society. Growth of human population especially in developing countries increases the demand for food and income security in rapidly changing environments. By combining results from exclusion experiments, pollinator surveys and field manipulations, this study for the first time quantifies the contribution of bee pollinators to smallholders' production of the major cash crops cotton and sesame in Burkina Faso.



Pollination experiments revealed that pollinators are required to significantly increase fruit set and quality. Exclusion of pollinators caused a yield gap of 37% in cotton and 59% in sesame. Pollination by bees increased the economically most important fibre weight of cotton by 62%, and seed weight of sesame was tripled compared to pollinator exclusion. Self-pollination experiments confirmed inbreeding depression among all quality parameters, including reduced seed germination rate of the F<sub>1</sub>-Generation. The pollination service by bees is clearly beneficial by enhancing the quantity and quality of cash crop yields in Africa. Our results have implications on the management of insect pollination services in cash crop fields and highlight potential consequences of any decline in specific taxa and advocate management targeted to the crop varieties.



## FUNCTIONAL COMPOSITION AND DIVERSITY ALONG A NATURAL METAL TOXICITY GRADIENT IN CENTRAL AFRICA

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High heavy-metal contents in soils have a strong filtering effect which structure the vegetation at fine spatial scales. In the south of D.R. Congo, about 200 hills present soils with natural gradients of increasing copper and cobalt contents from the bottom to the top, reaching more than 6000 mgCu.kg<sup>-1</sup> soil. These environments are extremely rich in plant species among which about 70 are endemic and highly threatened due to mining industry.

We investigated the variation of functional traits and functional diversity indices at the community level along the copper gradient of a typical hill. We considered 73 species including the most abundant and the endemics. Ten functional traits related to resource acquisition, dispersal, and metal tolerance strategy were measured at the species level. We selected a subset of 32 plots and 37 species in order to investigate the relative contribution of intraspecific trait variation and species turnover to community variation.

Size and dispersal related traits decreased while acquisition related traits increased along the gradient. Intraspecific trait variability was much smaller than species turnover for all the considered traits. These results reflect a replacement of slow growing, long living, stress tolerant perennials, on low Cu soils, by fast growing, copper and cobalt accumulator annuals on high Cu soils. The functional diversity indices showed contrasted patterns along the gradient and were different to what is observed along other types of stress gradients. Biotic interactions and the diversity of strategies to cope with the metallic stress could explain these idiosyncratic behaviours. This study highlights (1) the variation in functional composition and diversity and (2) the proportion of intraspecific trait variation along a natural copper gradient.

## ECOSYSTEM RECONSTRUCTION FOR METALLIFEROUS PLANT COMMUNITIES DURING DRY SEASON: THE IMPORTANCE OF MULCHING FOR PLANT SPECIES REGROWTH

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The copper flora species of Katanga region represent an important biological resource at the local scale, as they might serve in green technology and globally in green chemistry. Since the revival of mining exploitation in the southeastern DRC, biodiversity of natural copper hills and clearings are continuing to face irreversibly damage. *In situ* conservation methods are limited and against economical interest of mining companies. *Ex situ* conservation methods are thus preferable and rely on seed bank conservation and ecosystem reconstruction. Katangan metalliferous ecosystems are dominated by perennial resprouting species with limited seed production. Plant trait attributes characterizing perennial resprouting species of primary vegetation such as high lateral spreading capacity, xylopodia, bulb or corm bud bank, etc. are not easily recovered naturally in secondary habitats but also in reconstructed ecosystem.



Experiments conducted in the field of ecosystem reconstruction a few years ago, demonstrated whole-turf translocation to be the better technic for *ex situ* conservation of endemic Cu-Co species. The success of this technic depends on several conditions based on the rain availability during translocation. Therefore, translocation of vegetation mats during dry season will be challenging, and this study is the first attempt to translocate plant community as whole-turf during dry season on metalliferous ecosystems. The first monitoring revealed a success for all CPS (conservation Priority Species) translocated. Species abundance and plant communities evolution will be discussed as monitoring is continuing.



# SESSION 9

## THE MANGROVE BIODIVERSITY ENIGMA

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Mangroves are a dominant tropical and subtropical intertidal ecosystem based on widely-distributed, salt-tolerant trees and shrubs that occupy sheltered coastlines. Their global distribution once covered nearly 200,000 km<sup>2</sup> of riverbanks, estuaries, and seacoasts. Their extraordinary high rates of primary productivity, which often exceed 2 t.ha<sup>-1</sup>.yr<sup>-1</sup>, support terrestrial as well as pelagic and benthic marine food webs, and contribute significant carbon to many offshore fisheries. Healthy mangrove forests further reduce coastal erosion and often provide protection from tropical cyclones and tsunami waves.

These highly beneficial forested, however, are disappearing worldwide at an alarming rate of 1-2 % per year, a rate greater than or equal to declines in adjacent coral reefs or upland tropical rainforests. Mangroves are considered to be low in diversity, comprising fewer than 80 plant species worldwide from around 20 families of vascular plants. Thus, typically, mangrove forests have few species to begin with, and the number of species present is directly correlated with habitat area. As mangrove forests are cleared and as they deteriorate from the effects of pollution and altered environmental conditions, their species richness is expected to decline precipitously. The decline of mangrove forests not only imperils trees but also threatens associated biota.

Mangrove ecosystems support unique faunal assemblages, including semi-terrestrial brachyuran crabs, gastropods and fish. Their activity has a significant engineering effect on the sediment, which is constantly excavated and turned, especially by crabs. Increasingly it is becoming now evident that there are no healthy and resilient mangrove forests without viable and diverse invertebrate assemblages. Species extinctions can be followed by loss in functional diversity, and to a lesser extent of functional groups, as theoretical and empirical studies have shown. More importantly, models predict that species-poor systems have low redundancy and are more likely to experience functional loss with species extinction.

The goal of the proposed session is, thus, to:

- (i) Assess and quantify the real extent of diversity of mangrove systems;
- (ii) Update our knowledge on the relationship between floral and faunal diversity and mangrove ecosystem functioning;
- (iii) Assess the ultimate link between mangrove diversity and their provision of goods and services;
- (iv) Forecast the impact of mangrove destruction and alteration on their diversity.

## TERRESTRIAL AND MARINE CONSORTIA OF WOOD DEGRADERS IN MANGROVE FORESTS ARE DIVIDED BY A SHARP TIDALLY-DEFINED BOUNDARY

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Of the total marine biome, less than 2% is covered by vegetated marine habitats, yet they contribute close to half of the carbon burial in ocean habitats. Of those vegetated habitats, mangroves account for 0.5% of that area, but contain 15% of the total carbon accumulating in their sediments. Mangrove forests then are extremely productive, and mangrove productivity is often higher than that of neighbouring inland tropical forests. The breakdown, recycling and flux of nutrients from large woody detritus in mangrove forests are caused by a consortia of biodegrading organisms that range in habitat from terrestrial to marine environments.

We reveal the role of biodegrading organisms in fallen wood and also the environmental factors that influence the distribution of biodegrading consortia within the mangrove forests of East Sulawesi, Indonesia. Within the high intertidal, saprophytic decay upon fallen wood was dominant. Beetle larvae and termites were also abundant in decaying wood in the high intertidal, and also in the mid intertidal. In the low intertidal marine wood-borers, shipworms were the dominant biodegraders of fallen wood, and their activity greatly reduced the volume of fallen wood. In the mangrove forests, immersion time was the greatest environmental factor that influenced the distribution of the biodegrading consortia spanning from the high intertidal down to the low intertidal. The consortia of biodegrading organisms share the same fallen wood environment but they occupy a different niche: areas of different height above sea level. The change of biodegrading consortia in fallen wood between the terrestrial and the marine organisms was distinct, creating a biodegradation boundary in a distance as narrow as one meter on the mangrove forest floor – highlighting ecological issues from climate change for both mangrove flora and fauna.



## PATCHED DISTRIBUTION OF MANGROVE INSECTS URGES PROTECTION OF MULTIPLE AREAS TO MAINTAIN INSECT DIVERSITY

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**Rationale:** Mangroves might be poor in tree species, insects are unexpectedly diverse. Mangroves in Singapore are used as a model for in-depth study of this insect diversity in a simple tropical marine forest ecosystem. Site quality assessment techniques are evaluated.

**Methods:** Insects were collected during a month-long sampling campaign with Malaise traps in 2009 in 11 mangroves in Singapore (26 sampling stations) in order to see a relation between fragment size and species abundance and diversity. In addition, a non-stop two-year sampling (2012-2014) in 4 sites (13 sampling stations in 4 mangroves, and 2 terrestrial reference stations) gave us information on population dynamics and diversity.

**Results:** 32 insect groups were surveyed and insect phenology generally seems to depend on the monsoons with e.g. beetles, hover flies, robber flies and horse flies having their highest activity during the dryer periods while other groups such as dolichopodid flies are most active during the rainy seasons. Dolichopodidae proved to be good bio-indicators for site quality assessment, being one of the most abundant and diverse groups, specific for microhabitats as shown in DCA analysis. During both sampling campaigns 37,302 specimens belonging to 159 dolichopodid species were collected. The total species number of dolichopodids for Singapore's mangroves is estimated (EstimateS) to be at least 215. Hence, 74% of the expected species richness was found during the project. In each of the 4 sites around 60 species were found, apparently being the functional threshold. Only 24 species were common to all 4 sites showing a high complementarity of the different patches. Similar trends of patchiness were found for most other insect groups.

**Conclusion:** The results implement that several sites have to be protected if one wants to protect a complete mangrove fauna.

## DIVERSITY OF MANGROVE DOLICHOPODID FLIES (DIPTERA: DOLICHOPODIDAE) IN PENINSULAR THAILAND

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Habitat diversification and marine transgression probably played a key role in diversification of mangrove animals. During the last 2 million years sea level regressed and transgressed for more than 50 times causing fragmentation or merging of mangroves in the South China Sea and the Andaman Sea. Hence, Diptera Dolichopodidae of which the larvae of many species adapted to marine mangrove conditions radiated through allopatric speciation but probably also through sympatric speciation facilitated by female selection of the very diversified male sexual characters. More than 200 species are hitherto known from mangroves in Singapore (178 species) and Peninsular Thailand (63 species).



Here we highlight a survey conducted on both sides of peninsular Thailand during 2 years (2014-2015) using Malaise traps, yellow pan traps and hand collecting. 3,870 individuals belonging to 63 species in 24 genera were found. Interestingly, our results show that 17 species are strictly found on the Andaman coast only while 20 species are confined to the coast of the Gulf of Thailand only. The terrestrial habitats of peninsular Thailand apparently act as a natural barrier for species dispersal. Preliminary NGS sequencing showed an important genetic distance between mangroves of Singapore and Peninsular Thailand.



## CRAB COMMUNITY STRUCTURE AS ECOLOGICAL INDICATOR OF MATANG MANGROVE FOREST IN MALAYSIA

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Matang Mangrove Forest Reserve represents the largest contiguous mangrove area in peninsular Malaysia, and has been managed for silvicultural purposes for over a century. The management focuses on charcoal and poles production has ensured the continuous presence of a mangrove ecosystem over an area of 40,000 ha.

This ongoing research, aims at investigating mangrove functionality. To accomplish this objective, crab community composition and vegetation structure are assessed as ecological indicators. Visual census methodologies for mangrove crabs were applied taking into account differing spatial behaviour of the species. The census and vegetation structure record was carried out in five different functional forest types (i) cleared area, (ii) young plantation (5-7 years), (iii) mid-age plantation (15 years), (iv) mature plantation (30 years) and (v) unmanaged forest (> than 90 years).

A positive correlation between vegetation age and crab community structure is expected. The findings of this ecological study will be fed into a transdisciplinary assessment, including stakeholder perception, to improve conservation and sustainable management of this ecosystem.

## CAN WE ALL JUST GET ALONG; UNDERSTANDING COEXISTENCE IN FIDDLER CRABS

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Understanding the coexistence of closely related species is an important topic when furthering conservation. This study, using fiddler crabs as a model species, is looking into how highly sympatric species are able to coexist in a small area. This type of resource partitioning is a stabilising mechanism; whereby interspecific competition is reduced because species compete for different resources. On a small and remote island in the Wakatobi National Park, Indonesia, ten species of fiddler crab have been found coexisting on the same mudflat, at the fringe of a mangrove and on the edge of a small village. This remarkable level of biodiversity has been used to investigate the differences in these species that support coexistence.

Fiddler crabs are gregarious animals that are often found living in groups of hundreds or thousands. They are most often characterized by their bright colouration and the extreme claw asymmetry exhibited by males. Through studying their morphology, behaviour and the structure of their habitat it can be seen that they occupy distinct, but overlapping niches. Fiddler crabs, being deposit feeders, obtain their food from sifting through sediments and extracting organic matter. Due to the close proximity of the local village, there is an increase in nutrient availability and the crabs can also be seen living underneath the stilted houses. These anthropogenic factors are directly altering the ecosystem, allowing crabs to dwell in places otherwise uninhabitable. This stabilising mechanism is supported by the lack of interspecific competition, showing minimal agnostic interactions between individuals of different species, despite their territory overlaps.



## GENETIC DIVERSITY IN MANGROVE CRABS IS AFFECTED BY POPULATION FECUNDITY AND DEMOGRAPHIC HISTORY

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The genetic structure of populations and the amount of intraspecific genetic variation of organisms are strongly influenced by many biotic and abiotic factors, both current and historical. Comparative studies on multiple species living in the same habitat can help to elucidate the processes driving these variation patterns, and ultimately to draw ecosystem-based management and conservation programs.

Here, we will present the results of a comparative multispecies population genetic study on seven mangrove crabs co-occurring in the West Indian Ocean. All the study species are characterized by planktotrophic larvae with similar pelagic larval duration, but substantially different reproductive patterns. We investigated whether various parameters of individual and population fecundity, timing of larval release and the micro-habitat colonised by adult populations could affect within and among population genetic diversities of the study species in combination with historical demographic parameters. As the genetic marker, we used partial sequences of cytochrome oxidase subunit I gene.

The dataset show that biological parameters such as species dimensions and reproductive output, in combination with historical demographic parameters, can explain the intraspecific genetic variation indexes across the seven species. In particular, species producing consistently less eggs per spawning event showed higher values of haplotype diversity. Moreover, the demographic parameter Tajima's D well explained the recorded values for haplotype diversity and average GammaST. Our results suggest that, if not target by specific conservation plans, the current observed trends in reduction of the average size of highly exploited species (such as *Scylla serrata*) and in alteration of population fecundity, due to anthropogenic pollution, are likely to strongly affect the connectivity among mangrove forests of the Western Indian Ocean and, ultimately, their overall diversity.

## IMPACT OF MANGROVE FOREST MANAGEMENT ON BIRDS: FIELD ASSESSMENT AND REFLECTIONS ON ECOLOGICAL FUNCTIONALITY

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Matang Mangrove Forest Reserve in Malaysia is often presented as the 'best sustainably managed mangrove forest in the world'. However, the impact of extractive silviculture practices on biodiversity and ecological functionality is vastly under-researched. In 2015, we conducted a rapid biodiversity assessment and forest structure characterization in undisturbed protective areas and in managed mangrove stands of varying ages following extractive disturbance. We compared bird community diversity and composition and assessed the response of individual bird species and dietary guilds.

Analysis of forest structure in undisturbed mangrove stands shows structural development which cannot be found in managed stands. These areas are floristically and structurally complex and diverse and support more diverse and specialised bird communities, which suggests higher habitat quality. Managed forest, consisting of even-aged monospecific stands disturbed by subsequent thinning activities and eventual clear-felling, support bird communities that are drastically reduced in terms of species richness and abundance. Based on these results, we conclude that mangrove plantations exhibit a lower ecological functionality for resident forest bird communities due to habitat degradation. Moreover, response to disturbance varied between species and feeding guilds, and adverse effects are especially manifested in functionally specialised species such as mature-forest birds and nectarivores. This has important implications for the functioning of managed forest fragments as the changes in community composition are likely to disrupt biotic processes, and therefore ecosystem resilience in the long-term. Our findings emphasise the crucial role of habitat and landscape heterogeneity for supporting diverse avian communities and maintaining the ecological functionality of the ecosystem, especially in intensively managed mangrove forests where faunal populations are under continual anthropogenic pressure.



## A CONTRIBUTION TO THE UNDERSTANDING OF LONG-TERM ECOLOGY AND DYNAMICS OF THE MANGROVE FORESTS IN JAMBI, SUMATRA (INDONESIA)

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Mangroves provide numerous ecosystem services including coastal protection against hurricanes and tsunami, carbon sequestration and soil erosion prevention, and resources for local communities. The largest area of mangrove forests of the world, corresponding to almost 27% of the total, is found along the coastlines of Indonesia.

Despite their importance, mangrove ecosystems are rapidly declining in Indonesia due to conversion to agriculture and aquaculture. Beside human impacts, the relative sea-level rise could also represent a strong threat to mangroves in the future. However, sea-level have changed markedly in the Holocene, specifically in the Sundaland region. Following the rapid deglacial transgression, estimates indicate that sea-level was 5 m higher about 5000-4500 years ago (Holocene highstand) and then lowered over the following millennia to the current level. Thus palaeoecological reconstructions of mangroves dynamics in the Holocene have a great potential as they can show the dynamics of mangrove ecosystems over long-time scale and under different sea-level scenarios.

We present the preliminary palynological results from a sediment core taken from Mendahara Ilir in Jambi Province, Sumatra (Indonesia). The 5 m core was taken from a mangrove secondary forest (0°57'14.6"S 103°40'45.0"E). Radiocarbon dating indicates mangroves developed at the site around 2300 years ago, thus proving a temporal baseline for the establishment of the modern mangroves in the area. We use pollen and spores proxies to reconstruct the ecosystem development since then, with a particular focus on the diversity and rate of ecosystem changes. We discuss the results in the light of the past, current and future scenarios of change for the region.

### Merian Award Applicant

## COMING OF AGE - THE MANGROVE PROPAGULE, PARENTAL INVESTMENT AND THE DUAL FUNCTIONALITY TOWARDS AUTONOMY AND ESTABLISHMENT

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Mangrove tree species are few in number as compared to terrestrial species richness at a same latitude of any mangrove assemblage. Many of them show a degree of convergence in dispersal units: well developed and large structures often developed from the embryo through vivipary or cryptovivipary. Rhizophoraceae comprise some of the globally most important mangrove elements (genera and species), both for biogeographical range, reflecting ease of dispersal, and local ecological dominance, reflecting the degree of adaptation to the demanding intertidal environment. Both the range and the ecological success in part relate to propagule properties. The numerous and/or large propagules constitute a major parental investment, with a dual functionality: local recruitment and long distance dispersal.



In this contribution we expand on the gradual autonomy of the rhizophoracean mangrove propagule on the parental tree, the challenges when it is abscised and enters the dynamic mangrove biotope and its features and responses for long term dispersal. We indicate a number of challenges young detached propagules face. For this we bring together various elements of insight gathered in our research group on water relations, the dispersal physiology and mechanics, the nutrient relations, the genetics, and herbivore impacts, but we also establish major knowledge gaps in our understanding of the crucial life stage between abscission and successful establishment of the rhizophoracean propagule.



## TRACKING BIODIVERSITY BENEFITS OF A CARBON OFFSET PROJECT IN MANGROVES OF KENYA

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Mangrove crabs are vital for ecosystem functioning, providing an important role in bioturbation and breakdown of leaf litter. Similarly, it is thought that molluscs provide a similar service to the ecosystem, yet few studies demonstrate to what extent. 'Mikoko Pamoja' is the first mangrove based carbon offset project in the world, and explores the beyond carbon benefits of involving community in managing a carbon trading project.

This paper outlines biodiversity sampling in the Mikoko Pamoja plots, presenting a baseline description of fauna in the Gazi bay area, which was not previously available. Quadrat sampling (1m x 1m) was carried out in ten 10m x 10m permanent plots in triple replication, and crab burrows, burrow size class, mollusc count and size class recorded. Validation experiments specific to Kenya were used to estimate crab numbers from burrow counts. Species composition and zonation of crabs was identified, and the correlation between crab and mollusc density with forest cover, mangrove species and other forest characteristics were analysed. The selected plots' GPS locations were recorded for future monitoring of the same plots. Data will be collected regularly for the future of the Mikoko Pamoja project, to demonstrate the role of crabs and molluscs in ecosystem functioning and forest characteristics in the increasingly protected status of Gazi bay mangroves. A social survey was also carried out to assess the Gazi community perception of conservation. The majority of participants who responded to this question answered that they thought conservation had improved as a result of the Mikoko Pamoja project, with some quoting that the project had resulted in more fish. This study demonstrates the range of values presented by mangrove fauna, both in the quantitative sampling of the mangrove project sites and in the perceived value by local communities and user groups. Continued monitoring will inform us on the faunal response to the carbon offset project.

**Merian Award Applicant**

## INVADABILITY/INVASIVENESS OF NON-NATIVE MANGROVE PALM (*NYPA FRUTICANS* WURMB.) FROM LONG-TERM MONITORING OF PERMANENT SAMPLE PLOTS IN CAMEROON

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Conservation of Mangrove biodiversity and natural resources are at the cross road due bio invasions and climate change issues. Between 2002 and 2014, over to 15 (0.1 ha) permanent sample plots under perturbations regimes within and across the Cameroons' Mangrove and coastal wetlands were established, to monitor long-term mangrove stand dynamics. Plot establishment usually involves involved mapping and identifying to species. Monitoring the plots involved update species recording, mapping and recording new recruits or out sprouted species in 2002, in 2007, in 2010 and in 2015.



The aims of this paper were to provide scientific understanding of Non-native *Nypa* palm (*Nypa fruticans* Wurmb.) coexistence with Native mangrove species dynamics and descriptive appraisal as a bio-indicator of changes. We investigated Invadability/ Invasiveness at plot level from Cameroon Wildlife Conservation Society exiting field data. Results of multivariate analyses tests showed that they are sites differences for Non-native Mangrove Palm across the mangrove and coastal wetlands plots. Forest disturbance had significant effect on invasive plant species level but no time or interaction effect expect for mangrove fern (*Acrostichum aureum*). We discussed the "dilemma" of *Nypa* palm services with adverse of impacts on mangrove and wetlands ecosystem. Our results demonstrate the dynamic nature of the Mangrove palm community following disturbances at plot based level though with little or no pattern distribution revealed across sites. Hence, possible research should involve conceptualizing contemporary *Nypa* palm invasion using geo-referencing data at landscape level to contribute towards in-depth understanding of spread, areal extent and distribution patterns. These informations are used to predict future trends in *Nypa* palm invasions.

**Merian Award Applicant**



# SESSION 10

## FORESTS IN SPACE AND TIME

Chairs:

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Tropical forests are characterized by complex patterns, structures and processes that act on various spatial and temporal scales. Consequently, forest attributes like biomass stocks and carbon fluxes are strongly variable in space and time. Understanding and quantitatively predicting forest behavior is a major challenge for scientists and public policymakers. Estimates on tropical carbon stocks and fluxes diverge which leads to severe uncertainties. The IPCC reported that the uncertainty in forest biomass maps is one of the largest sources for uncertainty in the global carbon cycle. Empirical measurements, modeling approaches and remote sensing techniques were performed to improve estimates of forest attributes. However, every method has its limitation in accuracy, extent or resolution. Only in combination, they can be promising approaches to overcome limitations.

We want to explore possible linkages between remote sensing, field data and modelling at different spatial and temporal scales and discuss perspectives for future research. We encourage scientists of different fields to contribute novel experimental and theoretical approaches that characterize different patterns and structures of tropical forests.

S10-001 - FORESTS IN SPACE AND TIME

## MEASURING FOREST STRUCTURE BY MEANS OF SYNTHETIC APERTURE RADAR TECHNIQUES

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The development and implementation of interferometric and tomographic radar techniques in the last years opened the door for the investigation of the vertical structure of natural scatterers by means of Synthetic Aperture Radar (SAR) measurements. Across the different application fields, forest parameter estimation is by far the most developed and matured one. Indeed, applications as forest height estimation matured and developed from pre-operational to operational products. At the same time the coherent combination of multi-angular SAR images acquired at different polarisations allows the reconstruction of the vertical structure of forest scatterers and enables the estimation and/or characterization of vertical forest structure parameters. This, combined with the fact that spaceborne SAR configurations today have the unique capability to map systematic the whole earth with a high spatial (<10m) and temporal (≈1Week) resolution may establish them as a potentially an important component in a future forest monitoring framework.

In this paper we present the state-of-the-art of forest structure estimation from SAR measurements, discuss the potential and challenges the different approaches face - especially when it comes to derive ecological meaningful metrics from SAR measurements and to cross-validate them with reference ground measurements and/or inventories in tropical environments - and present examples, results and cross-validation from an actual large scale experiment performed in February 2016 in Gabon.



## OBSERVATION OF GLOBAL FORESTS WITH L-BAND SAR SATELLITES - TANDEM-L

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Tandem-L is a proposal for a highly innovative L-band SAR satellite mission for the global observation of vegetation on the Earth's surface with hitherto unparalleled quality and resolution (10 m). Main mission goals are the global measurement of 3-D forest structure and biomass for a better understanding of ecosystem dynamics and the carbon cycle, and high-resolution measurement of variations in soil moisture close to the surface. In addition the satellite mission can be used for systematic recording of deformations of the Earth's surface for earthquake research (with millimeter accuracy) and quantification of glacier movements and melting processes.

For this mission different bio/geo-physical information products have been developed and evaluated based on a larger number of field campaigns in the HGF Alliance 'Remote Sensing and Earth System Dynamics' (EDA). The presentation will give an overview on the Tandem-L project and main results of the field campaigns concerning forest structure, biomass, forest fragmentation and soil moisture.

## MAPPING AMAZONIAN BIODIVERSITY AND GEOLOGY FROM LANDSAT IMAGERY AND FERN SPECIES INVENTORIES

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Fern species composition has been found to be a predictor of species composition and turnover of other plant groups, as well as soil properties. Field inventories have allowed to document high local-scale plant heterogeneity, and to identify the interface of geological formations, but are labour intensive and can only cover certain selected regions of the Amazon basin. Satellite remote sensing is an indispensable tool in order to achieve a comprehensive mapping of Amazonian forest biodiversity and geology. Due to the high heterogeneity at the local scale, such mapping requires high resolution images like those acquired by the Landsat satellites. Previous research has shown that spectral patterns in individual Landsat images reflect patterns in fern species composition and geology, but radiometric artefacts in Landsat imagery –caused by, e.g., atmospheric contamination or the bidirectional reflectance distribution function- have for a long time hampered the use of Landsat over larger areas.



Recent advances in image preprocessing (atmospheric correction, directional normalization and image compositing) and processing capabilities have now allowed to generate a radiometrically consistent, cloud-free Landsat TM/ETM+ image composite covering the entire Amazon basin. We here combine these Landsat data with a large dataset of fern species inventories for the mapping of plant biodiversity and the underlying soil properties.



## PLANTATION ESTABLISHMENT AND NATIVE SPECIES REGENERATION IN TWO CONTRASTING SITUATIONS IN A RESTINGA FORMATION IN SOUTHEASTERN BRAZIL

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The Brazilian Restinga forests occur on sandy and nutrient-impooverished soils that are frequently associated with low-elevation plains (Quaternary or Tertiary) characterized by the presence of beach ridges and lagoon systems. This study was carried out in native tree plantations in formerly disturbed areas of Restinga vegetation in the Caruara Reserve in São João da Barra, state of Rio de Janeiro, Brazil.

The objectives of this study were to evaluate the growth and mortality of planted seedlings between 2012 and 2016, as well as the natural regeneration in two contrasting areas: dry and periodically flooded. A total of 930 seedlings from *c.* 40 tree species were planted per area, distributed in 30 rings of 31 seedlings. Each plant's height and diameter at soil level were measured. The mortality and the growth rate (GR) of each species were calculated.

After four years, the percentage of mortality in both areas was *c.* 50%. The highest diameter, height and GR were found for seedlings in the flooded areas. *Cecropia pachystachya*, *Tapirira guianensis* and *Inga laurina* were the species that showed the best response in both areas. *Myrsine rubra* and *M. parvifolia* had the lowest and *Eugenia pruniformis* the highest GR in dry area. Natural regeneration after 4 years was low in both the dry area (26 individuals from 8 species) and the flooded area (28 individuals from 7 species).

## THE IMPORTANCE OF FLORISTIC DATA FOR BIOLOGICALLY MEANINGFUL BIOMES IN LOWLAND TROPICAL SOUTH AMERICA (LTSA)

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Climate and vegetation structure are often used to map biomes, but both approaches have limitations. Plant communities are comprised of tree species with specific suites of traits with a strong influence on ecosystem function. Thus, as an alternative approach, at restricted spatial scales, biomes can be delimited and mapped based on tree species composition. Our aims were to determine where the main biomes of LTSA are located in geographic, compositional and climatic spaces. We also assessed if areas can be reliably classified to biomes based solely on climatic data. We compiled a database of 4103 georeferenced woody plant floristic inventories distributed across LTSA (< 1000 m.a.s.l.). Firstly, we performed a cluster analyses to check the identity of the biomes of LTSA. We then interfaced this classification with climatic variables used in biogeographic studies to assess how well they can discriminate the biomes.

Our analysis revealed five groups: Amazon Forest, Atlantic Forest, Cerrado, Seasonally Dry Tropical Forests (SDTFs) and Chaco. We also noted that: (1) the Amazon and Atlantic Forests represent distinct biomes in terms of climate and tree species; (2) semi-deciduous forests (e.g. gallery forests within Cerrado) cluster with the nearest moist forest biome; and (3) SDTFs from Bolivia to northeast Brazil form a single group, which is geographically interspersed with the Cerrado. Our results show that climatic variables alone cannot be used to delimit the main biomes of LTSA. Also, the tree species composition of transitional zones between biomes, such as Chiquitania and Pantanal, resembles the tree species composition of the nearby environments. Since climate cannot be used as an accurate proxy for tree species distribution, it cannot be used as means to map a given biome's distribution under climatic change scenarios. These results are important for the planning of conservation strategies and mitigation of possible changes brought up by climatic change.



## SPATIAL HETEROGENEITY OF BIOMASS AND FOREST STRUCTURE OF THE AMAZON RAINFOREST: LINKING A FOREST GAP MODEL AND REMOTE SENSING

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Natural and anthropogenic disturbances such as flooding and degradation have a strong impact on forest structures and dynamics and thus, on the amount of above-ground biomass stored in the Amazon basin. Estimating the current, spatial variation of biomass using vegetation models is still a challenge and is consequently a source of uncertainty in the assessment of the global carbon cycle. Precise estimates need to consider small-scale disturbances, on the one hand, and require large-scale information on the state of the forest that can be detected by remotely sensed data, on the other hand.

In this study, we link results of an individual-based forest gap model and a wall-to-wall canopy height map derived from spaceborne LIDAR. This methodological approach was applied to estimate above-ground biomass variation across the Amazon rainforest. The forest model simulated each individual tree and hence, allowed for the direct comparison of simulated and observed canopy heights. This comparison enabled also the detection of disturbed forest states from which we derived a simulation-based, current biomass map of the Amazon rainforest at 1 km resolution (elevation < 1000 m).

Simulated biomass values ranged from 20 to 440 t ha<sup>-1</sup> across the Amazon rainforest with a total above-ground biomass stock of 73 PgC. When we compared biomass values of the map with 114 field inventories, we found mean differences of only 16%. As additional attributes arose from the forest model, we could analyze the spatial variation of basal area and stem density across the Amazon basin. Linking a canopy height map with an individual-based forest model provides the basis for further large-scale analyses of anthropogenic impacts on the heterogeneous structure of tropical forests and their carbon cycle.

### Merian Award Applicant

## REMOTE SENSING OF TROPICAL FOREST CARBON FLUXES: WHAT CAN WE LEARN FROM AN INDIVIDUAL-BASED MODEL?

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Tropical deforestation and forest degradation are major processes in the global carbon cycle that are expected to cause additional carbon emissions of around 1 GtC/yr. While the extent of forest area can nowadays be tracked in near real time with optical remote sensing, and static maps of standing biomass stocks have been derived for various regions using Lidar and Radar technology, the detection of biomass change within degrading and regrowing forests remains a challenge.



We developed an experimental framework that combines an individual-based vegetation model with a remote sensing model to analyze time series of forest dynamics. Here, we present results about how changes over time in a forest's above ground biomass can be related to 3D remote sensing data. Exploring simulated datasets may ultimately lead to solutions on how to sample and process remote sensing data for the measurement of carbon stocks and fluxes and how to estimate the sequestration potential of tropical forest ecosystems.

### Merian Award Applicant



## THE PACKING OF TREES IN FORESTS AND ITS IMPLICATIONS FOR REMOTE SENSING

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Forests worldwide are characterized by complex and spatially heterogeneous structures. Tree size distributions are an important outcome of classical forest inventories and have long been used for describing such forest structures and for deriving attributes like forest biomass. There is a high interest to determine key forest attributes from remote sensing. However, detecting tree size distributions has not been reached so far.

Here, we present a physical approach for reproducing forest size structures based on stochastic geometry by interpreting forests as tree crown packing systems. The forest packing model is tested for reproducing observed forest structures of two large tropical forest inventories on Barro Colorado Island in Panama and Sinharaja in Sri Lanka (with a total area of 75 ha). The observed tree size distributions can be reproduced successfully as a result of a few simple principles, i.e. site-specific tree allometries, tree mortality, random placement of trees and competition for space. The heterogeneous local structure of forests is also reproduced successfully using our forest packing model. We quantify that most trees grow up to a height of 30 to 50m contributing to the densest height layer of up to 60% filled space.

Our approach is an important step towards identifying a minimal set of processes responsible for generating the horizontal and vertical spatial structure of natural forests. Knowledge, especially on the heterogeneous structure of forests derived from our study can potentially enhance the interpretation of remote sensing measurements.

## QUANTIFYING THE EFFECTS OF FOREST FRAGMENTATION ON TRANSPIRATION AND TOTAL SURFACE RUNOFF USING A FOREST SIMULATION MODEL

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Due to deforestation, intact tropical forest areas are increasingly transformed into a mixture of remaining forest patches and human modified areas. These forest fragments suffer from edge effects, which cause changes in ecological and ecosystem processes, undermining habitat quality and the offer of ecosystem services. Due to microclimatic changes such as higher light incidence, reduced humidity and higher temperatures, the forest structure in edges is remarkably different from interior forest, and these changes have been known to cause alterations in the water cycling of trees to the atmosphere through less transpiration, and less surface runoff because of lower infiltration. This can cause less water recharge of air masses which pass over fragmented areas, impacting precipitation patterns and cause temporal variation in flows of rivers within the same. Quantifying these hydrological changes due to altered forest structure however remains a large challenge. Here we use an individual based dynamic forest model, parameterized with local forest inventory, climate and soil data from the Brazilian northeastern Atlantic forest to understand the consequences of reduced forest fragment size and edge effects to the hydrological cycle. We simulate forest areas of 1-121 hectares with 100 meter edge influence during 500 years and observe the average changes to evapotranspiration and total surface runoff during the last 50 years of the simulation. Our results show a reduction of 54% of transpiration from a fragment of 1 hectare (mean = 363 mm/ha) to 121 hectares (mean = 790 mm/ha), and an increase of total surface runoff of 35% (1 ha mean = 1743 mm/ha, 121 ha mean = 1140). Most hydrological change for transpiration and runoff occur for fragment sizes up to 50 hectares. This work demonstrates the importance of forest models in quantifying ecosystem processes under disturbance regimes, and can be incorporated to remote sensing products in order to further model regional climatic changes in precipitation and impacts to watershed dynamics or water environmental services. This is possible since FORMIND outputs hydrological data in a spatial grid format compatible to most satellite data such as MODIS' SWIR, allowing to improve mapping and predictions of surface-water exchange under diverse land use scenarios.



## REMOTE SENSING INVESTIGATION OF HOW OIL PALM CULTIVATION IS DEGRADING MALAYSIA'S TROPICAL PEATLAND ECOSYSTEM SERVICES

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Malaysia's North Selangor peat swamp forest (NSPSF) is experiencing rapid and large-scale conversion of pristine peat swampland to oil palm agriculture, contrary to prevailing environmental guidelines. Given the global importance of tropical peatlands, and the uncertainties surrounding historical and future oil palm development, quantifying the spatial distribution of ecosystem service values, such as climate mitigation, is key to understanding the trade-offs associated with anthropogenic land use change.

The study explores the capabilities and methods of remote sensing and field-based datasets for extracting relevant metrics for the assessment of carbon stocks held in the NSPSF reserve, estimating both the current (2014) carbon stored in the above and below ground biomass, as well as the changes in carbon stock over time (40 year period) driven by anthropogenic land use change. Project findings will feed directly into peatland management practices and environmental accounting in Malaysia through the Tropical Catchments Research Initiative, and support Selangor State Forestry Department's Integrated Management Plan.

## REMOTELY-SENSED FOREST PRODUCTIVITY: PERFORMANCE OF SPECTRAL AND TEXTURAL INFORMATION

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The need for spatially explicit projections of forest carbon stocks and fluxes becomes a pre-requisite in conservation planning. These projections might be supported by estimates of forest productivity. Especially in remote regions of tropical mountain hotspot areas such as the Ecuadorian Andes, field work to derive forest productivity is time-consuming and cost-intensive. As a consequence, carbon pools of tropical mountain rainforests are highly uncertain. To date various studies analyse the capabilities of remote sensing data to model variables related to carbon stocks and fluxes. These measures are particularly assessed to surrogate forest productivity as spatially explicit indicators for species diversity and ecosystem functions. However, the relationship between forest productivity and remote sensing data might vary depending on the considered indicators and scale.



We tested the performance of spectral information, common vegetation indices and their image textural information derived from high-resolution airborne orthophotos as well as from Landsat images to model forest stand productivity parameters in a mountain rainforest ecosystem in South Ecuador. Data on stem diameter at breast height, above ground biomass increment and a measure of aboveground net primary production were collected. In addition, we measured the C/N ratio in plant tissues in the understory as a proxy for N availability in forest soils that is in turn related to nutrient use efficiency of plants. Partial least squares regressions were used to identify the most important indicators of forest productivity parameters which were subsequently mapped across our study area. Our results reveal the high potential of image textures for biomass predictions in highly diverse tropical forest ecosystems.

### Merian Award Applicant



## DETERMINATION OF CROWN CANOPY CLASSES MAP USING AERIAL PHOTOGRAPHS OF 1955 - 1995 AND GIS

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A massive area of Iranian forests is covered by Irano-turanian forests. Exploitation of the Irano-turanian forests along past years caused these worthwhile forests convert to a sensitive and delicate ecosystem. Considering soil and water preservation which is the most important role of these forests, these are announced as protective forests on behalf of the government. Crown canopy is the best factor which shows us their quantitative and qualitative condition (to study, changes assessment and monitoring). Using aerial photograph method needs lower cost and is faster than field

investigation, so it is used frequently.

This study was carried out in Shazand County – Sarsakhti oak forest reserve. The objective of this study was determination of crown canopy classes map based on orthophoto of the aerial photographs of 1955 – 1995 and GIS.

### Merian Award Applicant

## IMPACTS OF SELECTIVE LOGGING ON PLANT COMMUNITY STRUCTURE, FLORISTIC RICHNESS AND DIVERSITY IN THE EASTERN FOREST OF CAMEROON

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Tropical forests are very diverse in terms of composition, diversity, and structure. This study investigated the effects of selective logging on forest dynamics and structure in the East region of Cameroon. Permanent monitoring plots of 1 ha each were established in 2006 in plots logged 12 years ago, 22 years ago and unlogged forest management units (FMU). Demarcation and enumeration during the inventory and recensus followed standard protocols for permanent monitoring plots described in Condit (1998).



There was a decrease in plant abundance in both logged and unlogged plots and a decrease in species richness in unlogged than in logged plots where there was generally an increase over time. The most important species was *Sloetiopsis usambarensis* in unlogged plots and plots logged 22 years ago over time. The frequency distribution of stem size classes indicated a reversed J-shape and dbh varied significantly across treatments. Diversity indices indicated that plots logged 12 years ago were the most diverse. Mortality rates did not differ significantly ( $p = 0.308$ ) while growth differed significantly ( $P = 0.000$ ) across treatments. There was a significant difference for recruits ( $p=0.00$ ). These results suggest that plots logged 12 and 22 years ago were in their early and late successional stage respectively. Results of ordination showed that selective logging has completely changed the structure of the forests over time. The present study thus demonstrates that selective logging has major effects on species structure, richness and diversity in a single felling cycle.

### Merian Award Applicant





# SESSION 11

## FRAGMENTATION GENETICS AND BIODIVERSITY

### Chairs:

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Habitat fragmentation is a significant threat to the long-term persistence of biodiversity and native communities. The results of fragmentation on natural communities have been explored at a variety of scales and habitat types, yet our understanding on the impacts of fragmentation on many taxa and communities is still relatively poor. Besides its negative effects on species assemblages and species diversity, it is often accompanied by a reduction or interruption of gene flow and an increased genetic differentiation among populations, but a reduction of diversity within populations. As a consequence of fragmentation, genetic bottlenecks may occur in the resulting small, isolated populations. In the long term, the evolutionary potential of such populations may be lost, and the risk of extinction is likely to increase.

It is, however, still controversial whether or not habitat fragmentation has a negative effect on the genetic diversity and persistence of populations in general. While some studies on insects, amphibians, birds or mammals suggested such a negative effect, this has not been found universally. This symposium will provide the opportunity to present new data on this and related questions, to critically review the existing evidence and to point out important avenues for future research. Here we aim to review the state of knowledge on the true impact of fragmentation on natural communities, and to discuss the techniques available for understanding and exploring the consequences of fragmentation.

## NEW APPROACHES TO UNDERSTAND THE IMPACTS OF FRAGMENTATION ON THE LANDSCAPE SCALE

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With progressive forest loss we see an increasing level of fragmentation of forests across the landscape. Generally studies on the impacts of fragmentation on biodiversity have been limited to a relatively small number of studies on individual fragments with relatively little replication. To counter this and to reduce the impact of confounding variables on understanding the impact of fragmentation on biodiversity large scale experiments which deliberately alter landscape configuration to unpick the impacts of various facets of fragmentation on biodiversity.



Yet even these experiments only represent a small number of species and ecosystems and have generally occurred over a relatively short timeframe. Here we review the progression of fragment studies and some of the key outcomes, before presenting a different approach which combines survey data with remotely sensed fragment data. We discuss how using standardized data on demography and distributions and combining it with remotely sensed facets of fragmentation and landcover we can garner new perspectives of the impact of biodiversity across the landscape without the need for the intensively gathered data and limited area size that fragmentation studies were generally confined to. We discuss how remotely sensed data and the new “Essential Biodiversity variables” can provide a more robust understanding of the impact of fragmentation across the landscape, and how by using these complementary approaches in synthesis we can better implement the implications of the study into landscape level management.



## DOES HABITAT CHANGE AND DISTURBANCE INFLUENCE NEST-SITE CHOICE OF AN UNDERSTORY PASSERINE?

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Nest predation is the main cause of reproductive failure in many animal species. If specific characteristics of the environment reduce predation risk, individuals should have developed a preference for those cues to build their nest. However it is known that sudden changes in the environment can break the link between certain cues and success, and so it is crucial to understand animal habitat requirements and preferences for evaluating the impact of habitat fragmentation and disturbance on population dynamics.

Here we studied nest-site selection and nest predation of a cooperatively breeding Afrotropical songbird, the Placid greenbul (*Phyllastrephus placidus*), in a fragmented and disturbed cloud forest archipelago in southeastern Kenya. Our study was based on 22 different variables characterizing nest-sites and random sites in the forest. By using a logistic regression with information-theoretic model selection, we identified that several characteristics in the environment were indeed preferred as nesting sites, while none of these characteristics were associated with predation risk. As a consequence, highly preferred nest sites did not result in lower predation risk. We can explain our findings in the context of the typical recent and rapid deforestation and disturbance of tropical forests.

## SURVIVAL IN A FOREST FRAGMENT

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Does habitat fragmentation affect survival of individuals? If so, are all life stages impacted equally? I will address these fundamental questions in the case of an afro-tropical bird, the Placid greenbul (*Phyllastrephus placidus*), in the severely fragmented cloud forest of the Taita Hills (Kenya). The Taita Hills have been studied for twenty years leading to an impressive amount of data (mist net capture data, telemetry, breeding data).

Traditionally, the different types of demographic and survey data available are analyzed in separate models while they can provide complementary information if treated more holistically. Integrated population models (IPM) have been proposed as a way forward by combining all types of data in one statistical model. I developed such model for the Placid greenbul allowing me to estimate hidden population parameters as well as survival rates with a higher precision. Moreover, by implementing the model in a flexible Bayesian framework, I was able to propose a more realistic model, in accordance with the biology of the study species, and to take into account the heterogeneity observed in the dataset such as changes in the sampling design or missing data.



## IMPACT OF FOREST FRAGMENTATION ON ARTHROPOD TROPHIC GUILDS ON THEIR PATTERNS OF INTERACTIONS WITH HOST PLANTS

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In this study, we analyzed changes in biotic interactions in forest fragments by using a multitrophic approach. We classified arthropods associated with *Heliconia aurantiaca* herbs into: omnivores, herbivores and predators. We used this system as a model to assess the topological structure of intrapopulation plant-arthropod networks in fragments and continuous forests.

Habitat type influenced arthropod species abundance, diversity and composition with greater abundance in fragments but greater diversity in continuous forest. Coleopteran herbivores were more abundant in continuous forest and overall omnivores in fragments. Continuous forest showed a greater diversity of interactions than fragments. Only in fragments, however, did the arthropod community associated with *H. aurantiaca* show a nested structure, suggesting novel and/or opportunistic host-arthropod associations. *Heliconia* herbs, omnivores and predators contributed more to nestedness than herbivores. We found that *Heliconia*-arthropod network properties are not maintained in fragments mainly caused by the decrease of herbivores. Our study contributes to the understanding of the impact of tropical rain forest fragmentation on the structure and dynamics of multitrophic arthropod communities.

## MORE ABUNDANT AND WIDELY DISTRIBUTED: BIOTIC HOMOGENIZATION IN REGENERATION OF THE ATLANTIC FOREST, BRAZIL

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Understanding the capacity of secondary forests in retaining biodiversity has been a recurring challenge among ecologists, mainly in highly degraded landscapes by intense agricultural land use and in the absence of most of the disperser fauna. In this work we address what is the regeneration potential of abandoned areas after sugarcane plantation in a highly fragmented landscape?

The study was developed in a landscape composed of a mosaic of successional stands ages of abandonment, and fragments of mature Atlantic Forest in the northeastern Brazil. Secondary forest stands recovered quickly in terms of richness, diversity and number of individuals reaching the reference values after about sixteen years of regeneration. The most abundant species in regeneration stands were also the most abundant in the landscape as a whole, suggesting increasing biotic simplification.

However, tree species composition suggests that regeneration stands differ significantly from mature forest stands. The taxonomic composition was not influenced by the distance between areas, suggesting little or no dispersal limitation on assembly rules operating at this defaunated landscape. Also, vegetation cover had a small but significant effect on the composition suggesting that areas with same forest cover similar composition tend to have slightly similar species. The intense land use has led to a simplification of the landscape where the most abundant species are also widely distributed. This configuration reveals a trend to biotic homogenization of the regeneration highlighting the important role of the conservation of rare species to the maintenance of biodiversity and ecosystem services.



## RESPONSE OF WOODY PLANT SPECIES DIVERSITY AND TREE GROWTH IN ENCLOSURE TO SPATE IRRIGATION FROM GULLIES

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Severe deforestation has taken place over long years and continued until the last few decades in Northern Ethiopia. To reverse this phenomenon enclosures (areas set aside from human and animal interference) have been widely implemented in the Tigray region of Northern Ethiopia with many positive results in environmental rehabilitation (e.g. soil erosion reduction, soil fertility increment, biomass improvement) and socio-economic improvement. Nevertheless, the growth of trees and biodiversity increment in the enclosure are slow, which can be explained by the longer dry season (8 - 9 months) and recurrent drought in the region. Taking example from spate irrigation that is practiced onto croplands in nearby regions, storm runoff was diverted from gullies onto two enclosures (Hechi in 2002 to 2005 and Adikolakul in 2012 to 2016). This type of spate irrigation had the objectives, to reduce flooding risk; to facilitate downstream gully rehabilitation; and to enhance vegetation growth in the enclosure.

Hence, this study aimed to analyse the effect of the irrigation on the growth of woody vegetation and biodiversity improvement in the enclosures as compared to the non-irrigated adjacent enclosure areas. To this end, different forest and tree parameters (woody plant diversity, biomass, height, diameter, tree ring) data were collected at Adikolakul from sample plots systematically laid down along transects in the enclosure, while only tree ring data was collected at Hechi enclosure to see the long term effect of irrigation on tree growth through the analysis of tree ring increments. Preliminary results show larger average tree basal area (0.024 ft<sup>2</sup>) in irrigated area than the non-irrigated area (0.015 ft<sup>2</sup>) which indicate the positive effect of spate irrigation with storm runoff on tree growth. A vigorous tree growth as well as flowering in the plots with spate irrigation were also observed during field visit even in the dry season. Results of the complete quantitative analyses will be presented in the conference.

## EVALUATING REALISTIC CONSERVATION MANAGEMENT SCENARIOS IN AN AFROTROPICAL BIODIVERSITY HOTSPOT USING A NOVEL, INDIVIDUAL-BASED MODELLING PLATFORM

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Given rising food demands, the application of conservation approaches focusing on the protection or creation of large habitat areas will increasingly be constrained by land availability and socio-economic issues, especially in the tropics. Biodiversity conservation, hence, requires alternative management strategies that effectively improve the persistence of populations constrained to smaller habitat fragments. One potentially realistic option is to effectively connect subpopulations through dispersal, allowing them to function as one larger, more resilient population capable of tracking environmental variation in space (i.e. the creation of 'habitat networks'). However, evaluation of the effectiveness of such networks is challenging, as it requires predictive models that can capture the effects of management on functional connectivity.

Spatially explicit population models (SEPMs) potentially meet this requirement but in most applications the dispersal process is modelled unrealistically which may render predictions unreliable. In addition, progress yet has to be made to take into account temporal variation in environmental suitability in scenario evaluation. Given forecasted rates of climate change this likely is crucial. For instance, habitat protection may appear to be sufficient for a species to persist under the assumption of a stable climate but in reality, habitat corridors may be required that allow the species to shift its range.

RangeShifter is a recently developed SEPM that allows dispersal to be modelled mechanistically and here we illustrate how this likely is crucial in scenario evaluation. Simulations of the spatial population dynamics of an Afrotropical forest bird species, for instance, revealed that patches added to a habitat network compromised population persistence in some of the existing patches by acting as disperser sinks. Current work seeks to improve robustness of predictions and we are applying RangeShifter at a large spatial extent (Eastern Arc Mountains) for multiple species and, for the first time, taking into account effects of climate change.



## HISTORY OF THE FRAGMENTATION OF THE TROPICAL AFRICAN RAIN FOREST IN THE DAHOMEY GAP

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Palynological studies and reconstruction of paleo-environments show that the distribution of tropical African rain forest was affected by cyclical Quaternary climate changes, and suggest the formation of Dahomey Gap (DG, the savanna corridor that separates West and Central African rainforest blocks) during glacial periods. Nowadays, relics of semi-deciduous forests that contain Guineo-Congolian species like the pioneer trees *Distemonanthus benthamianus* and *Terminalia superba* are still present within the DG. Our objective is to use genetic data of both species to study the demographic history and timing of the fragmentation of the rainforest in the DG and the impact of this fragmentation on infraspecific biodiversity.

We genotyped 429 *D.benthamianus* and 247 *T. superba* individuals using nuclear microsatellites. We used Bayesian clustering and models to infer gene pools within these species, infer and date demographic changes within gene pool and determine the origin of the DG populations. For both species, DG populations form a distinct gene pool with less genetic diversity. Demographic analyses were consistent with diversity patterns and showed that DG populations of both species experienced a population bottleneck that could have occurred during the last glacial period for *D. benthamianus* and before for *T. superba*. For both species, DG populations originated from admixture events between West and Central African ancient populations that occurred during the humid Holocene for *D. benthamianus* but before for *T.superba*. Our genetic study tends to support hypotheses on forest history based on paleo-environmental data, although it also highlights difference between species.

**Merian Award Applicant**

## MOUSE LEMURS IN A FRAGMENTED LANDSCAPE: LONG-TERM EFFECTS OF FRAGMENTATION ON NEUTRAL AND ADAPTIVE GENETIC DIVERSITY OF *MICROCEBUS MURINUS* FROM THE LITTORAL FORESTS OF MADAGASCAR

Karina Montero<sup>1,2</sup>, Jean-Baptiste Ramanamanjato<sup>3</sup>, Refaly Ernest<sup>3</sup>, Jörg U. Ganzhorn (speaker)<sup>1</sup>, Simone Sommer<sup>1</sup>

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The effects of fragmentation have long been recognized as the main drivers of biodiversity loss and genetic erosion of threatened species in the vulnerable ecosystems of Madagascar. Here, we assess the impact of long-term effects of habitat fragmentation on the neutral and adaptive genetic diversity and structure of the mouse lemur, *Microcebus murinus*. We examine the patterns of adaptive variation of the major histocompatibility complex (MHC); a multigene family that plays a decisive role in pathogen resistance.

Our study focuses on the highly threatened littoral forests growing on sand along the southeastern coast of the island. As part of a long-term inventory, surveys of four forest remnants have been conducted during the last 15 years, and neutral microsatellite and adaptive diversity was monitored. How MHC variation is maintained in lemur populations that only persist in fragmented landscapes remains an important topic in evolutionary genetics and provides valuable insights on the evolutionary processes ensuring long-term viability of mouse lemurs in the highly threatened littoral forests of Madagascar.



## DNA BARCODING ISLAND PLANT COMMUNITIES AND BUILDING FOOD WEBS TO ASSESS THE IMPACT OF AN ANALOGUE SPECIES (THE ALDABRAN GIANT TORTOISE)

Rosemary Moorhouse-Gann<sup>1</sup>, Nik Cole<sup>2,3</sup>, Martine Goder<sup>3</sup>, Nicolas Zuel<sup>3</sup>, Michael Bruford<sup>1</sup>, Richard Young<sup>2</sup>, William Symondson<sup>1</sup>

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Species extinctions on islands are commonplace throughout history. Such extinctions can lead to dysfunctional ecosystems, especially when keystone species are lost. When the target species is extinct, a surrogate species can be introduced to restore ecosystem function. In Mauritius, exotic giant tortoises (*Aldabrachelys gigantea*) have been introduced to restore dysfunctional ecosystems after the loss of their endemic counterparts, which were thought to be keystone grazers. Dietary analysis is essential to understand the impact that tortoises have on the plant community, food web, and ecosystem function. Next generation sequencing of DNA from faecal samples provides us with an invaluable tool to recover detailed dietary information. Such dietary analysis is often inhibited by the absence of comprehensive DNA barcode libraries.

Here we discuss what the dietary analysis of introduced tortoises and two endemic species, Telfair's skinks (*Leiopisma telfairii*) and pink pigeons (*Nesoenas mayeri*), alongside field data is revealing about the impact of ecological analogues on food webs and ecosystem functioning on two ecologically important Mauritian islands. This work is assisted by the development of a DNA barcode library composed of all plant species found on these islands. To the best of our knowledge, this is the first time that entire island plant communities have been barcoded in order to carry out dietary analysis and it lays the foundations for the construction of more comprehensive food webs.

## HOOK A WORM TO CATCH A MAN

David Stanton<sup>1</sup>, Luis Cunha<sup>1,2</sup>, George Brown<sup>2</sup>, The TPI Network<sup>1,2</sup>, Peter Kille<sup>1</sup>

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The pre-European Amazon has historically been regarded as a pristine forest. This has now been thoroughly refuted, using evidence from a number of well-characterised archaeological sites, that date back to ~9000 years BP. The ancient human cultures that have lived in this region have had a measurable impact on the Amazon, including the adoption and transport of a number of cultivated plant species. It is also possible that the indigenous Amerindian groups transported soil animals, such as earthworms, along with their crops. This process of human-mediated transport would explain the distributions that are observed in Brazilian worm species such as *Pontoscolex corethrurus*. *P. corethrurus* has been linked to human movements elsewhere in the world, and as the species is so widely spread throughout South America, it seems likely that this is also the case in South America.



This project aims to use genomic approaches to track the movement of *P. corethrurus* across Amazonia, and investigate if this information can be used to test between competing hypotheses of ancient human migrations across this region. Here, I report on the progress of this project, including preliminary results on the development of genomic resources.



## CONNECTING IN A FRAGMENTED LANDSCAPE - DISPERSAL AND GENETIC STRUCTURE IN A TROPICAL SMALL MAMMAL, THE BORNEAN TREE SHREW (*TUPAIA LONGIPES*)

Jennifer Brunke<sup>1</sup>, Elke Zimmermann<sup>1</sup>, Michael W. Bruford<sup>2</sup>, Benoit Goossens<sup>2,3</sup>, Ute Radespiel<sup>1</sup>

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Large-scale logging activities and habitat conversion to agricultural landscapes impose huge threats to the Bornean wildlife inhabiting natural habitats. Negative population trends due to ongoing forest loss are widespread and have also been stated for the endemic Bornean tree shrew *T. longipes* (Scandentia, Tupaiidae).

Subpopulations of forest-dependent *T. longipes* are known to occur along the Kinabatangan River in north-eastern Borneo, where numerous woodlands have been cleared or converted to anthropogenic landscapes. Nowadays, forest is restricted to isolated patches. Constraints in migratory capabilities and disruptions of gene flow and genetic connectivity caused by habitat fragmentation are known to affect the long-term viability of species. However, such information is still lacking for the fragmented subpopulations of *T. longipes* in the Kinabatangan region.

In order to assess restrictions in migration and gene flow among the forest fragments along the Kinabatangan River, we analyzed the nuclear and mitochondrial genetic diversity, gene flow and genetic structure of *T. longipes*. Individuals of *T. longipes* were systematically captured and sampled at 19 sites belonging to eight forest patches, differing in size and connectivity, along both sides of the Kinabatangan River. The geographic setting stretched 75km along the river and showed a maximum of 32km direct distance between capture locations.

Variations in maternally inherited mtDNA sequences (cytochrome B) reveal that the Kinabatangan itself reduces the genetic connectivity among populations of *T. longipes* and therefore acts as a moderate barrier to gene flow. In order to assess the impact of forest fragmentation on the genetic connectivity among subpopulations in more detail, we employed a set of eight polymorphic nuclear microsatellites.

A total of 117 individuals were genotyped and nuclear gene flow and genetic structure will be evaluated. A Bayesian STRUCTURE analysis that explicitly searches for genetic structures and estimates the number of genetic clusters, in combination with classical AMOVA and Fst-analyses will be used to infer recent migration rates and assess the impact of fragmentation on genetic diversity and will help to update the conservation status of *T. longipes* as a whole.

## PROBLEMATIC MOLECULAR-MANAGEMENT OF A RARE AND WILD LARGE BOVID FOLLOWING THE DESTRUCTION OF TROPICAL FORESTS IN SABAH (MALAYSIA, BORNEO).

Penny Gardner<sup>1,2</sup>, Benoit Goossens<sup>1,2</sup>, Michael Bruford<sup>2</sup>, Maria Joana Ferreira da Silva<sup>3</sup>

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Timber harvesting and land conversion in Sabah (Malaysia, Borneo) has resulted in a highly fragmented landscape, which is occupied by the Bornean banteng; a rare and elusive wild bovid. Habitat loss and hunting threaten them with extinction and, due to habitat fragmentation, there is limited potential for dispersal, gene transfer and adaptation to their changing surroundings. Prior to 2014, no molecular information was available on this species. To facilitate conservation, their population genetics were investigated using fecal DNA. Four pairs of mtDNA markers were designed, and a concatenated 1,600bp fragment was assembled spanning the Cyt-b gene, tRNA and D-Loop region.

Reconstructed phylogenies indicated the Bornean banteng diverged from the Indian bison between 217-634 kya, therefore they warrant separate management. Six haplotypes were identified, and a star-shaped network indicated population expansion during the last ice age. Distribution of haplotypes across the landscape lacked structure, indicating that topographical features were not a limiting factor. The haplotypes group into two geographically-distinct areas that would be best managed as two separate units. Loss of rare haplotypes is great due to encroachment by hunters seeking banteng bush meat and trophies. Individuals carrying rare haplotypes are unrecognizable so management would be indiscriminate. Captive breeding is desirable but attempts to capture from the wild in 2012-2014 were unsuccessful due to their incredibly shy nature. There is a growing urgency to protect this species but there are large and numerous challenges to overcome if we are to be successful in preventing their extinction.



## GENOMES REVEAL MARKED DIFFERENCES IN THE EVOLUTIONARY HISTORY OF ORANGUTAN SPECIES

Michael Krützen<sup>1</sup>, Maja P. Greminger<sup>1</sup>, Alexander Nater<sup>1</sup>, Tomas Marques-Bonet<sup>2</sup>, Aylwyn Scally<sup>3</sup>

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Paleoclimatic changes may have triggered the demographic expansion of humans out of Africa into novel environments, causing the appearance of numerous local adaptations in the newly founded populations. In non-human great apes, linking demography and adaptive responses to paleoclimatic history has rarely been undertaken.

Here, we used whole-genome sequencing data from critically endangered orangutans from Sumatra (*Pongo abelii*, n=17) and Borneo (*P. pygmaeus*, n=20) to reconstruct demographic histories. Our dataset is based on wild-born individuals with known provenance and covers the entire range of extant orangutans.

Our analyses revealed three deep evolutionary lineages. Remarkably, the deepest split among these three lineages occurred among geographically defined Sumatran populations (~3.38 Ma ago), and not between both currently recognised species (~670 ka ago). Our analyses revealed four major genetic clusters in Sumatra and five in Borneo, with no or little gene flow among them. *Pongo abelii* and *P. pygmaeus* had markedly different demographic histories, during which effective population size of *P. abelii* was consistently higher. The last Toba volcanic super-eruption ~73 ka coincided with a drastic collapse in effective population size from which neither species recovered, suggesting limited ability of great ape populations to recuperate genetic diversity and thus lost evolutionary potential.

## NEUTRAL AND ADAPTIVE GENETIC DIVERSITY IN MONGOLIAN SNOW LEOPARDS

Lisa Preier<sup>1</sup>, Sarita Mahtani-Williams<sup>1,2</sup>, Munkhtsog B<sup>3</sup>, Chris Walzer<sup>1</sup>, Pamela Burger (speaker)<sup>1</sup>

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The snow leopard (*Uncia uncia*) is listed as endangered in the IUCN Red List of Threatened Species and is included in Appendix I of the Convention in International Trade in Endangered Species (CITES). China has the largest, and Mongolia the second largest number of wild snow leopards in the world. Its estimated total population size is between 4080 – 6590, with a global effective population size estimated lower than 2500 individuals and a decreasing population trend. Anthropogenic threats are the highest danger. Within the snow leopard, there is not much know about its genetic diversity and population structure. Therefore, we investigated neutral population genetic parameters in 62 snow leopard samples confiscated by the Mongolian border police, targeted by 20 microsatellite loci and the mitochondrial genes ND5 and cytochrome b.



We identified population structure within the snow leopard samples, which clustered into two different populations. Furthermore we investigated adaptive genetic diversity using a candidate region for immune response, the Major Histocompatibility Complex DRB exon 2, which is known for a high variability in mammals. However, within 42 successfully amplified samples we detected only two haplotypes. This is alarmingly low considering that other wild felid populations, e.g. cheetahs, show a minimum of five haplotypes for this region. A more comprehensive geographical sample set covering the whole distribution area would be necessary to trace back the origin of the confiscated samples, and also to provide the required information needed for an effective conservation of snow leopards.



# SESSION 12

## LARGE VERTEBRATES IN A CHANGING WORLD

### Chairs:

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Global changes are rapidly modifying our world and seriously impacting the tropical biome. The way animals adapt their behaviour and ecology to these changes is a major issue in eco-ethology and conservation biology. Primates and other large vertebrates are found in a wide range of tropical habitats where anthropogenic pressures they are faced with pose increasing challenges for their survival. Each species and each type of habitat feature unique sets of problems and responses, often requiring a case-by-case approach when developing conservation strategies.

The goal of this session is to document a diversity of scenarios and challenges encountered today, by presenting various researches in ecology, conservation biology and management of primates and other large vertebrates in tropical habitats. We will accept presentations addressing questions related to conservation and management issues, behavioural and feeding ecology, GIS and habitat use, as well as species distribution and status. The goal of the session will be to discuss the relevance of current conservation strategies based on the species behavioural and ecological knowledge, and explore new ideas.

## S12-001 - LARGE VERTEBRATES IN A CHANGING WORLD

### BORNEAN PRIMATES AND FOREST REGENERATION: HIGHLIGHT ON THE PROBOSCIS MONKEY (*NASALIS LARVATUS*)

Valentine Thiry<sup>1,2</sup>, Roseline C. Beudels-Jamar (speaker)<sup>2</sup>, Danica J. Stark<sup>3</sup>, Régine Vercauteren Drubbel<sup>1</sup>, Benoît Goossens<sup>3</sup>, Martine Vercauteren<sup>1</sup>

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Among all tropical regions, South-East Asia experiences the highest deforestation rate and is therefore of major conservation concern. The deforestation rate in Borneo has nearly been twice as fast as in all other tropical humid forests of the world and the major cause is clearly the conversion of primary forest into oil palm plantations. Primates are amongst the largest animals in tropical forests and they often play an important role in seed dispersal, particularly in terms of the volume of seeds they disperse. Thirteen primate species inhabit the Bornean rainforest, making this island the richest area in primate species in South-East Asia. Among them, only five are confirmed to be active seed dispersers. Belonging to the *Colobinae* subfamily, proboscis monkeys, *Nasalis larvatus*, are generally considered as seed predators. However, a previous study recorded the presence of intact seeds in more than a quarter of their faeces.



Here, we investigated the potential role proboscis monkeys play in seed dispersal and forest regeneration in the Lower Kinabatangan Wildlife Sanctuary, Sabah (Malaysian Borneo). The study was conducted from May to August 2015 and January to June 2016. We randomly observed proboscis monkey groups at their sleeping sites along the Kinabatangan River. In average, we collected  $13 \pm 7$  faecal samples every month. We analysed 113 fresh samples at the field research station and observed that 62.7 % of those contained intact seeds. Surprisingly, more than 98 % of these seeds belonged to a single species, *Nauclea orientalis*. We conducted seed germination trials using five different treatments: F1: seeds from faeces without faecal material (n=298); F2: seeds from faeces with faecal material (n=98); FR1: seeds from unripe fruits (n=68); FR2: seeds from ripe fruits without flesh (n=56); FR3: seeds from ripe fruits with flesh (n=40). At the end of the experiment (100 days), the seeds that have been passed through the digestive tract of proboscis monkeys showed a significantly higher germination rate than control seeds ( $\chi^2=133.34$ ,  $df=1$ ,  $P<0.001$ ). To our knowledge, these results are the first evidence of the potential role of proboscis monkeys as seed dispersers. These findings are of paramount importance for the conservation of this endangered primate species as well as the restoration of its habitat.



## CONSERVATION IN THE FACE OF CLIMATE CHANGE

Nima Raghunathan<sup>1,2</sup>, Louis François<sup>1</sup>, Eliana Cazetta<sup>2</sup>, Kristel De Vleeschouwer<sup>3</sup>, Alain Hambuckers<sup>1</sup>

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In the tropics, frugivorous primates often play a key role in seed dispersal. Loss of this function due to hunting can pose an additional risk to vegetation and forest composition already mishandled by habitat loss. In this research, after intensive collection of field data, we simulated the movement of an endangered primate species (*Leontopithecus chrysomelas*), its seed dispersal service, and plant growth in a context of climate change to evaluate the regeneration of one tree genus (*Pourouma*) in the Brazilian Atlantic forest.

A Hidden Markov Model analysis suggests that fruit availability index and sleeping site availability are main factors that influence this primates' movement. The distribution and presence of key fruiting species (for e.g. *Artocarpus heterophyllus*) also influences the movement and thus the dispersal kernel. Inter-disciplinary approaches, that link climate change, animal behaviour, and interactions between plants and animals, are fundamental and could provide a scientific foundation for conservation efforts. For example, by assessing the levels of risk of large-seeded tree species thanks to modelling, assisted regeneration projects can be designed with multiple species in degraded areas.

## IS THERE A FUTURE FOR *LEPILEMUR MITTERMEIRI*, AN ENDEMIC AND THREATENED LEMUR SPECIES OF THE AMPASINDAVA PENINSULA, IN NORTHWEST MADAGASCAR?

Leslie Wilmet<sup>1,2,3</sup>, Cédric Vermeulen<sup>1</sup>, Pierre Devillers<sup>2</sup>, Christoph Schwitzer<sup>3</sup>, Roseline C. Beudels Jamar<sup>2</sup>

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Madagascar is one of the richest biodiversity hotspots on the planet but it is, also, one of the most heavily impacted countries in the world in terms of forest degradation and general habitat loss and destruction. Most of the endemic fauna, including the lemurs, are in need of urgent and effective conservation measures. Sportive lemurs, of the genus *Lepilemur*, are small nocturnal folivores, exclusively arboreal. They have small distribution ranges, fairly small populations and are particularly negatively affected by deforestation and habitat fragmentation.

Our research focuses on a poorly-known taxon, *Lepilemur mittermeieri*, whose distribution range is restricted to the Ampasindava peninsula in northwest Madagascar. The species was described in 2006 on the basis of genetic material only. Since then, very little research has been conducted and the ecology of the species is still very little known. General information on this endangered species is urgently needed in order to identify robust conservation guidelines for the species and its forest habitat. As this lemur is fully forest-dependent, the threat of extinction is particularly severe in view of the very small amount of forest left on the peninsula, and the upcoming mining project in the area.

In this talk, we will present the results from three years field work on the species and its habitat. We will concentrate in particular on habitat use, home range, feeding ecology and sleeping sites characteristics as well as on the effect of forest fragmentation on *Lepilemur mittermeieri*.



## REPRODUCTION CONTROL AS A MANAGEMENT STRATEGY FOR LOCAL OVERPOPULATION OF PRIMATES IN TROPICAL HUMAN-DOMINATED HABITATS: A REVIEW

Fany Brotcorne<sup>1,2</sup>, I. Nengah Wandia<sup>3</sup>, Pascal Poncin<sup>1</sup>, Marie-Claude Huynen<sup>1</sup>

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Today, anthropogenic pressures are posing major challenges to Asian primates, forced either to adapt ecologically and behaviourally to the human massive encroachment into natural habitats, or to disappear. Species ability to survive in human-modified habitats greatly varies, with generalist species, such as Cercopithecines, being more likely to thrive. Several macaque species in particular proliferate in situations of commensal association with humans, which leads sometimes to local overpopulation. High density of primates, resulting from the combined effect of population spatial compression and positive demographics, systematically induces conflicts with humans over crop-raiding and nuisance issues. Different management strategies have been deployed these last decades, going from culling or trapping programmes to sterilization campaigns. Sterilization is an ethical and flourishing solution to mitigate the human-macaque conflict by limiting the population expansion, but very few empirical data are available about their efficiency and potential side effects.

We propose here to review various macaque sterilization programmes conducted in Asia, highlighting the pros and cons as well as the short- and long-term effects. As a study case, we will present data on population dynamics and side behavioural effects, as the base for an ongoing sterilization programme in a population of long-tailed macaques (*M. fascicularis*) in Bali (Indonesia). This population has experienced a tenfold increase over the last 30 years. Vasectomy undergone by several males in a former approach was not efficient to limit births. With others, we argue that macaque's reproductive profile requires female sterilization. The goal here is to stimulate discussion over management of forced coexistence scenarios between human and primates, since this phenomenon is an integrative part of conservation in this rapidly changing world.

## IMPACT OF CHANGING LAND-USE AND CONSERVATION MANAGEMENT ON MAMMAL FUNCTIONAL DIVERSITY IN SOUTHEAST CAMEROON

Daan Lameris<sup>1</sup>, Jacob Willie<sup>2,3</sup>, Jacques Kuenbou<sup>3</sup>, Nikki Tagg (speaker)<sup>3,4</sup>

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Beyond the loss of biodiversity, human activities may also affect ecosystem functioning. Estimating the diversity of ecological roles that species play within an ecosystem (i.e. functional diversity) can give insights into the state of an ecosystem and is arguably a better measure than estimates of biodiversity. This paper reports on a study performed to examine if changing land-use and conservation management affects mammal functional diversity. The study comprised three surveys in three different study sites: Madjuh, unprotected, suffering from high hunting pressures and having been intensely logged in the past; La Belgique, officially unprotected, yet managed as a research site with medium logging and hunting intensities; and Ekom, with an official protection status and has never been logged and experienced low hunting levels. We measured habitat composition, human activity levels and wildlife abundance, and calculated four indices for functional diversity. We calculated functional  $\beta$ -diversity to compare functional diversity between study sites.

The results show that the three study sites differ in habitat composition, human activity and wildlife abundances, but not in terms of functional diversity. Madjuh showed the highest abundance of young secondary forest, the highest overall human activity levels and the lowest wildlife abundances. La Belgique showed a higher abundance of young secondary forest, medium levels of overall human activity and medium levels of wildlife abundance. Ekom showed the highest abundance of old secondary forest, lowest overall human activity levels and the highest overall wildlife abundance. These results indicate that, even though human-induced threats have impacted upon habitat composition and wildlife abundance, they have not directly affected functional diversity. We therefore advocate that the ecosystem health remains fairly high in La Belgique, which may be a result of the active management offered by the research presence and associated conservation actions which has reduced hunting in the area. However, we warn that the higher human activity levels and lower wildlife abundances in the unprotected sites might indicate that functional diversity will be affected in the future if urgent conservation management measures are not taken.



## PHYLOGEOGRAPHY, POPULATION GENETICS AND CONSERVATION OF THE OKAPI

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The okapi (*Okapia johnstoni*) is an even-toed ungulate, endemic to the Democratic Republic of Congo (DRC). They have recently been classified as Endangered by the IUCN due to a rapid decline in the wild, and are subject to multiple threats such as habitat fragmentation, human encroachment and poaching. Okapi appear on the emblem of the Institut Congolais pour la Conservation de la Nature (ICCN); the DRC's conservation agency. They are a flagship species for the DRC and yet there is a paucity of information on okapi in the wild compared to other flagship species.

Here we present the results of a PhD project that constituted the first, and currently the only, genetic study on wild okapi ever carried out. The project used non-invasively collected samples from the wild, captivity and museums to investigate phylogeography in this elusive species and investigate if this genetic diversity is represented in captivity. We also use genetics to further knowledge about the distribution of okapi, and their behavioural ecology in the wild. This project provides valuable information for the conservation of this enigmatic and emblematic species.

## CONSERVATION OF GORILLA *BERINGEI GRAUERI* AND OF ITS HABITAT PROVES ALSO RELEVANT TO TRADITIONAL MEDICINE IN KAHUZI-BIEGA REGION, DR CONGO

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This work was carried out in the mountain region of Kahuzi-Biega National Park (KBNP) in eastern DR Congo. This Park was primarily created to protect Grauer's Gorilla, *Gorilla beringei graueri*, a subspecies being recently upgraded to Critically Endangered. The aim of the study was to analyze conservation management of plants most used by traditional healers and at the same time by gorillas as food or possibly self-medication. On the one hand, gorilla's diet was assessed through direct observations of four groups. On the other, we thoroughly interviewed 88 traditional healers recognized as specialists in Batwa, Havu, Bashi and Tembo ethnic groups living around KBNP. Data analysis was conducted through quantitative ethnobotany and numerical ecology approaches.



The use of medicinal plants by traditional healers compared to gorilla food choices show that 78% of plant species consumed by these primates are also used in traditional medicine, with a similarity of 80% regarding plant parts. The high proportion of overlap reflects a potential competition for these dual-use plants, which endangers plants, gorillas as well as local medicine. The results also show the need for a better understanding of self-medication practices by Grauer's Gorilla. These insights may foster measures emphasizing conservation of specific plant species of KBNP, which are valuable for both great apes and humans.



## WILDLIFE MONITORING TO ASSESS IMPACTS OF HUMAN DISTURBANCE

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In South Suriname, indigenous peoples are dependent on hunting and agriculture for food. Especially around large communities, these practices put a serious pressure on wildlife populations. To monitor wildlife population trends, the Amazon Conservation Team and Utrecht University started a joint project in 2015. The project aims at capacity building of Indigenous Park Guards, related to the sustainable use of natural resources and biodiversity conservation in the Trio and Wayana communities. This presentation shows the first results of the project.

In 2015 and 2016, the wildlife population around the Trio village Kwamalasamutu (app. 800 inhabitants) was monitored and in 2016 this was also done around the smaller village Apetina (app. 400 inhabitants). Data were collected using camera traps in 1km long transects with varying levels of human disturbance. Unique to this research is that all surveying efforts have been performed in close collaboration with the indigenous people and that the local park guards have been trained to independently perform future monitoring with camera traps.

The wildlife population around Kwamalasamutu does not differ between sampling locations, nor did it differ between the years. This might be the result of our sample sites not showing enough contrast in disturbance levels, as it is difficult to assess exact hunting degree. Since the species composition of the wildlife community of the smaller village Apetina seems different than that of Kwamalasamutu, this hypothesis could be true, but it remains to be tested.

Since this project is in its initial phase, and more years and more sites of monitoring will follow, this research will be elaborated. As local people do indicate that wildlife has become sparser over the past decades, more research is necessary to demonstrate disturbance effects and to make recommendations for sustainable use of natural resources in order to safeguard food sources. Furthermore, the study shows that it is possible to effectively monitor wildlife populations with trained locals, thereby lowering research costs and increasing engagement of the community in future research supported management and conservation practices.

## USING GIS TO AMELIORATE THE DEVELOPMENT AND MANAGEMENT PLAN OF ANDRIANTANTELY LOW-LAND FOREST IN BRICKAVILLE, MADAGASCAR

Maholy Ravaloharimanitra<sup>1,2</sup>, Hery Nirina Randriahaingo<sup>1</sup>, Tony King<sup>1</sup>

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Andriantantely is a rainforest once connected to the forest corridor of Ankeniheny Zahamena and is home of four critically endangered lemur species. We started to undertake conservation projects in the area in collaboration with local communities in the area after the detection of *Prolemur simus* occurrence. In that purpose, we are encouraging local communities to apply for a transfer of management contract beside the ministry responsible of forest and are helping them to elaborate a plan for the sustainability natural resources.



In fact, despite the claimed richness of the biodiversity, this habitat is largely understudied and is suffering from several threats and pressure. Local communities became aware about the impact of this loss and are willing to protect this patch of forest but need some help to formulate their management and development plan. We propose to link scientific research results with local perception and knowledge of the area and biodiversity for the formulation of the sustainability policy.

We have started to establish botanical plots inside the area to identify species occurring in the area and their phenology. We also have identified the use and needs of forest and non-forest products and their evolution according to the evolution of human demography. This study emphasizes the importance of reforestation for the sustainability of forest use, using temporal and spatial simulation.

We hope to shed light on the reason why reforestation failed to reconnect the existing corridor and recover the previous forest cover.





# SESSION 13

## RIPARIAN ECOSYSTEMS IN TROPICAL DRYLANDS

### Chairs:

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Jan C. HABEL, janchristianhabel@gmx.de

Rivers and riparian ecosystems in tropical drylands support high biodiversity and provide crucial ecosystem services. Even if intermittent, they constitute green life lines in dry landscapes otherwise characterized by more open and sparse vegetation. Naturally dryland rivers are surrounded by riparian gallery forests that are characterized by distinct species assemblages adapted to strong variations in water levels and often including endemic and endangered plant and animal species. Riparian forests are also expected to constitute crucial corridors for plant dispersal and animal migration. However, fertile soil, high water tables and trees as a source for charcoal and timber render gallery forests a favorable place for settlements and subsistence agriculture. As a consequence, the remaining riparian forests are often strongly fragmented and degraded. Deforestation and forest degradation predispose riparian ecosystems to invasion by exotic species with negative effects for the indigenous species assemblages. Furthermore, riparian species diversity and ecosystem functions are being affected by changing hydrological regimes as a result of climate change and human activities, such as dam construction, sand harvesting and water extraction. Despite the biological importance of dryland riparian ecosystems and the high level of threat, there is lack of concerted research and conservation efforts.

Therefore this session aims at bringing together a number of case studies that explore the biodiversity and ecological functions supported by riparian ecosystems in tropical drylands, highlight their livelihood importance and develop conservation strategies that reconcile biodiversity protection and human land use requirements. The session has an interdisciplinary character featuring studies from several fields such as land cover analysis, vegetation ecology, movement ecology (birds), ecosystem functioning and human ecology. The overall focus of the session is on riparian ecosystems in Africa, especially eastern Africa, but we also invite case studies from other dryland regions of the world. The presenters are encouraged to discuss the implications of their findings for riparian forest management and conservation.

## LAND USE AND LAND COVER DYNAMICS AND LANDSCAPE PATTERN CHANGES IN ABAYA-CHAMO BASIN, SOUTHERN ETHIOPIA

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Very few studies, spatially restricted to the river catchment level, have examined the land use and land cover (LULC) changes of Abaya-Chamo Basin (ACB), Southern Ethiopia. None of these past studies have sought to map LULC dynamics and quantify landscape pattern changes in time and space for the entire basin. Understanding the patterns of change in the whole landscape is increasingly necessary for planning sustainable land use systems and resource management practices in the basin.



This study uses a combination of remote sensing data, field observation and landscape indices to examine the dynamics of LULC and landscape pattern changes in ACB for 25 years from 1985 to 2010. A pixel based supervised image classification was applied using maximum likelihood algorithm to classify the images into nine LULC classes based on the extended CORINE Land Cover classification system, while the spatial analyst software, FRAGSTATS, was used to quantify spatial metrics at the landscape and class levels.

The LULC changes analysis showed that the proportion of shrubland, heterogeneous agricultural areas and natural grassland was reduced, whereas the proportions of arable land, inland wetlands and built-up area grew in the landscape of the basin between 1985 and 2010. No changes were observed in the overall area of forests, coffee agroforestry, and inland waters despite the change in size of the lakes found in the basin during the study period. The landscape patterns analysis revealed the formation of more fragmented landscape in 2010 than 1985. At class level, patches of shrubland and natural grassland became more fragmented, while patches of arable land tended to have a uniform landscape configuration dominated by fewer, but larger patches in 2010. The LULC changes and the related trend of increasing landscape fragmentation can lead to more degradation and damage to aquatic and terrestrial ecosystems of the basin if protective measures that take into consideration the economic, social and ecological dynamics in the area are not taken in the future.



## EFFECTS OF LAND USE PATTERN ON RIPARIAN PLANT DIVERSITY IN SEMI-ARID KITUI COUNTY, KENYA

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Riparian ecosystems in tropical drylands support high biodiversity and provide crucial ecosystem services, but are under strong human land use pressure. In Kitui county, southeastern Kenya, population density, the number of settlements and the destruction of riparian forest vegetation has been continually increasing since the 1960's. This study evaluated the relations between current land use pattern and floristic diversity along two rivers that represent different degrees of anthropogenic influence. Diameter at breast height (dbh), height and distance from river were recorded for woody species (dbh > 5cm) in transects (50m x 10m) laid out perpendicular to both sides of the Kalundu (n = 32) and the Nzeeu (n = 42) rivers at 300m intervals; the land use pattern was mapped for each transect.

In total, 631 plant individuals were recorded representing 87 woody species, of which 11 were exotic timber and fruit trees. Two of the encountered species are regional endemics. A few remaining forest fragments indicated that both rivers may have originally supported up to 50m wide strips of gallery forest, whereas the current riparian vegetation mainly consisted of individual trees on agricultural and grazing lands. On average, the proportion of indigenous vegetation was higher along Kalundu (22%) than Nzeeu river (5%). Species diversity was related to land use type and the distance gradient. For instance, *Shirakiopsis elliptica* was associated with patches of indigenous vegetation within 5m at Kalundu river, whereas four *Acacia* species mainly occurred at a greater distance from the riverbank and in different land use types along both rivers.

Overall the results indicate a decline in typical riparian tree species and an increase in exotic species with increasing land use intensity. It is recommended to protect forest remnants, plant trees on agricultural lands and promote natural tree regeneration along the river banks in support of soil protection and biodiversity conservation.

## HYDROLOGICAL GRADIENTS AND LAND USES IN A SUB-SAHARAN FLOODPLAIN: THE POTENTIAL USE OF INDICATOR PLANTS FOR BIO-MONITORING

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While flooding periods impede cultivation, extended soil moisture availability during dry seasons make flood plains and riparian environments suitable for continuous cropping activities and other agricultural uses. As a consequence of continuous cultivation coupled with the establishment of drainage structures, hydrological properties of agro-ecosystems can be degraded resulting in productivity decrease. Also from the ecological point of view, hydrological conditions of floodplains may be related to the habitat integrity for living organisms. Therefore, the use of bio-indicators such as vascular plants may provide a practical tool for quick assessment in large areas. In order to evaluate the potential capacity of vascular plant species for bio-monitoring, we assessed the shallow groundwater regime of a hydrological gradient in the floodplain of the Kilombero River around Ifakara (Tanzania). The area is mainly characterized by rice cultivation. Four hydrological indices were calculated from shallow groundwater monitoring time series data (March 2015 to June 2016) from 10 piezometers located along the hydrological gradient in the floodplain. These indices describe the overall shallow groundwater availability, their variability, flooding intensity and duration. In the proximity of each piezometer, vegetation surveys were carried out. The prevalence of plant species (optimum conditions for occurrence) was assessed using probability models (i.e. MaxLike).

Though most of the species had an optimum around intermediate hydrologic conditions, some species may indicate different combinations of levels such as general low water table regimes with strong fluctuations (e.g. *Panicum fluvicola* and *Heliotropium indicum*) or high, more stable regimes (*Leersia hexandra* and *Ammania baccifera*). Similarly there is a continuous sequence of species indicating low flooding intensity and short flooding periods (*Digitaria ciliaris* and *Eragrostis ciliaris*) to higher flooding intensity for longer periods (*L. hexandra* and *Persicaria senegalensis*). The implementation of the tested models and the interaction of their accuracy with land uses will be further discussed.



## SOLUBLE PROSOPIS PHENOLS INHIBITS REGENERATION OF ACACIA TORTILIS IN TURKWEL RIVERINE FOREST, KENYA

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*Acacia tortilis* widely distributed in Africa and is highly valued for energy, shade, fodder and construction materials, among others. However, *Prosopis* invasion has led to contrasting decrease of *A. tortilis* and increase of the invading *Prosopis* in Turkwel riverine forest. (Kenya) The impact of *Prosopis* invasion on regeneration of *A. tortilis* in Turkwel riverine forest was investigated under three contrasting canopies (*A. tortilis*, *Prosopis* and Mixed Species); and greenhouse studies that tested effects of: (a) litter on germination of *A. tortilis* and *Prosopis* seeds, and (b) litter and light intensity on *A. tortilis* and *Prosopis* seedlings dry weight.

Field studies revealed lack of *A. tortilis* seedlings under both *Prosopis* and Mixed Species canopies and occurrence of *Prosopis* seedlings in the three canopies types. Concentration of soluble phenols was higher in unleached *Acacia* litter than in unleached *Prosopis* litter. However, the leaching of *Acacia* or *Prosopis* litter with tap water revealed equal concentration of soluble phenols in both litter types after two weeks, and higher concentration of soluble phenol concentration in *Prosopis* litter than in *Acacia* litter thereafter. Increase of unleached *Prosopis* litter in the soil reduced germination of both *A. tortilis* and *Prosopis* seeds more strongly ( $R^2 = 0.77$ ,  $p < 0.05$ ), in contrast of no such effects from unleached or leached *Acacia* litter, and leached *Prosopis* litter. Seedling dry weight increased with addition of *Acacia* or *Prosopis* litter in the soil and increase of light intensity without interspecific variation, suggesting similar growth responses to litter and light treatments for both species.

We conclude that lack of *A. tortilis* seedlings under *Prosopis* canopies in the field is due to inhibition of *A. tortilis* seed germination by soluble *Prosopis* litter phenols, whereas presence of *Prosopis* seedlings under the three canopies can be attributed to prolific seeding of *Prosopis* and its high seed germination rates.

## ECOSYSTEM HEALTH EROSION ALONG EAST AFRICAN DRYLAND RIVERS - SOCIO-ECOLOGICAL PERSPECTIVES

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The destruction of intact, pristine habitats and their transformation into small and isolated habitat remnants is one of the main drivers of global biodiversity loss. Apart from a direct loss of biodiversity, ecosystem degradation leads to reduced ecosystem health and a subsequent decline of ecosystem functions which negatively affects human livelihood.



In this multi-stakeholder network we observed land cover degradation and performed vegetation assessments along a river system in semi-arid South-east Kenya. We tested for potential effects of reduced ecosystem functions (based on nutrition content, pollination and predation) on human livelihood needs. All parameters were collected in the same study region covering the same time frame.

Our land-cover analyses indicate a rapid deforestation of pristine riparian vegetation and land splitting during the past 7 decades. Exotic plant species are currently dominating the species composition in our study region, and regeneration of the pristine vegetation is prevented due to intense human activities. Ecosystem functioning decreases with increasing human disturbances. Data from our surveys on human behavior and awareness indicate that a major proportion of the local human population is aware about negative effects on the ecosystem health; However, peoples' behavior strongly deviates from their knowledge, especially when their owned sizes of land fall below 1.5ha. These findings show that uncontrolled human activities negatively influence ecosystem functions and subsequently human livelihood quality. This study highlights important synergies when combining social and ecological view-points.



# SESSION 14

## CORAL REEFS AT RISK

Chair:

Marc KOCHZIUS, marc.kochzius@vub.ac.be

Coral reefs are the most diverse ecosystem in the ocean, but are threatened on a global scale by overfishing, eutrophication, coral bleaching and ocean acidification, which can lead to a phase shift from coral- to algae-dominated reefs. Important for conservation planning is a profound knowledge on (1) the impact of these threats, (2) connectivity among populations, (3) exchange with adjacent coastal habitats (seagrasses and mangroves), as well as (4) socioeconomic aspects of coral reef utilisation.

This session aims to bring together coral reef scientist from different disciplines (e.g. physiology, population biology, ecology, genetics and sociology) to discuss future trajectories of coral reef ecosystems under various threats in different parts of the world and to identify knowledge gaps that need to be filled for an effective planning of coral reef conservation.

## S14-001 - CORAL REEFS AT RISK

### DEMOGRAPHIC VARIABILITY OF TWO COMMON CARIBBEAN CORAL SPECIES, *ORBICELLA ANNULARIS* AND *PORITES ASTREOIDES*

Francisco J. Soto-Santiago<sup>1</sup>, Alex E. Mercado-Molina<sup>1</sup>, Koralis Reyes<sup>1</sup>, Yaileen Vélez<sup>1</sup>, Alberto M. Sabat<sup>1</sup>

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The Caribbean coral reef builder *Orbicella annularis* has shown a population decrease in several localities after environmental stressful events (e.g. severe bleaching episodes). On the contrary, *Porites astreoides* colonies are projected to exhibit increasing populations within the current climate change scenarios. In this study, we assessed the spatiotemporal variability of *O. annularis* and *P. astreoides* vital rates. We developed a size-based population matrix model to estimate population growth rates ( $\lambda$ ) and determine the demographic transition(s) that contribute the most to spatiotemporal differences in  $\lambda$ 's. The model was parameterized by following the fate of 100 colonies for each species from 2012 to 2014 at two contrasting coral reef sites in eastern Puerto Rico.

Survival rate of colonies was similar for both species (more than 60 % survival at both sites and years). Demographic transitions varied, with a significant interaction between location on colony fate for both species. Spatiotemporal variations in  $\lambda$  were also observed. During the first year, populations of *O. annularis* exhibited  $\lambda$ 's below equilibrium (0.817 and 0.694), followed by a decline at both sites (0.700 and 0.667) during the second year. Populations of *P. astreoides* showed higher  $\lambda$ 's during the first census period (0.898 and 0.894) with a decline at one of the sites (0.681 and 0.893) during the second census period. Differences in  $\lambda$ 's in *O. annularis* within both sites were caused by a decrease in the probability of retrogression of medium to small -sized colonies for the first census period and the increase of stasis of large-sized colonies for the second year. However, for *P. astreoides* colonies, the differences in  $\lambda$ 's were due to an increase in the probability of stasis of large-sized colonies for the first year and a reduction of the stasis of this size class for the second year. Since vital rates and population growth were similar at both sites for both species we consider both species to be resilient to environmental stress. Our data also indicates that spatial variability in vital rates of both species was higher than temporal variability for the two years that the colonies were followed.



## PHYSIOLOGICAL IMPACT OF THERMAL STRESS IN THE SCLERACTINIAN CORAL *PORITES ASTREOIDES*

Neidibel Martinez<sup>1</sup>, Loretta Roberson<sup>1</sup>

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Coral reefs face a number of environmental changes, chief among them rising temperatures, with consequences that are not entirely understood. A rise in sea surface temperature can affect physiological processes in different ways during each development stage, leading to higher or lower growth rates, or decreased survivorship.

Here we determine the impact of thermal stress on photosynthesis and growth in *P. astreoides* at different developmental stages. Photosynthetic efficiency (Fv/Fm) of adults and larvae were measured using a Diving PAM (Walz). Growth rates of adults were measured using the buoyant weight technique and larval growth rates (planar area) were measured using light microscopy and Image J-Fiji software.

The preliminary data for both stages show high values of effective quantum yield (Fv/Fm) when exposed to a temperature of 30°C, which may suggest an ability to acclimate to higher temperatures. With an exposure time of five days however, there was a reduction in effective quantum yield, indicating that in the long term this may be a stressful condition for corals. We see similar responses in growth rates at 30°C for adult and larvae stages. This suggests that *P. astreoides* is relatively tolerant to high temperatures but that they are dependent on diurnal temperature decreases to avoid a build-up of damage to the photosynthetic machinery.

## DEMOGRAPHIC DYNAMICS OF THE COMMON DEMOSPONGE *IRGINIA FELIX*

Fabiola Rivera-Irizarry<sup>1,2</sup>, Jaime S. Fonseca-Miranda<sup>2</sup>, Yesenia Bruno-Laureano<sup>1</sup>, Alex E. Mercado-Molina<sup>1,2</sup>

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Sponges are one of the principal benthic components of Caribbean coral reefs. Despite the fact that they have multiple functional roles, little is known about their demography and ecology. Here, we present a demographic study of the common demosponge *Ircinia felix* performed at Tamarindo Bay, Culebra, Puerto Rico. Preliminary studies comparing size structure of two populations within Tamarindo Bay, Tamarindo North (TN) and Tamarindo South (TS), indicate that sponges at TN are significantly larger than sponges at TS. These data served as baseline for the present comparative study in which we aim to determine whether such spatial differences in population size structure can be explained by differences in rates of survival, growth, and/or recruitment.



Significant differences were only observed when comparing growth rates. We found that the noticeably high presence of gorgonians in TN in comparison to TS is likely responsible for such differences, given that sponges associated to gorgonians in TN had a significantly greater growth rate than non-associated individuals. Nevertheless, the fact that rates of survival and recruitment were similar between localities may be the causal factor for the lack of significant difference in population growth rates ( $\lambda$ ) which varied between TN ( $\lambda=0.90$ ; C.I.: 0.790-1.311) and TS ( $\lambda=0.80$ ; C.I.: 0.736-0.938). Interestingly, elasticity analyses suggest that the major contributor to  $\lambda$  at TN was survival of large sponges whereas at TS survival of small individuals contributed the most; suggesting that *I. felix* is able to adapt to site-specific environmental conditions by means of life history traits plasticity.



## CORAL REEFS AT RISK: SRI LANKAN CONTEXT

P.B. Terney Pradeep Kumara<sup>1,2</sup>, P.A. Kushlani N. Dissanayake (speaker)<sup>1,3</sup>, Aziz Hasan<sup>3,4</sup>

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Sri Lanka has productive coral ecosystems encompassing 2 % of its coastline. The reef habitats harbour a diverse array of biota, with 208 stony coral species, 35 soft coral species and over 900 species of shore fish. The tourism and fisheries driven economy of the country highly benefits from the ecosystem functions and services provided by the coral reefs. At present, due to natural and anthropogenic disturbances, these fragile ecosystems are at risk. Many impacts identified were intense, localized and site specific.

Due to the recent El Niño (2016), the majority of reefs were severely affected at the northwest and southern coast, where nearly 100 % bleaching was observed in some reefs. Corals at the North and East coast recovered well, but communities at the South coast died, resulting in < 5 % live coral coverage (eg. Polhena reef). Fast growing macroalgae, particularly *Halimeda* spp. and corallimorpharians, outcompete corals, which is significant in Pigeon Island Marine National Park (PIMNP). The temporal trend of its spread reflects signs of a phase shift from corals to algae-dominated habitats. Crown-of-thorns-starfish (COTS) were only recorded in Bar reef and PIMNP, but the impact was severe in PIMNP, contributing 61% to loss in coral cover. The invasion of algae and COTS may be due to nutrient enrichment in the waters, which is closely linked to flash flood pattern observed in the country. Although there are few studies on water quality, especially in PIMNP, nutrient values are in an unacceptable range for coral health.

Rapid urbanisation and tourism development related pollution exacerbate the adverse effects of climate change in the shallow reefs at the western and southern coast. Unregulated tourism activities, such as coral trampling, snorkelling, diving, bathing, boat movements, coastal constructions and unsustainable fishing practices cause profound effects in many reef areas. All these chronic stress conditions ultimately contribute to decimating the reef ecosystem in Sri Lanka. The protection measures of reefs in Sri Lanka is short-sighted and lack of management is frequent. In depth knowledge on dynamics and population connectivity in reef habitats is indispensable to make sound decisions coupled with the active participation of the local people, in order to safeguard these sensitive systems in the long run.

## CONNECTIVITY OF CORAL REEFS IN THE INDO-WEST PACIFIC

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A fundamental question in marine ecology is the connectivity of populations: are they open or closed? Most marine animals of coral reefs are rather sedentary. Adults are strongly site attached and connectivity among populations can only be facilitated by pelagic early life history stages (eggs and/or larvae). In an open population the majority of the offspring will not recruit to the parental population, but will disperse and recruit to other populations. In the contrary, offspring of a closed population will mainly recruit to the parental population, which is also called self-recruitment.



Connectivity of populations is a key element for resilience, which is the ability of ecosystems to absorb shocks, resist phase-shifts, and regenerate after disturbances. Therefore, the degree of connectivity among populations is crucial for re-colonisation and knowledge about connectivity is important for the management of marine protected areas.

Since the open ocean does not show any obvious barriers for dispersal, it was generally assumed that marine populations are open. However, recent studies have shown restricted connectivity in many different coral reef taxa and a substantial amount of self-recruitment in coral reef fish. Examples of different taxa, such as anemonefish, sea stars and giant clams show congruent patterns of genetic population structure in the Indo-West Pacific, which can be attributed to Pleistocene sea level fluctuations separating populations, as well as contemporary ocean currents.



## GENETIC CONNECTIVITY OF THE SKUNK CLOWN FISH IN THE INDIAN OCEAN USING TWO TYPES OF MARKERS

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Knowledge of connectivity, the exchange of individuals among populations on coral reefs, is vital for a correct spacing of marine protected areas (MPAs). For almost all coral reef associated fishes dispersal between reefs in this patchy environment is limited by a pelagic larval stage of several weeks or month. This study uses the Skunk Clownfish (*Amphiprion akallopisos*) as a model species to assess connectivity. It has a disjunct distribution, occurring in the Western Indian Ocean (WIO) and the Eastern Indian Ocean (EIO), separated by more than 4,500 km of open ocean. We use a combination of mitochondrial (mtDNA, control region) and 15 highly polymorphic microsatellite markers. Fin tissue of 394 individuals from 21 different sites in the WIO (Kenya, Tanzania, Madagascar, and Mozambique) and the EIO (Indonesia) was analysed.

Mitochondrial and nuclear markers concurred in detecting strong population structure between the EIO and the WIO populations (AMOVA:  $\phi_{ct} = 0.63$ ;  $F_{ct} = 0.10$  respectively,  $P < 0.001$  for both), and panmixia within the EIO. Within the WIO, however, results were different depending on the marker. With mtDNA, a genetic break was detected between the East-Madagascar population of St-Marie and all other populations. Microsatellite markers also identified a genetic differentiation between Madagascar and the East African coast, but the break was located more to the West of Madagascar. Microsatellite also revealed differentiation between the northern Kenyan populations and all other populations, not detected by mtDNA. Both genetic breaks can be explained by dominant sea surface currents that promote larval retention in the Mozambique Channel, creating a barrier to dispersal across the channel, and the influence of the Somali Current which may hamper dispersal towards North-Kenya from populations further South. Alternatively, the differentiation of the North-Kenyan populations may be driven by hybridization with sister species *Amphiprion nigripes*, occurring in the Central Indian Ocean.

## SERIATOPORA HYSTRIX, A CORAL WITH SHORT PELAGIC LARVAL DURATION, REVEALS CLEAR GENETIC SUBDIVISION ALONG THE EAST AFRICAN COAST

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Coral reefs are declining at an alarming rate, primarily due to local disturbances as well as global events such as mass bleaching. The ability of coral reefs to adapt to, and recover from such environmental stressors depends highly on population genetic diversity and connectivity among reefs. Connectivity between coral populations can be influenced by the life history of a coral species, the geographic location of the reefs and oceanographic barriers between populations.

The aim of this study is to determine the genetic diversity, population structure and connectivity of the widespread reef-building coral *Seriatopora hystrix* in the Western Indian Ocean and Red Sea. It is hypothesised that the life history traits of *S. hystrix*, such as the brooding reproduction mode and short pelagic larval duration (PLD), lead to short-distance dispersal resulting in high levels of genetic subdivision.

A total of 285 samples were collected from 12 sites in Saudi Arabia, Kenya, Tanzania, Mozambique and Madagascar. The coral fragments were genotyped using 10 microsatellite markers. Analyses included population genetic estimations of diversity and differentiation, principal coordinate analysis, Bayesian clustering approaches and migration rates.

A clear genetic break was found between populations in the Red Sea and East Africa, most likely due to limited exchange through the Bab al Mandeb strait, which connects the Red Sea to the Indian Ocean. Sites in Madagascar are also highly differentiated, only showing limited exchange with sites in Mozambique. The Bayesian cluster analyses revealed no obvious genetic break along the East African coast, but clearly indicate a latitudinal gradient, which can be explained by the influence of the northbound East African Coastal Current carrying larvae northward. Sites surrounding the Northern Mozambique Channel had a higher level of genetic diversity compared to other locations, congruent with the higher species diversity found in this area.

These results indicate that it is essential to implement or extend several marine protected areas to maintain connectivity between populations of this species over short distances and emphasise the need for protection of the reefs in the Northern Mozambique Channel as these can act as a source of genetic diversity for lower-diversity reefs downstream.



# SESSION 15

## FOOD PRODUCTION AND BIODIVERSITY CONSERVATION

### Chairs:

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In the context of the dramatically declining tropical biodiversity and an increasing demand for food, the reconciliation of both biodiversity conservation and agricultural food production is one of the major challenges of the 21<sup>st</sup> century. Whereas the biodiversity conservation benefits of agroforestry as compared to more intensively managed agricultural land have been demonstrated, evidence is also mounting that many tropical plant and animal species do require undisturbed tropical forest to survive. Furthermore, agroforestry often comes at a yield cost as compared to more intensively managed agricultural land. When demand for food is increasing, this may imply that the extent of the additional land area required to meet this demand will be higher under an agroforestry scenario than under a scenario of agricultural intensification, at the cost of primary forests.

To feed this ongoing debate with hard data, this session welcomes all contributions that provide insights in both the biodiversity value of tropical agroforestry systems and in the ecosystem services that they provide. Especially welcomed are talks that explicitly contribute to resolving the land sharing vs. land sparing debate in tropical ecosystems. Furthermore, this session will especially focus on the role of indigenous fruit tree species (IFTs) which can supplement daily diets and ensure balanced nutrition. IFTs are adapted to local conditions and provide fruits even when other crops fail. Due to their potential to improve livelihoods also in harsh conditions, IFTs could be used to adapt farming systems to climate change by enhanced cultivation of wild and domesticated IFTs, which may likewise contribute to the conservation of the species genetic resources. Integrating IFTs in farming systems may also provide further ecosystem services such as improved microclimate, carbon sequestration, enhanced soil quality and increased agricultural biodiversity in farming landscapes. However, the development of successful conservation and sustainable use strategies requires information on the species' biology and ecology. In addition, detailed knowledge is needed in the fields of agronomy/horticulture and of social/economic sciences. In this session, we also present recent findings of multi-disciplinary investigations in ecologically and economically significant IFT species to understand relationships between intraspecific diversity patterns, human impact and environmental conditions. Presentations may cover topics such as molecular markers, morphological variability, nutrient contents, propagation methods, conservation strategies, niche modelling, sustainable resource use, ethnobotany and traditional knowledge regarding IFTs.

## S15-001 - FOOD PRODUCTION AND BIODIVERSITY CONSERVATION

### INDIGENOUS FRUIT TREE SPECIES (IFTS) ARE A RELIABLE SOURCE OF NUTRITION AND ENTERPRISE FOR THE FUTURE IN GABON

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Gabon – a heavily forested country of 1.6 million people – has experienced rapid urbanisation over the past 60 years. However, up to 400,000 people remain in forest villages and agricultural production in the country is minimal. Products harvested from IFTs still form an important nutritional and cultural role for both rural and urban dwellers. However, in a context of environmental change - forest loss and degradation and climate change - how do we expect the phenology of tropical trees to respond? Will IFTs be a reliable resource in the future?



We identified important IFTs (seven species, 76 individuals) from a larger sample (70 species, 856 individuals) of forest trees monitored each month for reproductive phenology since 1986 at Lopé National Park. Using a Fourier-based approach, we identified dominant reproductive cycles for all species and assessed change in reproduction over time. We also interviewed forest-dependent people from the Gabonese interior to better understand indigenous knowledge of the reproductive phenology of one of the IFTs, Moabi (*Baillonella toxisperma*, Sapotaceae). Similar to the closely related Argan and Shea or Karité oils, Moabi has been the focus of an artisanal enterprise to develop supply of nut oil for commerce in urban areas.

Of the IFTs, five had strong annual reproductive cycles, but two – *B. toxisperma* and *Dacryodes normandii* - were more chaotic and unpredictable. Despite finding reduced predictability over time in reproduction for many species at Lopé, we found no evidence of fruit decline for the seven IFTs. Villagers were well acquainted with the seasonality of Moabi flower and fruit production but also appreciated the unreliable inter-annual phenology. They were unable to explain this variability but were able to predict fruiting events within a season from other phenological signs.

Despite a context of change, we find evidence that IFTs will remain a reliable source of nutrition and enterprise for the future in Gabon.

#### Merian Award Applicant



## GENETIC RESOURCES OF *ADANSONIA DIGITATA* L. IN EAST AFRICA: PREDICTION OF PERSISTENCE UNDER CHANGING ENVIRONMENTAL CONDITIONS AND LAND-USE

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Drylands of sub-Saharan Africa have been undergone significant changes in climate, environmental conditions and land-use. Persistence of species growing under changing conditions strongly depends from their genetic resources allowing for immediate and long-term adaptation to their habitat. *Adansonia digitata*, also known as baobab, is one of the most important indigenous fruit tree species for food security and subsistence of local communities. Morphological variation of the tree species is high, and formation of special adapted variants is expected. Verification and thus a classification of the species' variability is missing, i.a., explained by only few genetic analyses especially in its eastern distribution range. Determination of a species' variability, e.g., ecotypes, landraces, varieties, increases the development of efficient conservation programs and sustainable management strategies in the view of changing climate and environmental conditions, and land-use.

A detailed survey was performed to investigate genetic resources of *A. digitata* in Southeast Kenya. Phenotypic analyses under field conditions were added by leaf morphological and molecular analyses using microsatellite markers. In general, variation is high and significantly differentiated despite the limited regional scale of the study. For example, strong differentiation of genetic resources was found between inland and coastal populations regarding phenotypes and genetic variation, which cannot exclusively be explained by geographic distances among them. Structure of genetic resources rather indicates for the existence of variants adapted to special conditions in their habitat. Such association of variation to special conditions can be interesting to conserve the species. Moreover, knowledge of adaptive variants increases the success of breeding and management strategies in order to persist changing habitat conditions.

## DOMESTICATION OF BAOBAB (*ADANSONIA DIGITATA* L.) IN KENYA: PAST SUCCESSES AND PLANNED ACTIVITIES

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Baobab (*Adansonia digitata* L.) is an important indigenous multi-purpose tree of semi-arid sub-Saharan Africa. Leaves and fruit pulp are highly nutritious and are used for home consumption and sale at domestic and – for fruit pulp – export markets. In Kenya, however, baobab can be regarded as underutilised and little is known regarding its characterisation, population structure and use levels. The high potential of baobab products to contribute to improved nutrition and livelihoods of rural communities in Kenya together with claims of decreasing abundance of baobab trees call for increased efforts in its domestication and cultivation. This presentation aims at summarizing results of past studies on morphological and genetic diversity of Kenyan baobabs, the nutritional value of fruit pulp, the species' population structure and first successes in its vegetative propagation. In addition, planned activities towards characterisation and domestication of baobab in Kenya in the frame of the new 'BAOFOOD' project will be presented.

For the performed scoping studies, the status of baobab populations was evaluated along the road from Voi to Taveta and fruits of 64 baobab trees from a transect from Kibwezi to the coast were characterised regarding morphology (using a newly developed descriptor list for baobab) and nutrient contents (using standard AOAC methods). Genetic diversity was determined by using microsatellite markers. Two selected mother trees were used as scion materials for grafting experiments at ICRAF's nursery in Nairobi.

The surveyed baobab populations were very patchy with high tree densities or young baobabs only documented in some areas. The morphological study revealed a high diversity of traits, including fruit weight (range 62-627 g, mean 172). Also pulp nutrient contents varied largely, e.g. for vitamin C (range 63-311 mg per 100 g edible portion, mean 175). Molecular marker analysis revealed high genetic diversity reflecting the high morphological diversity. The grafting trial resulted in a mean survival rate of 63%. Planned research activities will extend studies on morphological diversity and population structure of baobab in Kenya and repeat grafting experiment to increase survival rates. Superior mother trees will be identified and manuals for sustainable use and propagation of baobabs developed.



## POSITIVE AND NEGATIVE EFFECTS OF COFFEE MANAGEMENT IN SW ETHIOPIAN LANDSCAPES

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Coffee is one of Ethiopia's most important crops generating income for local small holder farmers as well as the country. It is also an important cultural asset for the country. The question of whether coffee plays a positive or negative role for biodiversity conservation in Ethiopia is complex. Here, I summarize some evidence of both aspects to give fuel to discussions of how to reach both the goals of biodiversity conservation and food security.

Coffee is grown primarily at elevations between 1500 and 2000. In two landscapes in SW Ethiopia conversion of forests to open agricultural fields was larger at higher altitudes than at coffee growing altitudes, implying a positive role for coffee in conserving tree cover. This could be both through the widespread use of shade coffee, but also for coffee management as a buffer for preventing penetration into deeper forests.

Coffee agroforests or semi-forest coffee systems (which is the name of the most common type of coffee management system in SW Ethiopia) has fewer birds than natural forests. Also the composition of tree species differs from natural forests. Importantly this pattern is revealed with a time lag effect, whereby farmers slowly replace tree species.

Still, however, when coffee is present in the landscape (compared to for example Khat or annual crops) there is substantial biodiversity in terms of both forest species, but also generalist species that need trees and complexity and contribute to a rich agroecological biodiversity.

Since coffee is such an important crop in regulating both economy, local biodiversity and landscape tree cover patterns we need to utilize the positive sides while avoiding the negative sides of coffee management when searching for win-win solutions to the biodiversity – food security goals in SW Ethiopia.

## BIODIVERSITY AND CARBON STORAGE CO-BENEFITS OF COFFEE AGROFORESTRY ACROSS A GRADIENT OF INCREASING MANAGEMENT INTENSITY IN THE SW ETHIOPIAN HIGHLANDS

Koen Vanderhaegen<sup>1</sup>, Lore Geeraert<sup>2</sup>, Jan Mertens<sup>2</sup>, Maarten Van Geel<sup>2</sup>, Raf Aerts<sup>1</sup>, Olivier Honnay<sup>2</sup>, Bruno Verbist<sup>1</sup>, Bart Muys<sup>1</sup>, Matthias De Beenhouwer<sup>2</sup>

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Agroforestry is a way to reconcile biodiversity conservation, food production and the delivery of other ecosystem services in tropical landscapes. One such a key ecosystem service, especially in the light of climate change mitigation, is carbon storage. Increasing human disturbance and management intensification, however, are known to affect the carbon storage potential of forests. In this study we assessed how carbon stocks in Ethiopian Afromontane forests co-varied with their biodiversity, and with increasing management intensity for the production of Arabica coffee. We also broadened our scope to the whole landscape and assessed the biodiversity conservation and carbon storage potential of all land uses. We quantified above- and belowground carbon stocks across a gradient of agricultural intensification ranging from natural forest, over two different coffee agroforestry systems, to intensified shade plantations. Ground beetle and woody plant diversity was defined based on the same plots.



We found that carbon stocks in natural forests ( $413 \pm 55.6 \text{ Mg ha}^{-1}$ ) and in the most extensively managed agroforestry systems ( $387 \pm 50.0 \text{ Mg ha}^{-1}$ ) were significantly higher than those in the more intensified agroforest system ( $258 \pm 39.4 \text{ Mg ha}^{-1}$ ) and in shade plantations ( $219 \pm 22.8 \text{ Mg ha}^{-1}$ ). Diversity of woody plants, but not of ground beetles, declined with increasing management intensity and decreasing carbon stocks. The carbon account of the 106 ha studied landscape window emphasized the importance of non-forest land uses, storing 80% of the total carbon stock. Agroforests were found to harbour almost half of all encountered native tree species. To keep these extensive land use systems economically viable, which is required to avoid management intensification and associated carbon and biodiversity losses, we advocate payments for ecosystem services (PES) at the landscape scale.





# SESSION 16

## PALAEOECOLOGY OF TROPICAL ECOSYSTEMS

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Tropical ecosystems are important for their unique biodiversity and for the services they provide both locally and globally. As a consequence, conservation and protection of these ecosystems are the main focus of much of scientific research internationally. However, traditional conservation strategies that aim to maintain the current status of a particular habitat, are not realistic or desirable. New approaches aim to find a balance between biodiversity conservation and environmental variability caused by climate change, land use change and economic development in tropical countries. One example is the development of more sustainable land use on tropical peatlands using economically or socially important plants which naturally grow in waterlogged conditions. By both keeping peatlands wet and providing a source of income for communities, this approach enables sustainable socio-economic development that is consistent with climate change mitigation as the below ground carbon store is maintained. As in the example above, to be successful and realistic management strategies should be adaptive and incorporate an understanding of the full range of dynamic variability inherent in natural ecosystems, including anthropogenic activity. Palaeoecological research has emerged as a fundamental tool which complements modern tropical ecology by adding a much longer temporal dimension than it is possible to achieve by direct ecological observation alone.

We welcome contributions from tropical palaeoecology (typically millennial to centennial timescales) and dendrochronology, especially where an interdisciplinary and/or multi-proxy approach is taken.

The goal of the session will be on the presentation and discussion of case studies where palaeoecological and dendrochronological tools have been used to obtain knowledge or test hypotheses on: climate change and adaptation (e.g. vegetation dynamics, taxa reshuffling and migration); ecosystem baselines, thresholds, resilience and tipping points; ecosystem changes (e.g. biodiversity over time); fire-ecosystem-climate interactions; wetland functions and development in time; mode and time of establishment of cultural landscapes and the effects of historic and prehistoric management and land use on biodiversity and ecosystem functions.

## THE CONTRIBUTION OF PALAEOECOLOGY TO TROPICAL PEATLAND SCIENCE

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The importance of peatlands in the global carbon cycle is becoming increasingly appreciated, yet the focus so far has been overwhelmingly on temperate and boreal peatlands. Tropical peatlands are now also emerging as important carbon stores but they are much less well understood than their northern counterparts. Efforts to model peat accumulation and distribution in northern systems and, ultimately, incorporate them into dynamic earth system models, are now extending to tropical systems but are constrained by our limited knowledge about low latitude peatlands, particularly those only recently described, e.g. in the Amazon and Congo basins.



Key parameters such as water table variability, vegetation composition, productivity and decomposition rates, long-term rates of carbon accumulation, and sensitivity to climatic change and other disturbances, remain poorly known for the tropics. Some of these parameters will require concerted monitoring efforts while others require the long-term (decadal to millennial) perspective provided by palaeoecology which encompasses a wider range of variability than it is possible to capture using direct measurements alone. The role of palaeoecology in peatland science is particularly pertinent because of the ability of peatlands to record their own history *in situ*; using records in peat cores we can “coax history to conduct experiments”<sup>1</sup>.

This presentation will review recent examples of the contribution palaeoecology can make to our understanding of the processes, dynamics and functioning of tropical peatlands. It will consider its specific contributions to improving models of peat accumulation and distribution, and discuss how the resulting improvements in understanding can inform conservation and management decisions in relation to these important and highly threatened ecosystems.

<sup>1</sup>Deevey, E.S. (1969) *BioScience* 19, 40-43.



## HOLOCENE VEGETATION RESPONSES TO CHANGING ENSO REGIMES IN THE SOUTHWESTERN ANDEAN CORDILLERA, ECUADOR

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Ecosystems in the Ecuadorian Andes support an exceptionally high botanical biodiversity and endemism. The presence of many endemic and specialized species makes these ecosystems fragile and vulnerable to climate change. Temperature and precipitation in the Ecuadorian Andes are strongly affected by the El Niño – Southern Oscillation (ENSO). The future frequency and magnitude of ENSO in a world with global climate change is still highly uncertain and topic of intense debate. Hence, future impact of the ENSO on the fragile ecosystems of the high Andes remains uncertain. The consequences of variations in ENSO activity for regional hydrology and vegetation composition can be assessed by studying past environmental changes from long sediment records under changing ENSO regimes. One of the most detailed continuous records of past long-term El Niño dynamics from a terrestrial setting is the Laguna Pallcacocha record from Cajas National Park, Ecuador. Previous analysis revealed hundreds of El Niño-driven light-coloured inorganic, clastic laminations, in the dark organic lake sediments which reflect increased frequency of El Niño events during the past 5000 years, with millennial-scale oscillations. While used worldwide as a key record of ENSO variability, the direct effect of increased rainfall events on the regional vegetation has not been investigated.

We present the first Holocene pollen record from Laguna Pallcacocha that reveals clear responses of vegetation to phases of high ENSO frequency. Especially, the *Alnus* genus, occurring in the montane forest belts, is clearly responding to increased frequency of El Niño events during the past 5000 years. Additionally, an ultra-high resolution pollen analysis of the last century allows to calibrate interannual changes in pollen deposition to regional precipitation and temperature variability forced by ENSO. This analysis helps to bridge the gap between long-term vegetation and annual-scale responses to ENSO variability.

## SOUTH AMERICAN SAVANNA AND FOREST DYNAMICS DURING THE LATE QUATERNARY

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Several late Quaternary pollen records from savanna and forest-savanna transition regions of the South America, north and south of the equator, provide insight on past savanna and forest dynamics. During glacial times, environmental changes in savannas are spatially complex. Some records show either stable savanna where forest exists today, and some records show signs of a repeated alternation between forest and savanna. During the full glacial period, neotropical savannas, both north and south of the equator, covered large areas due to markedly drier conditions. The Amazon rain forest and Atlantic rainforest area must have been strongly reduced. In the southern tropical regions of South America, the savanna area was reduced and replaced by subtropical grassland by cold climatic conditions during glacial periods. Early Holocene distribution of savanna was much larger than during late Holocene periods, reflecting drier conditions in most of the tropical South American regions than today. There is in different regions a marked expansion of forests after about 6000, 3500/3000 and 1000 years. The role of past fire will be discussed. The general synchrony of palaeoenvironmental changes since the full glacial, from neotropical savanna sites north and south of the equator, suggests that changes in the latitudinal migration of the Intertropical Convergence Zone may have played an important role. The movement of the high-pressure cell over the South Atlantic and changes in frequency of the tracks of the Antarctic cold fronts were also important.



## LATE QUATERNARY VEGETATION AND ENVIRONMENT RECONSTRUCTION BASED ON POLLEN AND DINOFLAGELLATE CYSTS IN EASTERN SOUTH AMERICA

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Pollen, spores and dinoflagellate cysts of the marine sediment cores GeoB 2107-3 and GeoB 6211-1 located in the South Atlantic Ocean off southern Brazil have been studied by to reconstruct the vegetation as well as the environmental changes during the last glacial and Holocene period. The aim is to understand the interactions between vegetation and ocean and the role of climate dynamics on the vegetation over long time periods.

The results show that during glacial times, grassland was the dominant vegetation in eastern South America. Tropical rainforest was markedly reduced, indicating cold and dry climatic condition. During glacial times, due to the low sea level, grassland and patches of subtropical forest covered the exposed continental shelf. Araucaria forest on the highland was frequent during early glacial times and rare during mid- and last glacial maximum (LGM) period. *Nothofagus* pollen and dinoflagellate cysts indicate that the Malvinas Current which derived from the sub-polar front had a markedly stronger influence particular during the LGM period. During Holocene period, the expansion of Atlantic rainforest and tree ferns indicate humid and warm climate condition. During the late Holocene, the Araucaria forest expanded on the highland. Dinoflagellate cysts indicate the increase of the sea-surface temperature in the South Atlantic Ocean during the Holocene. The results suggest that changes in the South Atlantic Ocean had a strong influence on the vegetation dynamics in South American continent during last glacial and Holocene times.

**Merian Award Applicant**

## CHARCOAL ARCHIVES REVEAL HOLOCENE FIRE-VEGETATION-CLIMATE LINKAGES IN CENTRAL AFRICA

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Understanding the role of different drivers of past African climate and vegetation change may contribute significantly to our understanding of forest dynamics observed over the last decades and of trends expected for the near future. Wetland ecosystems and lakes provide high-quality sedimentary archives which integrate over large regional scales. Unfortunately, wetlands and lakes with useful stratified sediment layers are absent in large parts of Central Africa, impeding our knowledge of pan-African past climate and vegetation dynamics. We therefore use another archive that can be highly complementary to the more established fields of lake and wetland sediment analysis: charcoal from terrestrial soil layers. Central African charcoal archives have hardly been explored, mostly due to the lack of straightforward identification techniques coping with species-rich environments. Therefore we recently developed a transparent charcoal identification procedure for Central Africa. Moreover, we illustrated how combining imaging techniques can provide optimal visualization of charcoal anatomy, enabling evaluation of specific difficulties encountered during charcoal examination. This eventually leads to high-level identification of charcoal taxa.

Here we present how these techniques resulted in charcoal records demonstrating a direct temporal link between Holocene palaeofire, vegetation change, climate and humans in the Democratic Republic of Congo.

We find three distinct periods of local palaeofire occurrence linked to well-known Holocene drought anomalies: the 8.2 ka BP event, the third millennium BP rainforest crisis and the Medieval Climate Anomaly. Charcoal identifications show increased occurrence of pioneer and woodland savanna taxa during and just after these disturbance periods. Furthermore, first results from the Central Congo basin indicate that disturbance through increased burning by humans after 0.5 ka BP could be at the origin of present-day patchy distribution patterns of long-lived secondary forest stands. An example is a forest type dominated by the famous flagship species *Pericopsis elata*. These results support the notion of a dynamic forest ecosystem at multi-century timescales across the central African rainforest.



## ANTHROPOGENIC DISTURBANCE AND RESILIENCE OF A TROPICAL PEATLAND: A MESSAGE FROM THE PAST

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Pressures on peatland in Southeast (SE) Asia due to land use and conversion escalate in the past few decades, following the increase in population demand for food, settlements and resources. In order to prevent loss and to maintain the important functions of this ecosystem, management strategies are urgently required. Historical information can provide valuable knowledge on ecosystem response to disturbance and their resilience. Thus, in order to create effective management strategies on peatland, it is important to include a historical perspective.

Unfortunately, knowledge on past disturbance of peatland in SE Asia remains a large gap, particularly of how past human interventions controlled vegetation composition and C accumulation in peatlands. Due to lack of evidence, extensive human disturbance in tropical peatland is considered to be novel. Thus, understanding the impact of peatland resilience to human-induced disturbance prevails to be a huge challenge.

By conducting palaeoecological study in a peatland on the coastal area of Jambi, Central Sumatra, we found strong evidence of extensive human disturbance from 1100 to 500 years ago, indicated by the openness in vegetation and decreased ecosystem ability to accumulate peat and carbon. The disturbance is noticed to be resulted from logging and grazing activities conducted by the inhabitants of Malayu Empire in the 9<sup>th</sup> to 14<sup>th</sup> century, whose temple remains is located close to the peatland. After the site abandonment following the Empire migration to the hinterland area, the record interestingly showed that ecosystem has recovered. Additionally, the record suggests that socioeconomic condition indirectly affected the peatland dynamics and its function.

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## PREHISTORICAL AND HISTORICAL HUMAN-LANDSCAPE INTERACTIONS AT THE LINDU PLAIN AND THE LINK TO CLIMATE VARIABILITY OF CENTRAL SULAWESI (INDONESIA)

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The Lindu plain, located in the northern mountainous region of the Lore Lindu National Park in Central Sulawesi (Indonesia), provides many ecosystem services and harbors a unique biodiversity. Multi-proxy palaeoecological analyses of a 123-cm long sediment core from Lake Lindu (-1.339789, 120.071049; 1000 m asl) were used to reconstruct the vegetation, climate and fire history at the Lindu plain.



Combined results reveal that, during the past 1000 years, the Lindu plain was modified by human activities. Evidence of frequent burning and shifting cultivation from AD 1000 to AD 1200 might be related to the metal age population which erected megaliths in the Central Sulawesi area. From AD 1200 to AD 1700 wetter climate conditions established. At the same time, decrease of macro-charcoal concentrations and pioneer vegetation indicate that a more permanent use of the landscape at the Lindu plain occurred. Following a phase of forest recovery from AD 1730 to 1910, the most recent part of the Lake Lindu sediment record shows a trend towards deforestation that intensified from the late 20<sup>th</sup> century until now. A decreasing trend of the lake level started at the beginning of the 20<sup>th</sup> century as revealed by an increase in sedimentation rate and supported by low pollen concentration, palaeomagnetic data and historical accounts. Such an event has no link to the climate variability suggesting that the recent siltation of the lake is linked to increasing deforestation and human activities around the lake. This highlights the need for a better management of the forests surrounding the plain and for improved irrigation systems for agriculture.

The Lindu sediment record represents one step further defining the human and landscape history of Central Sulawesi and it highlights the potential and the need for further palaeoecological and archaeological investigations in the area.

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## THE MEMORY OF BONES: HOW HUMAN OCCUPATIONS SHAPED THE SQUAMATE DIVERSITY OF GUADELOUPE ISLANDS (FRENCH WEST-INDIES) DURING THE LAST 5000 YEARS.

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A consensus now exists concerning the existence of an ongoing mass extinction crisis affecting all organisms due to human impact on the biosphere. However, quantifying the effect of such a crisis on terrestrial vertebrates can sometimes be problematic in the case of extinctions that had occurred on unknown taxa. Such phenomena are frequent on islands because of the vulnerability of their endemic biotas that are often quickly eliminated by human habitat destruction and introduction of exogenous competitors and predators. The only solution to obtain information about extinct faunas is therefore to search for subfossil deposits containing osteological material, the last remaining evidence of their original condition.

This study is focused on the subfossil snakes and lizards from the Guadeloupe archipelago. Squamate remains collected in 30 sub-fossil deposits, dated from the Late Pleistocene (30 000 B.P.) up to present, were studied. The goal of this work was to analyze the evolution of squamate species over time on these islands and to investigate the impact of pre-Columbian (between 3000 BC and 1492 AD) and later European human populations on this fauna. The results show the strong stability of the squamate biodiversity of Guadeloupe through Late Pleistocene and Holocene climatic transition. However, after the first minor perturbation occurring after pre-Columbian Human colonization, fossil data indicates that between 47 and 56% of Guadeloupe squamate populations went abruptly extinct after European colonization and partly replaced by exogenous taxa.

These results show the strong impact of modern extensive agriculture of sugarcane and introduction of exogenous predator on Guadeloupe fauna that was partly decimated between the 17<sup>th</sup> and the 20<sup>th</sup> century before being studied and recorded by scientists. This work highlights the interest of studying late quaternary fossil faunas to better understand and quantify the impact of past and present Human societies on faunas.

## EIGHT CENTURIES OF SUSTAINABLE FOREST EXPLOITATION BY THE ANCIENT MAYA AT NAACHTUN (NORTHERN GUATEMALA, 150-950 CE)

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Researchers have long argued that the ancient Maya actively exploited forest resources, but the nature of these forest economies and their long-term impact on the tropical landscape are still vigorously debated, due to a lack of systematic studies. Specifically, archaeologists have proposed that overexploitation of the environment was one of several major factors that contributed to the collapse of the large centers in the El Mirador region at the end of the Preclassic period (circa 150 CE), as well as the subsequent abandonment of many other Central Lowlands sites by the end of the Classic period (250-950 CE). Clearly, the exploitation and evolution of forests in the Central Lowlands is a significant component of this proposed "collapse" model, both explicitly and implicitly.



We address this hypothesis through the study of archaeological charcoal at the Classic Maya site of Naachtun\*. We systematically analyse the use of domestic firewood in different contexts over eight centuries of occupation. Wood constitutes a key economic and ecological indicator for understanding socio-environmental interactions over time. It was indeed an indispensable resource for the Maya (used for firewood, construction, craftwork, rituals, etc.) that was abundant in the local environment but nevertheless exhaustible. The data we present here show that the pattern of forest resource exploitation reflects a system closely linked to agriculture practices, and which transformed the local landscape through sustainable strategies, rather than provoking degradation.

\*Naachtun Archaeological Project, 2010-2018, CNRS UMR 8096



## NAILING THE FACTS: LEGACY OF 66 YEARS OF INDIVIDUAL TREE GROWTH IN CENTRAL AFRICA SHOWS DIFFERING GROWTH RATES

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Long-term tree growth observations are scarce in Central Africa. Permanent sample plot data on average do not go back in time further than a few decades, whereas tree ring analysis can if properly crossdated. This study combines diameter measurements with analysis of tree ring descriptors in order to link radial increment to xylem increment. The Nkulapark is a forest monitoring plot established in 1947 which lies in the Luki Biosphere Reserve (33,000ha) which is part of semi-deciduous tropical rainforest situated at the southernmost edge of the Mayombe forest near the

Atlantic Ocean (western D.R. Congo).

In this study, old records of diameter data of 6300 trees measured from 1948-1957 (INEAC 1947), were digitized and analysed. Moreover, old maps and trees with original number tags allowed us to relocate 400 trees in the field during a 2014 field campaign. Rediscovered trees were measured and the nails that carry the original 1948 number tag, can be considered as a timestamp, as the cambium was wounded that year. This provides us the unique opportunity to assess the individual long term response of these trees at the xylem level, as the distance between the nail wound reaction and the cambium can be measured.

A subset of 100 of these trees was cored adjacent to the nail for macroscopic inspection of the xylem structure as well as an assessment of the tree ring descriptors via an X-ray CT field-to-desktop toolchain. After 66 years, the average radial increment was highly variable, with some understory trees showing no radial increment at all. When the xylem structure was examined, it was shown that only a few rings were formed in understory trees, pointing out the high degree of missing rings, whereas other canopy trees showed considerable radial growth, had clear rings and thus give a reliable view on the tree's past.

## X-RAY CT-BASED HIGH-THROUGHPUT INCREMENT CORE ANALYSIS

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X-ray CT scanning is a powerful tool for non-destructive three dimensional visualization and analysis of the interior of an object. This tool has proven valuable in many different research fields and has also significant potential in tree ring research on increment cores. Not only does it minimize sample preparation, it also allows to screen, archive and study cores at different resolutions. Tree ring width measurements – on species with density-related growth ring boundaries –, density profiling as well as quantification of certain wood anatomical features can be derived from the virtual 3D core volumes.



We will exemplify the use of such a multi-resolution approach on increment cores of Central Africa, more specifically from the Mayombe forest in the Democratic Republic of Congo. Therefore, we will use the Nanowood facility of Woodlab-UGent, part of the Ghent University Centre for X-ray Tomography (UGCT). Standard cone-beam scanning at 110  $\mu\text{m}$  resolution for high-throughput screening and archiving of 33 cores up to 60 cm can be accomplished in a single run (step 1) and with related software density profiling – and in some cases tree ring analysis – is within reach (De Mil et al. 2016). When more detail is required based on the analyses of screening step 1, helical cone-beam scanning at 35  $\mu\text{m}$  resolution can be accomplished on 6 intact cores of 30 cm length in a single run (step 2) and analysis can be performed with the same software allowing tree ring boundary demarcation, density profiling (De Ridder et al. 2011, Van den Bulcke et al. 2014) and for certain species quantification of specific wood anatomical features. For resolving anatomical features at higher resolution, single growth rings of interest derived from step 1 or 2 can be scanned and analysed at resolutions between 5-10  $\mu\text{m}$  (step 3). Multi-resolution guided scanning of increment cores is as such a valuable tool for building a virtual increment core database without sample destruction.



# SESSION 17

## COMPLETE ALTITUDINAL RAINFOREST TRANSECTS

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There are only few places in the world where we can find complete altitudinal rainforest transects (CART) spanning from near sea level to the tree line limit. These transects are often amongst global maxima of species diversity. They are of particular interest to study the full range of distribution of species and the environmental or geometric effects affecting it. These transects are also needed to appreciate the biodiversity generated in a landscape by the elevational factor. They also allow species to freely migrate under the pressure of climate shifts and are crucial for the future of biodiversity conservation. On mountains not high enough to reach the limit of tree distribution or with lower elevations deforested, some phenomena, such as mid-elevations diversity peaks, can be missed simply because the observable elevation range is too short.

We propose here to review a few complete or near complete altitudinal transects spread over the tropics (Africa, South America, Southeast Asia, Oceania). It will be an opportunity to think more broadly about fundamental processes along tropical elevation gradients, and how consistent and variable they are in different regions.

## AN ELEVATION TRANSECT IN THE SOUTHERN PERUVIAN ANDES

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We report on results from over ten years of studies by the Andes Biodiversity and Ecosystems Research Group, which have focussed on understanding how ecosystem structure, functioning and tree community composition vary with elevation in the Kosñipata Valley, near Cusco, Peru. We describe how climate, hydrology, biomass and productivity vary with elevation, and their effects on the diversity of trees, epiphytes, birds and termites



The primary environmental gradient along the transect is temperature, but this appears mediated by a substantial influence from cloud immersion at higher elevations. Decomposition and nutrient cycling processes decline more rapidly with elevation than productivity and growth processes. The decline in productivity with elevation seems not to be driven by temperature but rather by increase in cloud immersion. Despite overall declines in productivity, there is no trend in the allocation of productivity between canopy, wood and fine roots. We close the overall water budget of the catchment, showing that 90% of the precipitation input comes from rainfall and 10% from cloud water interception. A number of plant morphological and chemical traits show strong gradients with elevation, and changes in ecosystem function seem largely driven by turnover in species rather than by plasticity within species. The elevation transect has provided string insights into how temperature controls the rates of autotrophic and heterotrophic processes.



## BIODIVERSITY AND ECOSYSTEM FUNCTIONING OF A TROPICAL MOUNTAIN IN THE ANTHROPOCENE

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Tropical mountain ecosystems are centers of biodiversity and maintain ecosystem functions of pivotal importance. In the past decades, human population growth has led to a dramatic expansion of human land use from mountain bases to highest elevations with little understood consequences for biodiversity and ecosystem functioning.

Here, using the most comprehensive data set of biodiversity and multiple ecosystem functions along the broad-scale climatic gradient at Mt. Kilimanjaro, we show that land use has differential, climate-dependent impacts on plant and animal communities, biotic interactions, and biogeochemical ecosystem processes. Human impact caused largest losses of species richness in less productive arid and cold ecosystems and highest rates of species turnover in ecosystems with ambient climate and high productivity. Ecological functions and ecosystem properties strongly varied with climate and were influenced to a variable degree by human land use. Our study reveals how human impact transforms biodiversity and ecosystem functioning at macroecological scales and reveals climate-land use interactions as an important component to consider when predicting biotic consequences of global change.

## MOUNT KINABALU: A CRADLE OF BIODIVERSITY

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Tropical mountains are hotspots of biodiversity and endemism, but the evolutionary origin of their unique biotas are poorly understood. Mountains may either act as “museums” where older lineages persist through evolutionary time, or as “cradles” where new species continue to be generated.



We investigated the evolutionary routes to endemism on Mount Kinabalu (Malaysian Borneo), one of the richest biodiversity hotspots on earth. We collected types of organisms with locally-endemic species, including frogs, insects, arachnids, snails, leeches, mosses, flowering plants, ferns, and fungi. The specimens were sequenced using high-throughput facilities. This enabled us to obtain a unique overview of the evolutionary routes by which Kinabalu's special biota has evolved.

We show that most of its unique biota is younger than the mountain itself and evolved from a mixture of immigrant and local lowland ancestors. However, probably as a consequence of the rapid emergence of the mountain and its unique alpine summit conditions, many of these neo-endemics have not evolved by drastic niche shifts from local ancestors, but rather by immigration of pre-adapted propagules from elsewhere.



## OUR PLANET REVIEWED 2012 BIODIVERSITY SURVEY ALONG MT WILHELM, PAPUA NEW GUINEA

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The ultimate aim of the terrestrial biodiversity survey “Our Planet Reviewed – Papua New Guinea” was to estimate biological diversity generated by altitudinal turnover of arthropod species. It took place on Mount Wilhelm, Papua New Guinea highest peak (4509 m a.s.l.), and one of the few equatorial mountains outside the Andes left with a continuous undisturbed forest from the sea level all the way to the timber line limit. An unprecedented sampling effort was concentrated over 16 days in 2012 with a semi-simultaneous sampling at eight different elevations (every 500 m from 200 m to 3700 m a.s.l.).

Arthropods were collected with various methods: flight interception traps (targeting Coleoptera), Malaise traps (targeting Hymenoptera, Diptera and Hemiptera), Steiner traps (targeting tephritid flies), beating of the understorey vegetation, and insecticide spraying on tree barks (various groups targeted). A botany survey was conducted at each elevation to characterize vegetation. An additional site, Wanang, was sampled according to the same protocol, as replicated lowland site. A series of complementary projects was also conducted until June 2014.

Our team combined international experts with local postgraduate students, paraecologists and villagers. Arthropod samples collected during the biotic survey were pre-sorted in Papua New Guinea and forwarded to taxonomists worldwide. So far project outputs included not only species discovery (over 150 new species and 6 new genera), but also direct financial benefits to landowner communities, raised profile of conservation areas, training of paraecologists and postgraduate students, education programmes and, finally, crucial biodiversity information needed for ecological analyses and conservation management.

## CROSS-CONTINENTAL COMPARISON OF THE FUNCTIONAL COMPOSITION AND CARBON ALLOCATION OF TWO ALTITUDINAL FOREST TRANSECTS IN ECUADOR AND RWANDA

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Tropical forests are key actors in the global carbon cycle. Predicting future responses of these forests to global change is challenging, but important for global climate models. However, our current understanding of such responses is limited, due to the complexity of forest ecosystems and the slow dynamics that inherently form these systems. Our understanding of ecosystem ecology and functioning could greatly benefit from experimental setups including strong environmental gradients in the tropics, as found on altitudinal transects.

We setup two such transects in both South-America and Central Africa, focussing on shifts in carbon allocation, forest structure, nutrient cycling and functional composition. The Ecuadorian transect has 16 plots (40 by 40 m) and ranges from 400 to 3000 m.a.s.l., and the Rwandan transect has 20 plots (40 by 40 m) from 1500 to 3000 m.a.s.l. All plots were inventoried and canopy, litter and soil were extensively sampled. By a cross-continental comparison of both transects, we will gain insight in how different or alike both tropical forests biomes are in their responses, and how universal the observed altitudinal adaption mechanisms are. This could provide us with vital information of the ecological responses of both biomes to future global change scenarios. Additionally, comparison of nutrient shifts allows us to compare the biogeochemical cycles of African and South-American tropical forests.



## PLANT-INVERTEBRATE-VERTEBRATE BIODIVERSITY AND FOOD WEB PATTERNS ALONG MT WILHELM AND OTHER COMPLETE ALTITUDINAL RAINFOREST GRADIENTS

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This is a review of ideas and empirical patterns of biodiversity and food web structure along CARTs - Complete Altitudinal Rainforest Transects spanning from the lowlands to the natural timberline, with particular attention to the Mt Wilhelm CART in New Guinea. Where are these transects, and what interesting questions can we ask about their biodiversity? How much do they contribute to the local and regional diversity?

We survey plants, frogs, birds, bats, butterflies, moths, leafhoppers, and ants in search of unifying patterns and key environmental as well as historical drivers of diversity. Further, what are the trends in plant-herbivore-predator/parasitoid interactions defining food web structure along CART transects? Here we can advance a number of ecologically plausible hypotheses, but are largely missing solid data to test them. Finally, what interesting experimental manipulations could we perform with communities and interaction webs to test our ideas on their dynamics at present and under changing climate?

## THE ECOLOGY OF FICUS ALONG THE MT WILHELM TRANSECTS: PLANTS, POLLINATORS AND HERBIVORES

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The Mt Wilhelm Continuous Altitudinal Rainforest Gradient is located in the Central Range of Papua New Guinea (PNG), which is both very young and geologically complex. The New Guinea region is also incredibly species rich with high levels of endemism. Here we summarise x years of research on the keystone plant genus *Ficus*, which has its centre of diversity in PNG. This genus is also widely distributed all the way from lowland forest up to the tree line at 2,700m, with half of the country's 157 species being found at our site. We will try to convince you that the genus *Ficus* is an excellent model system to study patterns in diversity and speciation. These patterns can be linked to both ecological and evolutionary processes through the consideration of the species specific pollinators and diverse herbivore communities associated with the genus.

Firstly we will explore baseline patterns in alpha and beta diversity, demonstrating a distinct mid-elevational turnover in fig community composition. This turnover is explored using a detailed set of environmental variables. Pollinating wasp communities are also explored through DNA barcoding and detailed morphological studies, revealing undocumented taxonomic diversity. We will then show how this mid-elevational turnover may be the result of more widespread barriers to geneflow mediated by climatic and biological limitations to pollinator wasp dispersal (e.g. through temperature and *Wolbachia* infection status). Such barriers might even be responsible speciation in *Ficus* along elevational gradients. Local adaptation is also likely to cascade up to the next trophic level, and we show that herbivory rates and defensive traits are correlated, despite herbivory rate itself showing a wide range of species level patterns along the gradient. Finally we present data from whole food-web studies and explain how these are structured through both experimental predator exclosures of ants and birds and the translocation of *Ficus* trees beyond their normal elevational range. We conclude with a brief discussion of the questions raised during our research and perspectives for studies at the site.



## PLANT-HERBIVORE FOOD WEBS: SUCCESSIONAL TRENDS ALONG AN ALTITUDINAL GRADIENT IN PAPUA NEW GUINEA

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Understanding the manner in which various elements of diversity interact and how local and regional diversity is generated and maintained remain key objectives of ecological studies. Despite decades of investigation, our knowledge of community assembly, persistence and dynamics is still in its infancy. To answer these questions we must look past traditional community descriptors that focus solely on a single trophic level and instead investigate the interaction between two or more levels. Here we attempt to shed light on how communities of herbivores and plants interact in local networks, and how these local networks can change along altitudinal and successional gradients.

A total of 4.4 hectares of forest was felled along an elevation gradient in Papua New Guinea. Sampling was carried out at 100 m asl, 900 m asl and 1700 m asl within both primary and secondary forest. In total over 65,000 externally feeding Lepidoptera individuals were collected using our felling approach, which allows us to effectively access typically inaccessible forest canopies. Analyses focused only on those individuals with a reliably observed trophic link and those found on trees greater than 5 cm dbh. From this, we were able to construct some of the most robust and comprehensive plant-herbivore tropical food webs to date.

We present an analysis of a range of network metrics which describe the underlying properties of network structure, from which we may gain insight into how communities assemble and remain stable. Furthermore our results can help us understand how such networks may change through the influence of forest degradation and climate change. Much of this information is completely novel, as community ecologists have largely overlooked montane forest networks and changes to networks throughout the process of succession.

**Merian Award Applicant**

## INSECT HERBIVORY ALONG CLIMATIC AND LAND USE GRADIENTS ON MT. KILIMANJARO

Henry Njovu<sup>1,2</sup>, Marcell Peters<sup>1</sup>, Ingolf Steffan-Dewenter<sup>1</sup>

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Our understanding of the patterns of herbivory along elevational gradient is critical for conservation planning and for predicting the response of insect herbivores and their functions to climate change. Here we analyzed the influence of elevation on herbivory along an extensive elevational gradient on Mount Kilimanjaro.

We tested three partly contrasting hypotheses: (a) herbivory peaks at mid elevations due to the highest primary productivity and an ambient climate supporting high densities of insect herbivores; (b) herbivory declines monotonically with elevation due to the temperature-dependence of foraging in ectothermic insects. (c) land use increases herbivory due to its negative effect on insect predator and parasitoid populations. A standardized visual estimation method was used to estimate a proportion of leaf area damaged or loss by leaf chewers, leaf miners, and/or gall formers insects. We estimated herbivory from thirty randomly selected leaves collected from each of 840 sampled trees found in 56 study plots strategically positioned along the elevational gradient.

Preliminary results show that in natural habitats herbivory increases to mid elevations and then declines again at higher elevations and that land use leads to a shift of this pattern. More details of the results will be presented during the conference as the study is in progress.



## MAMMALS AND DUNG BEETLES ALONG AN ELEVATION AND LAND USE GRADIENT ON MT KILIMANJARO

Friederike Gebert<sup>1</sup>, Marcell Peters<sup>1</sup>, Ingolf Steffan-Dewenter<sup>1</sup>

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Can differences in dung beetle diversity and ecosystem services provided by dung beetles be explained by mammal diversity?

Dung beetles (Scarabaeidae) have been recorded to be closely related to mammals and to reach their peak in African tropical savannas where the most diverse mammal fauna can be found. Dung beetles rely upon mammalian dung as a food resource for both adult and larval stages and their local declines have been linked to decreasing mammal biodiversity.

We studied the relationships between dung beetle diversity, climate, mammal diversity and dung availability in both natural and disturbed habitats along an elevational gradient from 870 to 4550 m a.s.l. on Mt. Kilimanjaro, northern Tanzania. For recording mammals, we used camera traps while we used baited pitfall trapping for recording dung beetles.

Our data suggests an exponential decline in the species richness of dung beetles with increasing elevation and a significant impact of land use. We show how the structure of dung beetle communities is related to climatic factors and resources.

**Merian Award Applicant**

## CLIMATE VARIATION ALONG THE EASTERN ESCARPMENT OF THE SOUTH ECUADORIAN ANDES

Jörg Bendix<sup>1</sup>, Katja Trachte<sup>1</sup>, Rütger Rollenbeck<sup>1</sup>, Brenner Silva<sup>1</sup>, Thorsten Peters<sup>2</sup>

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The tropical Andes of Ecuador are globally the second hottest hotspot of biodiversity. Here and elsewhere in tropical high mountains, it is intensively discussed if and how climate change might affect biodiversity. However, mostly neither biodiversity nor climate are well understood in the remote areas of tropical high mountains.

In 1998, a transect was realized in the southeastern Andes of Ecuador along the Rio San Francisco valley, ranging from 1,000 to 3,000 m a.s.l. elevation. Several research programs investigated taxonomic and functional biodiversity, ecosystem functioning and services, and environmental change impacts. Some aspects as meteorological observations could be conducted since the beginning of the research, providing a unique data set to study climate variations along the transect.

The talk will start with a short introduction to the climate along the transect, will present important aspects of cloud and rain formation processes in the area and finally discuss observed changes in the atmospheric conditions and its possible reasons.



## DROUGHT EFFECTS IN AMAZON-TO-ANDEAN FOREST

William Farfan-Rios<sup>1</sup>, Miles Silman<sup>1,2</sup>, Alexander Shenkin<sup>3</sup>, Yadvinder Malhi<sup>3</sup>

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Increases in drought frequency and duration could fundamentally shift the composition of tropical forests, altering forest structure and ecosystem function. In the last decade, two dry events associated with the abnormal sea surface temperatures were identified in 2005 and 2010, resulting in large effects on forest structure and function of the Amazonian lowland. How Andean forests respond to drought events is unknown and the causes of tree mortality following drought remain poorly understood. The aim of this study was to explore if (1) the 2005 and 2010 droughts affected tree mortality in per-humid forests across an Amazon-to-Andes elevational gradient? And, if so (2) what tree size and taxa were more vulnerable to the droughts?

The study site was in the Manu Biosphere Reserve located on the eastern slope of the Peruvian Andes. Field data was collected for adult trees in multiple censuses over a decade (2003-15) in 23 1-ha permanent forest plots. Mortality was modeled as a function of maximum climatological water deficit (MCWD), a measure of dry season water stress across the elevation gradient.

Results show high tree mortality related to MCWD. Small diameter trees were more susceptible to drought stress as well as taxa with low wood density. High tree mortality was found at the cloud base (~1500-2000m). These results quantify for the first time the negative effects of droughts in Andean tropical montane forest. It suggests that trees will not be able to tolerate multiple droughts, or at least will go through landscape-wide bottlenecks with projected droughts.

### Merian Award Applicant

## ASSESSMENT OF SOIL WATER AVAILABILITY IN TWO MOUNTAINS OF THE VOLCANOES NATIONAL PARK IN RWANDA

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This study assessed water availability in soil of the Volcanoes National Park using plots located along elevation gradients in two mountains (Bisoke and Muhabura). A total of 56 soil samples were collected at Bisoke and 58 at mountain Muhabura during both rainy and dry seasons.

The soil water content was consistently higher in the high elevation than low elevation plots. Seasonal comparison in soil water content showed no significant differences along altitudinal gradient. The porosity of the soil of the Volcanoes National Park soil causes its water to infiltrate from high altitude to reappear at low altitude as water sources, therefore, soil water content should at contrary be higher at lower altitudes, but our findings argued the opposite. Agriculture practices by the local people outside the Virunga Massif are likely the major contributing factor to water loss in the Massif. This hypothesis can be supported by the progressive disappearance of wetlands located closer to the park edge. Most of the lower altitude swamps and lakes have already dried up while wetlands located upward are still intact. Water loss has a serious negative impact on Biodiversity of the Park as far as most of the wetlands were located at lower altitude.



## AREA-WIDE FUNCTIONAL INDICATORS FOR CHANGES IN ECOSYSTEM WATER FLUXES AND BIOMASS PRODUCTIVITY IN A MOUNTAIN RAINFOREST OF SE-ECUADOR

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The investigation of a tropical mountain ecosystem is linked to a range of different physical conditions where fundamental ecosystems processes take place. Using evapotranspiration and primary productivity as indicators, we should be able to assess the organization state of the landscape and to represent self-regulation of the different habitats found in a mountain ecosystem under environmental change.

In this work, we present our approach to estimate area-wide evapotranspiration, primary productivity, and water use efficiency at the crown level and to assess canopy water relations and ecosystem water regulation up to the landscape level. A stronger focus is given to evapotranspiration, where the comparison between optical satellite estimates and ground observations showed good agreement deploying different techniques of leaf and area-averaged measurements (coefficient of determination between 0.6 and 0.9, p-value < 0.001). Using the case of SE-Ecuador, we would like to discuss the relationship between the area-wide indicators and the functional tree diversity that is observed along the elevation gradient in our study site. Furthermore, additional remote sensing variables (e.g. canopy structure or topography) could also be used to explain the observed functional diversity.

## VARIATION OF TREE SPECIES RICHNESS WITH ELEVATION IN THE ANDES OF S. ECUADOR (TREE DIVERSITY VS FUNCTIONAL DIVERSITY VS PHYLODIVERSITY)

Jürgen Homeier<sup>1</sup>, Jaime Peña<sup>2</sup>, Nixon Cumbicus<sup>3</sup>, Johanna Lindemann<sup>1</sup>, Philipp Obst<sup>1</sup>, Yvonne Tiede<sup>4</sup>, Selene Báez<sup>1</sup>

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Tree species richness is known to decrease along most elevational transects in tropical mountains. But there are still few studies on patterns of functional diversity and phylodiversity of trees along these gradients.

We studied tropical montane forests in southern Ecuador using a matrix of permanent plots distributed to old-growth forest stands at three elevation levels (1000m, 2000m, and 3000 m asl). Eighteen plots of 400m<sup>2</sup> were established at three different topographic positions (lower slope, mid slope, upper slope) per elevation level (54 plots in total), allowing us to investigate also the influence of topography on tree species richness.



## LOCATION, LOCATION TRANSLOCATION: THE RESPONSE OF NEOTROPICAL TREE SEEDLINGS TO SIMULATED WARMING AND UPSLOPE MIGRATION

Pippa Stone<sup>1</sup>, Patrick Meir<sup>1,2</sup>, Caroline Nichol<sup>1</sup>, John Grace<sup>1</sup>

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We have a limited understanding of how Neotropical tree species will respond to climate warming: currently, vegetation models that simulate species responses to shifts in climate do not adequately account for migratory ability or the potential for acclimation. This is partly due to a lack of mechanistic data on tropical species' responses to warming.

I will give a brief overview of a seedling transplant experiment carried out along an elevational gradient (400- 3500 m asl) in the Peruvian Andes, which aims to explore the species-specific mechanisms behind successful upslope migration and acclimation of tropical seedlings. The study focuses on eight species with differing elevational range widths and central transplant elevations. During the talk I will address the following questions:

(1) Can Neotropical tree seedlings survive outside their natural elevational range?

I will present tree seedling survival data in relation to species' location within and out with their estimated local and Neotropical elevational ranges.

(2) Can Neotropical tree seedlings acclimate to changes in temperature and elevation?

For those surviving seedlings I will describe changes in a number of physiological leaf traits in relation to elevational acclimation and discuss the implications for our understanding of how Neotropical trees will respond to climate warming.

## TOPOGRAPHY HAS A NON-TRIVIAL EFFECT ON VASCULAR EPIPHYTE DIVERSITY IN ANDEAN FORESTS

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Epiphytes remain one of the most poorly-studied functional groups despite of their ecological relevance, high species richness and endemism, especially in Andean forests. Recently it has been shown that tropical Andean forests on ridge crests and upper slopes can contrast markedly from forests on lower slopes in terms of key ecosystem processes such as herbivory and nutrient cycling, productivity, stand structure and tree species composition. Although vascular epiphytes are a salient feature of tropical montane forest ecosystems, the effects of slope position on their diversity remain unknown.

Using single rope techniques we studied vascular epiphytes assemblages in 16 forest plots of 10 x 10 m distributed on ridges and in ravines (i.e. near valley bottoms) at c. 2230 m.a.s.l. in southern Ecuador. We hypothesized that slope position affects composition and structure of epiphytes. We registered over 15000 epiphytic individuals, belonging to 30 families and 301 species of vascular epiphytes. We found significant differences in composition and structure of epiphyte assemblages between crown vs. understorey and in ridge vs. ravine. Results further indicated that the slope position explained a larger percentage of the variation in assemblage structure than temperature and light, as measured with data loggers for about 2 months. Moreover, geographical distance was not a significant factor. Contrary to expectations, crown assemblages differed more strongly than understorey assemblages, in despite of lesser differences in solar radiation, air temperature and humidity in crowns among forest types than in understoreys. Whereas assemblages in the sheltered understorey of both ridge and ravine comprised a large number of uncommon species. In conclusion, our study suggests that species turnover along the topographical gradient can be an important driver of high diversity of vascular epiphyte assemblages in Andean forests.



## ALTITUDINAL DISTRIBUTION OF AN EMBLEMATIC HYGROPHILOUS FERN FAMILY ON LA RÉUNION ISLAND: CURRENT PATTERNS AND HISTORICAL FACTORS

Jean-Yves Dubuisson<sup>1</sup>, Isabelle Dajoz<sup>2</sup>, Sabine Hennequin<sup>1</sup>, Catherine Reeb<sup>1</sup>, Lucie Bauret<sup>1</sup>, Marc-André Sélosse<sup>1</sup>, Yannis Robert<sup>4</sup>, Edmond Grangaud<sup>4</sup>, Jean-Maurice Tamon<sup>4</sup>, Claudine Ah-Peng<sup>3</sup>

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Most studies on the altitudinal distribution of species propose to test if such distribution is “hump-shaped” (i.e. maximum diversity at middle elevations) which would be the most commonly observed pattern. The processes explaining these distributions mainly rely either to changes in environmental conditions and to ecological optima or to a stochastic “mid-domain effect” (MDE), but rarely to historical and biogeographical factors. Such latter factors could nevertheless explain as well competition due to niche conservatism as, conversely, adaptive radiations, both influencing the species occurrence at diverse elevations.

We studied precisely the distribution of a hygrophilous fern lineage (Hymenophyllaceae family) as emblematic of the rainforest biodiversity in the oceanic tropical La Réunion Island (Indian Ocean) from sea level to the maximum elevation (3070 m) in order to first describe then understand the evolution of Hymenophyllaceae diversity along a full transect.

Our data clearly show an unexpected global pluri-modal pattern which could represent the overlap of at least three “hump-shaped” distributions combining the repartition of at least four ecological groups, three being more or less related to vegetation zonation and the fourth involving ubiquitous species. We also used a phylogenetic framework in order to test the contribution of phylogenetic aggregation or over-dispersion to the observed distributions, and the role of history of the family at the regional level on such distributions in La Réunion is thus discussed.

## LONG TERM DECOMPOSITION PROCESSES AND SOIL FAUNA COMMUNITY CHANGES ALONG AN ALTITUDINAL GRADIENT IN A TROPICAL MONTANE RAINFOREST IN SOUTHERN ECUADOR

Franca Marian<sup>1</sup>, Dorothee Sandmann<sup>1</sup>, Valentyna Krashevskaya<sup>1</sup>, Mark Maraun<sup>1</sup>, Stefan Scheu<sup>1</sup>

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We investigated the effect of altitude, litter origin and litter type on long term decomposition rates and soil microarthropod communities along an altitudinal transect in the tropical montane rainforests of southern Ecuador. Leaf litter from three abundant tree species and roots of different diameter from sites at 1000, 2000 and 3000 m were placed in litterbags and incubated for 6, 12, 24, 36 and 48 months. The remaining amount of C and N, microbial parameters as well as microarthropod abundance and oribatid mite community structure were determined.



Altitude and time were the main factors driving the investigated parameters, while origin and therefore quality of the litter was of minor importance. At 2000 and 3000 m decomposition of litter declined for 12 months reaching a limit value of ~50% of initial not decomposing further for about 24 months; after 36 months decomposition commenced at low rates resulting in an average of 38% and 44% of initial remaining after 48 months. In contrast, at 1000 m decomposition continued for 48 months with only 11% of the initial litter mass remaining. Changes in decomposition rates were paralleled by changes in microorganisms and soil microarthropods with microbial biomass decreasing after 24 months at 2000 and 3000 m, while varying little at 1000 m. Soil microarthropod abundance and oribatid mite diversity also decreased after 24 months indicating that they either closely rely on microorganisms or are driven by similar regulatory forces as microorganisms. The results suggest that site specific conditions, i.e. variations in temperature, moisture and low nutrient supply, inhibit decomposition processes at high altitudes resulting in the sequestration of carbon in thick organic layers. We suggest that these thick organic layers inhibit positive interactions between the microbial community in the litter layer and the mineral soil, causing the microbial and microarthropod community at high altitudes to largely depend on plant derived resources leading to closer trophic linkage between plants and the decomposer community.



## ANT INCIDENCE AS AN INDICATOR OF ENVIRONMENTAL CHANGE AND ECOSYSTEM PROCESSES

Yvonne Tiede<sup>1</sup>, Jan Schlautmann<sup>1</sup>, David Donoso<sup>2</sup>, Christine Wallis<sup>1</sup>, Jörg Bendix<sup>1</sup>, Roland Brandl<sup>1</sup>, Nina Farwig (speaker)<sup>1</sup>

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Environmental stressors and land use changes lead to a rapid and dramatic loss of species. Therefore, we need effective monitoring programs that focus not only on losses of certain single species but also on functional changes of species assemblages and associated ecosystem functions. Ants play important roles within ecosystems, e.g., within terrestrial food webs and for numerous ecosystem processes. Their quick reactions to environmental changes suggest them as indicator group for abiotic, biotic and functional changes within ecosystems.

In this study we tested the suitability of the incidence and functional richness of ants as indicators for environmental change, forest degradation and predation on herbivorous arthropods. Path analysis was used to disentangle the causal relationships of the environmental factors temperature (with elevation as a proxy), season, and forest degradation with the incidence and functional richness of ants and their consequences for the ecosystem process predation. The incidence and functional richness of ants declined with increasing elevation but did not change with forest degradation. Ant incidence was higher during the dry season. Predation on artificial caterpillars decreased with increasing elevation. The driver of the pattern was ant incidence, which positively affected predation, and not elevation itself. Forest degradation and functional richness did not affect predation, but predation was higher during the wet season. Our results suggested more active ant assemblages with ongoing climate change which would mediate increased predation on herbivorous arthropods. Our results also suggested that slightly degraded forests might provide suitable habitat for epigaeic ant assemblages that do not differ in activity, functional richness, composition, or predation on arthropods from assemblages of primary forests. Most importantly, our results highlight that changes in the incidence of ants can be used as an effective indicator for temperature changes and predation within mega-diverse forest ecosystems.

## CONTRASTING THE ANT DIVERSITY AND DISTRIBUTION BETWEEN GROUND, UNDERSTOREY AND CANOPY FOREST STRATA ALONG MT WILHEM

Petr Klimes<sup>1</sup>, Maurice Leponce<sup>2</sup>, Tom Maurice Fayle<sup>1,3,4</sup>, Justine Jacquemin<sup>2</sup>, Jimmy Moses<sup>1,3</sup>, Jerome Orivel<sup>5</sup>, Vojtech Novotny<sup>1,3</sup>

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There is increasing awareness of the importance of mountain slopes for promoting the diversity and endemism of all taxa. Mt. Wilhelm, the highest peak of Papua New Guinea, represents one of the last complete altitudinal rainforest transects (CARTs) with extremely high-levels of biodiversity, yet poorly known in terms of both taxonomy and ecology. We studied the diversity and distribution of ant communities from 200 m to 3700 m a.s.l. using a range of various sampling techniques during the Our Planet Reviewed 2012-2013 survey. For the first time, the ants were sampled across three different forest strata along a CART.



The ants occurred up to 2700 m a.s.l. with general decline of their abundance and species richness with altitude, but not in the same way across forest strata. While the abundance linearly declined on the ground, it was highest at mid altitude on the vegetation. Species richness peaked also at mid altitudes in all strata (700 or 1200 m), where a mixture of the low and high-altitude specialists and species with a wide distribution was found. Stratification of the forest had also significant effects on the ant communities with their composition varying among ground and canopy levels, and understory representing a transition stage among them. However, while some of the numerically dominant canopy species foraged on the ground in the lowlands, there was an increase of ground-nesting taxa being observed also on the plants with increasing altitude. Only 45% of 257 species recorded could be assigned to the described species, while the remaining species likely represents undescribed and endemic species to the mountain, with many of them being typical only for a single altitudinal site. Our study demonstrates the need to study ant communities not only at the ground, but also at the vegetation level, in order to understand the factors shaping their distribution across CARTs in the tropics.



## SPATIO-TEMPORAL VARIATION IN BIRD ASSEMBLAGES ALONG ELEVATIONAL GRADIENTS

Vinicio Santillán<sup>1,2,3</sup>, Marta Quitián<sup>1,2</sup>, Boris Tinoco<sup>3</sup>, Edwin Zárate<sup>3</sup>, Katrin Böhning-Gaese<sup>1,2</sup>, Matthias Schleuning<sup>1</sup>, Eike Lena Neuschulz (speaker)<sup>1</sup>

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Understanding the spatial and temporal dynamics of species in ecosystems is a main research effort in ecology. The mechanisms that shape species communities and their temporal fluctuations along tropical elevational gradients are however poorly understood. In this study we examined the spatio-temporal dynamics of bird assemblages along an elevational gradient in southern Ecuador, spanning from 1000 to 3000 m a.s.l..

While bird richness generally decreased from low to high elevations, we found significant changes in bird abundances between wet and dry season at each of the three elevations. Climatic factors were the most important predictors of these temporal fluctuations. While temperature had significant positive effects on the abundance of birds at high elevations, precipitation negatively affected bird abundance at low elevations. In contrast, local resource availability contributed little to explaining the temporal fluctuations in bird communities. Our study highlights that bird assemblages along tropical elevational gradients can show pronounced seasonal fluctuations, mainly driven by temperature and precipitation. Understanding the spatio-temporal dynamics of bird assemblages along elevational gradients is important to project how bird assemblages might respond to future climatic changes.

## PERVASIVE SPATIO-TEMPORAL DYNAMICS OF ANDEAN BIRDS IN BOLIVIA - IMPLICATIONS FOR ELEVATIONAL SPECIES RICHNESS PATTERNS

Stefan Kreft<sup>1</sup>

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Based on a multi-year ornithological field survey and a comprehensive literature review, I studied the altitudinal movements of Andean birds and their eco-ethological control.



I conducted my field study in Carrasco National Park and its surroundings in the Chapare region, Dept. Cochabamba, Bolivia, in the years 2000 to 2003. The altitudinal transect of humid tropical forest reached from lowlands (300 m asl) to timberline (around 3,500 m asl). Out of 420 bird species encountered during field work, for 89 species data, I considered sufficient for a solid analysis. One third of these species were found to be partial altitudinal migrants. The remaining species had resident status. Of these residents, however, more than one third comprised vagrant individuals of varying numbers. Vagrancy was observed for more than half of all bird species studied. The highest number of altitudinal migrant species overlapped at 500-600 m asl and at 1,800-1,900 m asl, respectively ("camel's back pattern").

Looking at the group of the altitudinal migrants, more than 40% of their entire elevational ranges across the annual cycle are inhabited during the breeding or the non-breeding season only. In addition, both the literature review and own field data indicate spatio-temporal fluctuations between years as well as long-term changes.

Thus, the overall picture shows a bird assemblage that is pervasively dynamic spatio-temporally. The altitudinal movements of highly mobile species in tropical mountain ranges have several important bearings on the calculation and interpretation of elevational species richness patterns. Among others, analyses including mobile taxa should consider both their intra- and inter-annual variability regarding elevational distribution.



# SESSION 18

## THE TROPICAL FOREST IN A CHANGING CLIMATE

Chairs:

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In the tropics, habitat conversion and deforestation continue at an alarming rate, threatening the continued survival of many rainforest species. These impacts only promise to be further exacerbated by the effects of severe future climate change. Preliminary projections suggest rainfall patterns will change dramatically and mean global temperatures will rise by more than 1.5°C.

This symposium sets out to evaluate how environmental changes might alter current distribution patterns of species and the relative importance that evolutionary adaptation, phenotypic plasticity and landscape connectivity might play in mediating future threats from climate-driven alterations to the tropical landscape. In this session, we welcome contributions from researchers focusing on a diverse array of systems studying ecological factors driving distribution patterns and phenotypic and genomic differentiation along gradients e.g. by using experimental common garden and reciprocal transplantation settings and modelling approaches to estimate patterns of genomic and phenotypic variability across tropical landscapes.

S18-001 - THE TROPICAL FOREST IN A CHANGING CLIMATE

## THERMAL SENSITIVITY OF TROPICAL AMPHIBIANS AND THEIR VULNERABILITY TO CLIMATE CHANGE

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The impacts of climate change may be more severe on tropical than temperate ectothermic organisms. Tropical ectotherms have evolved in relatively stable aseasonal climates compared to temperate species. As a consequence, negative impacts of climate change should be the greatest on tropical ectothermic species. The thermal tolerance ranges of species reflect their physiological adaptation to climates. They provide appropriate data for the assessment of the impact of global warming in geographic distribution.

To predict how climate change will impact a species, we are investigating the thermal limits of the tropical ectothermic organisms from the Congo and Amazon Basin and from the Gamboa Rainforest (Panama). We are using the critical temperatures, performance breadth, optimal temperature, and acclimation ability as proxies to evaluate the vulnerability of this species to climate change. So far, our ongoing study supports that a tropical amphibian can exhibit a wide tolerance range (~32°C) and can acclimate to high and low temperatures. Despite their adaptive capacity to tolerate extreme temperatures, the temperature performance breadth matches closely the climate of the natural habitat with a narrow safety margin. The optimal physiological temperature, which is rarely available, seems to be a more reliable proxy to evaluate a species thermal sensitivity.

Thus, our study highlights the importance of a comprehensive study on the performance curve parameters to be able to better understand the species thermal sensitivity and its vulnerability to climate change. The vulnerability of a species to a changing environment depends on its sensitivity, resilience, and its potential to adapt to change. Despite the complexity of factors contributing to an organism's vulnerability to climate change (e.g. dispersal, rainfall, disease, species interaction), a robust understanding of a species sensitivity and response to temperature is necessary.

**Merian Award Applicant**



## CLIMATE CHANGE SHIFTS THE DISTRIBUTION RANGE OF AN ENDANGERED PARAKEET: IMPLICATIONS FOR CONSERVATION

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Tropical mountains harbor among the highest concentrations of biodiversity on Earth. Yet, climate change causes montane species to shift their distribution ranges upslope in response to warming temperatures. These range shifts have important implications for conservation, as they potentially lead to species extinctions. One species affected by global warming is the El Oro Parakeet (*Pyrrhura orcesi*), which is endemic to the premontane cloud forests of southwestern Ecuador. This bird has shifted its range uphill within the last decades.

In our study, we investigated how climate change may alter the distribution range of the El Oro Parakeet in the future. We assessed the species' temperature niche by combining field data of their preferred elevation zones over the years 2000 to 2015 with data on temperature anomalies over the same time period. Then, we projected the temperature niche to four climate change scenarios described by the Intergovernmental Panel on Climate Change and modelled the future range shift.

All four scenarios implied an upslope shift of the El Oro Parakeet's distribution range at different rates until the end of the 21<sup>st</sup> century. While in the best-case scenario the mean distribution range would only move 100 m upwards from now 1100 m to about 1200 m, the worst-case scenario predicted a shift to an elevation of over 1700 m within this century. Depicting the projected altitudinal ranges on a forest fragment map yielded evidence that in large parts of the El Oro Parakeet's range, the size of the distribution range and the forested area is decreasing with increasing altitude. Moreover, the range shift will contribute to disrupting linkages between different parts of the distribution range. By reducing the habitat availability and connectivity between populations, a continuing upslope shift could lead to a strong decrease in population size and possibly to local extinction of the El Oro Parakeet within the second half of the 21<sup>st</sup> century.

**Merian Award Applicant**

## ECOLOGICAL NICHE MODELLING IN MADAGASCAR: THE RESPONSE OF SEVERAL INSECTS GROUP TO GLOBAL WARMING

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Global warming is the most challenging problem in the near future. As such, the fauna and flora of Madagascar is particularly exposed to global change considering the high endemic rates of particularly rich groups. In the frame of several surveys aiming to describe the biological richness of the entomofauna of Madagascar, we model the ecological niche of several group of insects (namely Hemiptera Cercopidae, Heteroptera Tingidae and Coleoptera Scarabaeidae) considering the three main scenarios and three different climatic models to evaluate their reaction to global warming, using maximum entropy method.



Depending of the group, the reactions are different, ranging from almost a disappearing distribution area, a shift of the distribution area and an increasing distribution area. These preliminary results are discussed regarding the ecology and the history of each group.



## DO TREE SPECIES FROM SEASONALLY DRY FOREST DIFFER IN THEIR SENSITIVITY TO DROUGHT AND LOGGING, HOW DOES THIS IMPACT ON BIOMASS AND DEMOGRAPHY?

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Tree species in tropical forest may decline as a result of drought and various human impacts. We aimed to assess whether the tree species of a seasonally dry Atlantic forest has experienced any significant change in above-ground biomass (AGB) and demography over a 12-year period (1996-2008), during which a severe drought was reported. We tested the hypothesis that tree species respond differently to drought and logging. In March 1996, 2002, 2003, 2004 and 2008 all live trees ( $\geq 10$  cm dbh) were measured in four 50 m x 50 m replicate plots in each of the two stands, unlogged (US) and logged (LS). We assessed the variation in occurrence and abundance of tree species, AGB, recruitment and growth. Climatic variables were compared among the three periods: (1) Drought onset, 1996-2002; (2) Drought, 2002-2004; (3) Post-Drought, 2004-2008. The lowest recruitment ( $US=0.24$ ;  $LS=0.00\%yr^{-1}$ ) and the highest mortality ( $US=5.2$ ;  $LS=10\%yr^{-1}$ ) rates occurred during the drought. There was a sharp decrease in AGB from the drought onset period into the extreme drought, associated with increased tree mortality. The number of dead trees increased especially in the LS where only 3 species died during the drought onset period, reaching 38 during the drought. The distribution of the AGB by species indicated that biomass is concentrated in rather few species, with only 15 species accounting for about 80% of the total AGB in most censuses. *Metrodorea nigra* alone accounted up to 40% of total AGB in both stands. Using a drought impact factor (which considered the AGB before (1996) and after (2004) the drought) for each main species, our results showed that *Pseudopiptadenia contorta* was the species with the highest drought impact factor. *Paratecoma peroba* and *Parapiptadenia pterosperma* only suffered a high impact of drought in LS. *P. peroba*, the main tree logged in the past, had a decrease on its AGB contribution in LS. In conclusion, tree species differed in sensitivity to drought and logging impact, especially in terms of mortality and AGB.

## WATER RELATIONS AND CARBON ACQUISITION AS INDICATORS OF SLOW CLIMATE CHANGE EFFECTS ON TREES IN A TROPICAL MOUNTAIN FOREST IN SOUTH ECUADOR

Simone Strobl<sup>1</sup>, Eduardo Cueva<sup>2</sup>, Brenner Silva<sup>3</sup>, Michael Schorsch<sup>4</sup>, Johannes Knuesting<sup>4</sup>, Renate Scheibe<sup>4</sup>, Joerg Bendix<sup>3</sup>, Erwin Beck<sup>1</sup>

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The effects of increasing moisture on the mountain rain forest of the South Ecuadorian Andes was investigated, using the daily total water consumption (TWC) and the instantaneous water use efficiency (WUE, ratio of CO<sub>2</sub> uptake per water loss by transpiration) of three representative tree species, namely *Vismia tomentosa*, *Spirotheca rosea* and an as of yet unknown Lauraceae as test objects.

Seasonal changes as well as a long-term (18 months) increasing trend of the precipitation regime caused an inverse reaction of the TWC of the test trees, which could be explained by a rather unlimited water supply to the trees from the water-saturated soil. Transpiration followed mainly the atmospheric demand of water vapor, and increasing moisture hence reduced water loss by transpiration. Concomitant measurements showed the hypothesized increase of WUE in *V.t.* and *S.r.* but no clear reaction of the Lauraceae. Accompanying measurements of the stem extension growth showed undiminished growth of *V.t.* and *S.r.* but suspended growth of the Lauraceae during the wettest months which fits well with the responses of WUE to the increase in humidity. While TWC can be continuously monitored with the heat dissipation technique, WUE is determined by leaf porometry in campaigns for which access to the canopy is required. The method can be used in combination with remote sensing data to identify more suitable indicator trees.



## INSELBERGS IN SOUTH-EASTERN BRAZIL: BIODIVERSITY ENCAPSULATED IN SPACE AND TIME

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Identification of the ecological and evolutionary processes that affect the biodiversity of ecosystems is a central problem in biology. Over the last few decades, the study of islands has advanced our understanding regarding questions related to the factors affecting biodiversity, especially aspects of evolution and speciation processes, providing insights about naturally fragmented habitats. Granitic and gneissic rock outcrops, known as inselbergs, form climatic, hydrological and pedological contrasts with surrounding landscapes, are considered as terrestrial islands, and are located in both temperate and tropical regions. Monocot mats occur on open rocky slopes, forming "cradle" habitats on these outcrops, and can be considered good models for studies of biodiversity issues. The Brazilian and Malagasy inselbergs have species-rich mats with high numbers of endemics, in contrast with the West African inselbergs which have a much lower percentage of endemics and richness. The Bromeliaceae species stand out as characteristic elements in the Brazilian communities, and seem to influence the high plant diversity on these rock outcrops.

For the first time we have provided a checklist of mat-forming bromeliads on inselbergs in Brazil. We have also investigated whether the regional species-pool influences species diversity of mats, in order to shed light on the factors influencing diversity. Furthermore, through modelling analysis, we have looked for the potential distribution of bromeliads endemic to inselbergs, expecting that they would show a narrower niche width when compared to non-endemic species.

Our data indicate the existence of a particular phytogeographic region in the Atlantic Forest in south-eastern Brazil, comprising inselbergs harbouring a highly diversity of Bromeliaceae, which we have christened *Sugar Loaf Land*. In addition, our projections have revealed smaller predicted areas for bromeliads endemic to inselbergs compared to non-endemic species, the former seems to be mainly controlled by climatic factors. In addition to climatic and regional species pool factors, the island-like character of inselbergs seems to play an important role in the speciation of rupicolous Bromeliaceae.

## DISTRIBUTION PATTERNS AND GENOMIC DIFFERENTIATION OF THREE VALUABLE TIMBER SPECIES OF THE MOUNTAIN FORESTS OF ECUADOR

Carlos Manchego<sup>1,2,3</sup>, Augusta Cueva<sup>3</sup>, Patrick Hildebrandt<sup>1</sup>, Sven Günter<sup>2</sup>, Bernd Stimm<sup>1</sup>

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Deforestation and uncertainty of climate change in the Tropical Andes are two major threats to biodiversity and ecological processes, thus indirectly affecting the wellbeing of local people that rely on ecosystem services from forests. With temperature and precipitation shifts already detected in mountain areas of Ecuador, and the conventional uncertainty of global circulation models to project future scenarios inside a particular timeframe, we used high-resolution environmental layers (Karger et al. 2016; chelsa-climate.org) to produce species distribution models for three key timber species under the only assumption of one-degree increase of temperature.



Our results point to an upward displacement of the mean altitude of distribution, supporting the notion of an upslope migration. In addition, we evaluated the genetic variability of 4 distinct provenances for each of our study species as a proxy for their potential resilience against environmental change. We are confident that this study contributes to highlight the importance of genetic variability assessments and landscape connectivity via biological corridors as safeguard for species survival and precaution against threats from a changing climate.



## PHENOTYPIC VARIABILITY ALONG A TROPICAL AFRICAN CLIMATE GRADIENT - THE PERENNIAL FOREST UNDERSTOREY HERB *SARCOPHRYNIUM PRIONOGONIUM* (MARANTACEAE)

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Climate modelling suggests drastic changes of the world's climate in the future – also in the tropics. Little is known about the potential of tropical plants to tolerate, adapt to or escape those changes. Depending on the assumptions on the upper temperature threshold of tropical plants and the speed of predicted climatic changes scenarios on expected vegetational responses range from no to fundamental losses of the current biota in tropical Africa.

Here we test in a widespread perennial herb (*Sarcophrynum prionogonium*, Marantaceae) its phenotypic plasticity and potential for evolutionary adaptations. We conduct a phenotypic survey and reciprocal transplantation experiment across a latitudinal and altitudinal gradient as surrogate for different climatic conditions from warm and dry/humid to cold and dry/humid in Cameroon.

Phenotypic variability across sites was detected and some degree of genetic fixation of those traits. In an upcoming phylogeographic analysis of next generation sequencing data using SNPs of neutral and coding markers genetic traces of adaptations will be searched. This study should then be extended to further species as preliminary data from the literature predict a species-specific response amplitude to climatic changes with a lower adaptive potential to increased dry than to humid conditions.

## HYBRIDIZATION AND PATTERNS OF ADAPTIVE GENETIC VARIATION IN TROPICAL TREES OF THE *BERTHOLLETIA* CLADE (LECYTHIDACEAE) IN FRENCH GUIANA

Myriam Heuertz<sup>1</sup>, Quentin Jehanne<sup>1</sup>, Katharina B. Budde<sup>1</sup>, Henri Caron<sup>2</sup>, Veronica El Mujtar<sup>3</sup>, Alain Franc<sup>1</sup>, Pauline Garnier-Géré<sup>1</sup>, Erwan Guichoux<sup>4</sup>, Caroline Scotti-Saintagne<sup>5</sup>, Jean-François Molino<sup>6</sup>, Daniel Sabatier<sup>6</sup>, Stéphanie Mariette<sup>1</sup>

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Tropical rainforest tree genera often comprise multiple closely related species occurring in sympatry. The genetic mechanisms that explain such sympatric coexistence are poorly known. Inter-specific hybridization has been proposed as a key mechanism in the maintenance of highly diverse communities, potentially retarding the (local) extinction of rare species and also allowing the sharing of beneficial genetic variants across species borders. Hybridization could be an especially relevant evolutionary process under climate change, where changes in relative species abundance, distribution ranges and/or phenology can affect interspecific gene flow, and where the sharing of adaptive genetic variation could allow a faster response to environmental change.



We set out to empirically test the importance of hybridization, and particularly, adaptive introgression, in closely related tropical tree taxa of the *Bertholletia* clade (Lecythidaceae) in French Guiana. In this clade, plastid DNA haplotype sharing has frequently been observed between closely related species. We sampled 10 and 3 species belonging to two sub-clades, as well as outgroup species, and resequenced all samples at two types of markers derived from restriction site associated DNA sequencing (RAD-Seq): anonymous markers and genic markers for which a putative gene function has been assigned. Since hybridization can occur only when taxa are in the same local population, i.e., within pollination distance, we included samples from two geographic sites to distinguish hybridization vs. incomplete lineage sorting as causes of allele sharing. Our ongoing work provides evidence for variable levels of allele sharing and genomic admixture between sympatric species in both focal subclades, suggesting that inter-specific hybridization took place in their evolution.



# SESSION 19

## SEED DISPERSAL

Chairs:

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Seed dispersal has ecological and evolutionary implications ranging from the fitness of individual plants through the diversity and regeneration dynamics of plant communities to the carbon storage potential of tropical forests. This also means that seed dispersal processes need to be studied on different spatial and temporal scales.

The aim of this session is to bring together studies that examine seed dispersal on these different scales. Contributions are invited from studies on biotic and abiotic seed dispersal. Studies that provide long-term data and new methodological approaches to temporal and spatial analyses are particularly welcome.

S19-001 - SEED DISPERSAL

## HIDDEN FOUNDERS OR HIGH CONNECTIVITY OR BOTH? INVESTIGATING THE EXPANSION PATHWAY OF MANGROVES ALONG THE CAMEROONIAN COASTLINE

Magdalene NGEVE<sup>1</sup>, Nico Koedam<sup>1</sup>, Ludwig Triest<sup>1</sup>

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The probability of mangrove propagules released from their mother trees to leave the immediate environment of their mother trees is dependent on several factors, such as availability of dispersal vector (water) at the time of release, the density of trees and root network in the vicinity of the mother trees, as well as other barriers. And although mangrove propagules have potentials of long distance dispersal, short dispersal distances are mostly observed, giving rise to leptokurtic dispersal kernels. *Rhizophora* spp. form dense root networks which strongly increases retention of large propagules, such as those of *Rhizophora* spp. Genetically, the expected end result of such high retention rates over time is a spatial aggregation of genetically related individuals. Although *Rhizophora* species have a high potential for such a fine scale genetic structure, several site-specific features can alter expected outcomes.



We investigated the comparative fine-scale genetic structure of *Rhizophora racemosa* populations from the entire coast of Cameroon, using 11 polymorphic microsatellite markers. Populations of the most anthropogenically disturbed mangrove area in Cameroon (the Cameroon Estuary complex) were those with significant fine-scale genetic structure, and these populations also had evidence of significant reduction in effective population sizes (bottlenecks). This led us to hypothesize that due to the high anthropogenic pressures on these sites, these were the most “recent” mangroves in Cameroon, due to recent expansions replacing the lost mangrove sites. We, therefore, tested four expansion models of mangroves along this coastline, which supported this claim. Although we observed high levels of gene flow in mangroves of this estuary, based on the results, we conclude that both high connectivity and hidden founder effects characterize the spatial patterning of genetic diversity in the Cameroon Estuary complex.



## EFFECTS OF ELEVATION AND FRAGMENTATION ON INTERACTION NETWORKS OF FRUGIVOROUS BIRDS AND FRUITING PLANTS IN SOUTHERN ECUADOR

Marta Quitián<sup>1,2</sup>, Vinicio Santillán<sup>1,3</sup>, Jürgen Homeier<sup>4</sup>, Carlos Iván Espinosa<sup>2</sup>, Katrin Böhning-Gaese<sup>1</sup>, Matthias Schleuning<sup>1</sup>, Eike Lena Neuschulz<sup>1</sup>

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Tropical forests harbor diverse ecological communities of plants and animals that are organized in complex interaction networks. The diversity and structure of plant-animal interaction networks may change along environmental gradients, such as mountain slopes. At the same time, human land-use can have profound effects on species communities along these gradients. While previous studies have analyzed the effects of elevation and land-use change on species interaction networks in isolation, no study to date has investigated their combined effects.

In this study, we analyzed the effects of elevation and habitat fragmentation on plant-frugivore interaction networks at both, plant and bird species level. Over a period of two years we monitored plant-frugivore interactions across an elevational gradient in a natural and fragmented tropical montane forest in southern Ecuador. We built interaction networks for three elevations and both habitat types and calculated the number of effective partners and the degree of specialization ( $d'$ ) at species level for both plant and bird species.

In general, we found a strong effect of elevation on fruit-frugivore networks. For plants we observed a decrease of the number of effective bird partners and constant specialization with increasing elevation. For birds we observed a constant number of effective plant partners and an increase of specialization with increasing elevation. Fragmentation had a relatively weak effect on the interaction networks at both plant and bird species level, but significantly increased bird specialization at high elevations.

We conclude that elevational gradients strongly shape plant-frugivore interaction networks in tropical forests. Our results suggest that in particular species poor communities at high elevations might be most sensitive towards forest fragmentation.

### Merian Award Applicant

## ZOOCHORIC TREES AS RECRUITMENT FOCI IN AFROTROPICAL FORESTS

Franck Trolliet<sup>1</sup>, Pierre-Michel Forget<sup>2</sup>, Jean-Louis Doucet<sup>3</sup>, Jean-François Gillet<sup>3</sup>, Alain Hambuckers<sup>1</sup>

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The influence of animal-mediated seed dispersal on the spatial organization of plant communities has received increasing attention. Yet, the causal mechanisms leading to clumped dispersal patterns and recruitment foci remain poorly understood.

Here, we aimed at (i) comparing the influence of hornbills and primates in generating recruitment foci under zoochoric trees, and (ii) exploring the influence of fruit availability in the neighborhood, and the amount of forest cover in the landscape on such patterns.



We found that the density and species richness of hornbill-dispersed seedlings were higher under hornbill-dispersed trees than at control locations, and that an increasing amount of forest cover in the landscape tended to increase the density of hornbill-dispersed seedlings. Although significant, those tendencies were weak and suggest non-negligible influence of other processes in the composition of the seedling community.

We concluded that both local and landscape factors influence animal-mediated recruitment foci and that the bi-trophic system investigated plays a structuring role in Afrotropical forests. This finding has important consequences for our understanding of the causal mechanisms responsible for spatial patterns in tropical communities.

### Merian Award Applicant



## HOW DOES TERRITORIALITY BEHAVIOR OF SEED DISPERSERS AFFECTS SPATIAL GENETICS OF DISPERSED PLANTS? CASE STUDY: TAMARINS AND LEONIA CYMOSA

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Seed dispersal has been seen like the main determinant of restricted gene movement in populations. Seed deposition patterns are deeply influenced by animal behavior. We analyzed whether territoriality can create an ecological barrier strong enough to create genetic differentiation between plant individuals located in different territories.

We analyzed microsatellite markers on individuals of *Leonia cymosa*, an insect-pollinated, primate dispersed Neotropical understory tree, found on the Peruvian Amazonia. *Leonia cymosa* on our study site is only dispersed by mixed species groups of tamarins: *Saguinus mystax* and *Leontocebus nigrifrons*. These groups have defined territories where they forage, feed and range, without overlapping each other over the years. We combined movement data from the last 12 years with genetic information of *L. cymosa*. We analysed differences in genetic diversity and spatial genetic structure and genetic differentiation between plant individuals dispersed by different tamarin groups.

We found spatial genetic differences to be negligible possibly due to a strong influence of insect pollination that might be able to attenuate the genetic effects of restricted seed dispersal in the tropical environment.

## LANDSCAPE SCALE CONSEQUENCES OF DISPERSAL TRAITS OF TREES IN A FRAGMENTED FOREST ECOSYSTEM: A CASE STUDY OF A TROPICAL HUMID FOREST OF MADAGASCAR

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Tropical deforestation continues to be the major driver of forest fragmentation and biodiversity loss. In Eastern Madagascar, demand for agricultural land is the main threat to biodiversity. If forest removal reduces population of trees and habitat extent, forest fragmentation and degradation may affect the ability of tree species to persist in a long-term by disrupting key biological processes such as seed dispersal.

In this study, I tested the effects of historical change in forest configuration and dispersal traits on the realized dispersal of tree species in a tropical humid forest of Madagascar. First, I used remote sensing tools to characterize temporal changes in vegetation cover and configuration based on 30m spatial resolution Landsat images. For each 1990, 2000 and 2010 vegetation cover map, forest configuration was characterised in terms of patch size, distance to neighbouring patch, distance to the edge and perimeter area ratio. Second, 160 forest plots of 20m by 20m were established across the Ankeniheny-Zahamena forest stratified with respect to current and historical forest configuration. Trees in plots were identified to species and placed into approximate age classes. Dispersal traits (seed longevity and seed size) were collected in the field and from herbarium specimens. Third, I analyzed plot data based on the difference in prevalence between mature and immature of each species and used it as response variable. I used landscape configuration and dispersal traits as covariates and ran distribution models for each species using Maxent.

Vegetation configuration influenced realized dispersal of tree species. Area sensitive species show lower prevalence of immature individuals in small patches. This is potentially because larger patches support higher densities of seed dispersers. However, patch compactness and isolation had no significant effect on prevalence of immature individuals. Finally, seed longevity and seed size influenced the realized dispersal of trees, potentially mediated by the suitability of the habitat for dispersers of large seeds such as lemurs and birds.





# SESSION 20

## INTEGRATIVE TROPICAL ECOSYSTEMS DYNAMICS

Chairs:

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Reconstructing the history of natural ecosystems is useful to assess the processes driving their dynamics at a wide range of spatio-temporal levels. To this end, the integration of different disciplines, such as palaeoecology, biogeography, macroecology and evolutionary genetics, that provide historical insights is of upmost interest. This integrative approach is needed to understand the mechanisms organizing biodiversity patterns, the evolutionary histories of species and their abilities to respond to future environmental changes, especially in tropical ecosystems. Moreover, we consider that the imprints left by past environmental changes on the evolutionary trajectories of ecosystems and populations can be used to reliably identify conservation and restoration targets and priorities.

This session aims to bridge different disciplines that can complement each other to better understand the history and dynamics of tropical biomes. Innovative contributions that approach historical inferences from biome to genome, in the fields of (but not limited to) palaeoecology, biogeography, phylogeography, population genetics, and evolution are welcome.

## WHY ARE THERE FEWER PLANT SPECIES IN AFRICAN RAIN FORESTS?

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Although tropical rain forests represent the most species rich terrestrial ecosystem on the planet, the three main regions (neotropics, Southeast Asia and Africa) are not equally diverse. Africa has been labeled the “odd man out” because of its perceived lower species diversity when compared to the neotropics or Southeast Asia (SEA). Understanding the origins and evolutionary processes underlining lower species diversity of certain regions within the same biome is as important as understanding the origins of hyperdiverse ones.



In this talk I review the evidence in favor of an “odd man out” pattern and the different hypotheses that have been advanced to explain and test this pattern using ecological, biogeographical and diversification studies. The lower apparent species diversity is not the result of a single cause but is probably linked to numerous intricate causes related to present and past events. Future comparative studies should combine numerous variables including novel ones such as plant functional diversity. Finally, though more extinction in Africa is apparent from the fossil record it is still hard to precisely quantify to what degree extinction varied between the three major regions. The apparent lower species diversity of African rain forests remains an understudied question with numerous preconceived and largely untested ideas for which we are still far from having a synthetic explanation. An integrative approach involving archeologists, climatologists and biologists coupled with intercontinental data and analyses should be privileged.



## PHYTOGEOGRAPHY AND PHYLO-DIVERSITY OF TROPICAL AFRICAN FLORA: INSIGHT FROM A MEGA DATABASE ON THE DISTRIBUTION OF VASCULAR PLANTS

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Documenting plant species assemblages and identifying ecological/evolutionary processes that drive their changes are of fundamental importance for predicting their responses to global changes. Biogeographical patterns remain poorly characterized for some regions of tropical Africa partly because distributional data lack standardization. To overcome this issue, we merged several herbaria specimen datasets into the largest ever compiled database for Tropical Africa, RAINBIO, which contains ca. 600 000 georeferenced occurrences for ca. 24,000 plant species.

Using RAINBIO, we aim to provide new insights into delimitations and drivers of biogeographic regions in Tropical Africa. We employ a network approach to delineate floristic regions. We assess (i) compositional (i.e. floristic) and (ii) lineages (i.e. phylogenetic) similarities among identified regions and assess correlations with geographical and ecological distances. Finally, patterns based on different growth forms (trees, herb, liana, shrub) were compared to verify their congruence.

We identified 14 floristically biogeographical regions that match most of currently recognized classifications, but also highlight previously under-recognized regions. Both geographical and ecological (climatic) distances among regions explain floristic similarity. Phylogenetic similarity, by contrast, is much less correlated to geographical distance, but remain well correlated with ecological distance, suggesting climatic niche conservatism. Growth form showed somewhat contrasted spatial patterns, with high congruency among woody growth forms while herb tends to display different pattern.

Floristic affinities among regions seem to highlight relatively recent ecological processes (dispersion and environmental gradients) while lineages similarity seem to reflect ancient biogeographical events. Overall, our results give new insight into “old” perception-based classification of tropical Africa.

## HOW OLD IS THE AFRICAN FLORA? NEW INSIGHTS IN THE EVOLUTION OF AFRICAN BIOMES BASED ON LARGE-SCALE DATING AND DIVERSIFICATION ANALYSES

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Biome distribution and vegetation dynamics are mainly influenced by global climate shifts and large-scale geological events, resulting in a unique species composition and species richness for every known ecoregion. On the African continent, a large number of biomes and ecoregions can be determined ranging from Sahel to Guineo-Congolian, each characterized by a distinctive species arrangement. Despite the broad knowledge on the current species distribution along these different African biomes, very little is known about the origin and evolution of the species within each of these ecological regions. Moreover, several assumptions have been made in the past on the age and origin of these biomes.

Here we demonstrate that large-scale dating analyses and biogeographic assessment on an elaborate set of African species provided new insights on the origin and evolution of African biomes. Current results indicate that a large proportion of the current African flora only recently evolved and that multiple extinction events probably had a large influence on the present species composition.



## DETARIOIDEAE, I PRESUME? A STUDY OF THE EVOLUTIONARY ORIGIN OF DETARIOIDEAE, A CLADE OF ECOLOGICALLY DOMINANT TROPICAL AFRICAN TREES

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Tropical rain forests are one of the most biologically diverse habitats on the planet. Yet their description and the understanding of their evolutionary history are far from complete. West Central Africa represents the area of greatest biodiversity richness in tropical Africa and has the highest percentage of untouched pristine forest in all of Africa and Madagascar.

Our study is focused on the recently established subfamily Detarioideae (Leguminosae), which are the dominant tree components of West Central African forests. Detarioideae includes 81 genera (and approximately 750 species), 58% of which occur in Africa and Madagascar (with 329 species). We attempted to generate the first fully sampled phylogeny, including genera never sequenced before, using a phylogenomics approach (sequence capture). Our bait design includes 283 nuclear genes (359, 222 bp) and we aimed to obtain the plastid genome from the off target reads. Here we compare our results with the previous reconstructed the biogeographical history of the group and we have investigated biome shifts within the subfamily. Implications of the origin of the group and its role in shaping African diversity are discussed.

## ESTIMATING THE TIMING OF DIVERSIFICATION AND THE POTENTIAL ROLE OF PAST CLIMATE IN THE EVOLUTION OF *ANTHONOTHA* IN THE GUINEO-CONGOLIAN REGION

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The Guineo-Congolian rain forest constitutes the second largest region of rain forest with a remarkable biodiversity and endemic species. Subfamily Detarioideae (Leguminosae) is particularly species rich in this geographic region and it displays a great diversity of floral morphology, yet its evolution is poorly understood.

Here we attempt to increase our understanding of the evolution of this group by designing new molecular markers (target enrichment) on the entire subfamily. Using four transcriptomes from the Detarioideae we developed a set of baits to capture and sequence 283 nuclear genes (totalling 359, 222 bp) and applied it to *Anthonotia* s.l., a group of about 30 species that diversified in this geographic region. The bait captured 80.27 % ( $\pm 4.11$ ) of the targeted region within the ingroup and 50.42 % ( $\pm 21.58$ ) on more distantly related species within the Detarioideae. Here we used this phylogenomic framework to explore the timing of diversification and the role of past climate change on the evolution of *Anthonotia* through the Guineo-Congolian rain forest.



## LAKE BAMBILI, CAMEROON: 90 000 YEARS OF MONTANE FOREST HISTORY IN CENTRAL AFRICA

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Mountains of Central Africa are particularly suitable for paleoenvironmental and paleoclimatic studies because they host a large number of sites favorable to the preservation of sedimentary archives. Moreover, they are true “hot spots” of biodiversity that harbor environments known to be extremely sensitive to climate change.

Lake Bambili (Cameroon) yields an exceptional pollen series which documents for the first time the history of the Equatorial montane forests and their vulnerability facing climate change over the last 90 000 years with a resolution of decades to centuries.

Here we discuss several aspects such as the evaluation of plant diversity, of biome distribution and of up and down movements of the upper treeline in relation to climate and CO<sub>2</sub> changes. Quantitative reconstructions of relevant climate parameters are addressed via inverse modeling approach and model simulations.

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## PAST ENVIRONMENTAL AND CLIMATIC CHANGES OF CENTRAL AFRICA FROM A MULTIPROXIES ANALYSIS OF THE ADAMAWA PLATEAU, CAMEROON.

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During the last three decades, research on past environmental changes of equatorial and subtropical forests of Central Africa showed that despite the high biological diversity that can be observed today in certain areas, this region underwent significant environmental changes in the past. It is now clearly admitted that the monsoon flux from Atlantic Ocean penetrated more/less deeply in the continent entailing a succession of humid and dry phases that are now well dated. Between 10 000 and 6000 yrs BP, higher summer insolation entailed globally an intense monsoon flux and forest development both in low and highlands along this South-North transect. The termination of this African Humid Period (AHP) occurred between 5 500 and 5000 yrs, with the pattern that varies from one site to another. After the AHP, an alternation of humid/dry phases is shown in several sites along this transect, one of the most documented is dated at 2400-2200 yrs BP.

The Adamawa plateau in Central Cameroon appears to be a key area in order to make a link between the Equatorial zone of the South and the Saharan/Sahelian zone in the North of Cameroon. Developing multiproxies analyses of two cores from Lake Mbalang and Lake Tizong from the Adamawa plateau, the chronology of Middle to Late Holocene environmental and climatic changes was established. Globally the monsoon flux was higher before 2800-3600 cal yrs BP; this higher Precipitation-Evaporation balance allowed the development of more forested vegetation. After that date, the climate was drier and/or more seasonal; around 2400-2200 yrs BP, a more arid event is registered in both sites as it is also observed in several sites of central Africa. Savannah vegetation thus colonizes landscapes, and was maintained until the present days showing that the climate is no more favorable to forest ecosystem. Several centennial to millennial timescales events are superimposed on this general trend.



## BIODIVERSITY DIVERSIFICATION PATTERNS IN AFRICAN MONTANE FORESTS: A CASE STUDY OF RODENTS IN THE CAMEROON VOLCANIC LINE

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Tropical montane forests are considered as terrestrial islands in which different evolutionary processes led to the development of several lineages. The consequence is the high species richness and the original level of endemism known for these environments. Evolutionary scenarios that have promoting this exceptional biodiversity are still however poorly elucidated. The so called Cameroun Volcanic Line (CVL) is a unique geological feature of tectonic and volcanic origin, with an unclear chronological history. This ecoregion within the Guineo-Congolian biome harbours a remarkable amount of biodiversity for both plant and animal. Covered by both lowland and montane forests that are distributed from sea level up to 2800 m asl, the CVL is appropriate to assess evolutionary processes that have promoted the biodiversity in afro-tropical montane forests. Previous studies in tropical and temperate regions pointed out the importance of small mammals for inferring biotic history from patterns of diversity.

Using five genera and about 10 rodent species, we conducted a study on the origin of biodiversity in the CVL, based on molecular data produced from five genes (two nuclear and three mitochondrial) and by using both phylogenetic and phylogeographic analyses. Our results suggested complex diversification patterns in the CVL, favouring by both volcanism and climatic fluctuation from Late Pliocene to Pleistocene ages. The CVL as a dispersion barrier, neighbouring riverine system and lowland/montane movements in response to climatic oscillations can all be used to explain the actual geographical distribution of the diversity and endemism in this ecoregion. Otherwise, some evidence got from our phylogenetic analyses and divergence age dating suggested that recurrent exchanges persisted between the CVL and the East African Montane Arc. Finally, at the level of CVL, our data allowed us to propose a biodiversity structuration model that has been compared to previous available results based on other taxa. Data on fossil record, as well as an exhaustive history of CVL montane environments during the whole Pleistocene, are needed for a better understanding of the observed CVL evolutionary diversification patterns.

### Merian Award Applicant

## TEMPO OF DIVERSIFICATION IN AFRICAN RAINFORESTS, APPLYING NEW GENOMIC TOOLS TO PHYLOGEOGRAPHY

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Exploring what we know about the evolutionary history of African rain forests is a prerequisite to predict their potential response and resilience capacity to ongoing and future perturbations. According to palaeoecological proxies, the story of African rain forests is closely linked to Plio-Pleistocene climate oscillations: the contraction of forest cover during cold and dry glacial periods was counterbalanced by its expansion during warmer and wetter interglacial episode. But, the role of climate as motor of evolution of tree species is difficult to assess with palaeoecology at a fine taxonomical scale, and there is still much uncertainty regarding the spatio-temporal species turnover, the intensity of past forest fragmentation, the size and location of forest refugia during glacial maxima. One key proxy to address these questions consists in studying the genetic diversity and structure of rain forests and disentangling the singular and repeated evolutionary trajectories of their constituent tree species through integrative phylogeography.

The development of next generation sequencing through the capture of chloroplast genomes at deep multiplexing levels has been undertaken on 140 individuals of the rainforest long-living and shade-tolerant tree *Greenwayodendron suaveolens* (Annonaceae), which is characteristic of Central African mature forests. In parallel, 80 individuals of the pioneer and short-living tree *Musanga cecropioides* (Urticaceae) have been also analyzed. The polymorphism found on almost whole chloroplast genomes (several hundreds of SNPs along c. 130,000 bp) provides a very detailed phylogeographical signal to infer the evolutionary history of populations. Both forest populations of *Greenwayodendron* and *Musanga* are characterized by distinct cpDNA phylogroups, mainly in Upper Guinea and in northern, eastern and western parts of the Lower Guinean and Congolian forests. Populations could have been fragmented into a restricted number of refugial areas in the past that seems display diverse demographic signatures. Ongoing molecular dating should provide a more precise temporal framework for comparing speciation and the diversification of each phylogroups, and the role of their life history traits in terms of resilience during glacial/interglacial oscillations.



## TROPICAL TREE GENOMICS REVEALS FRAGMENTATION OF THE AFRICAN RAINFOREST DURING THE ICE AGES

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The fossil record in tropical Africa suggests that **dry conditions** during the **Ice Ages** caused the **contraction of rainforests** in favor of savannas. This seems to explain why the African rainforest harbours less species than the other two main rainforests in South America and South Eastern Asia. Based on the rate of endemic species, the location of several refuge areas for the rainforest in Central Africa has been proposed. However, **to what extent** the forest was fragmented, **where** it survived, and the **timing** of demographic events remain unknown.

In order to address these questions, genomic data from 500 individuals of **eight rainforest tree species** were generated using **nuclear microsatellites** and **Genotyping By Sequencing** (GBS). GIS tools showed remarkable congruence of the intraspecific genetic discontinuities across species in Central Africa, pointing at common past barriers to gene flow. Demographic tests revealed clear genetic signals of population expansions, possibly following bottleneck events, compatible with a history of forest fragmentation. Estimates of expansion times support a scenario of colonization after the Penultimate Glacial Maximum rather than after the Last Glacial Maximum, which may be explained by more arid climatic conditions during the former.

## GENETIC DIVERSITY AND POPULATION STRUCTURE IN THE MALAGASY BIG-HEADED TURTLE, CONSEQUENCES FOR ITS CONSERVATION

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The Big-Headed Turtle (*Erymnochelis madagascariensis*) is a critically endangered endemic freshwater turtle species to Madagascar. Big-headed turtles live on slow moving rivers, lakes and swamps, and are constrained to a range between the Mangoky River on Madagascar's West and the south of the Sambirano region on the North of the country. The relatively small distribution range of the species, in combination with a long generation time (approximately 25 years) and the existing annual export quota for the species, has resulted in a continuous decrease of the species population over time.



In this study we analysed over 450 animals representing almost 400 wild samples and animals kept in captivity by Durrell for the species breeding plan. We genotyped a total of eight microsatellites in these samples and sequenced a portion of their cytochrome b mitochondrial gene.

The microsatellite data revealed a total of four clusters spread over 23 sampling sites on Western Madagascar. The mitochondrial DNA divided the samples in three main groups that were concordant with the population structure observed with the microsatellites. The captive population represents a fraction of the genetic diversity observed in the wild, with only two mitochondrial haplotypes from among over twenty observed in the wild present among the captive big-headed turtles. The results described here reflect how the genetic diversity of this iconic Madagascan turtle is divided by watersheds, and are relevant for the further development of the species captive breeding program.



## EVOLUTIONARY HISTORY AND PHYLOGEOGRAPHY OF STRANDESIA OSTRACODS FROM FOUR MAJOR BRAZILIAN FLOODPLAINS

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South American floodplains have exceptionally large sizes and hold a variety of (indigenous) floating aquatic plants, where the root systems can host a complex ecosystem of invertebrate communities (including ostracods) called pleuston. *Eichhornia crassipes* (Mart.) is one of the most common plant species in these floodplains, and is also one of the most persistent invasive species in (sub-) tropical regions outside of the Neotropics.

Here, we study the potential of non-marine ostracods for past and present long-distance dispersal at a (sub-) continental scale (>2000 km) using DNA sequence data from the mitochondrial COI and nuclear Elongation Factor genes. We investigate the genetic connectivity and phylogenetic relationships of four morpho-species and 13 cryptic species in the ostracod genus *Strandesia* Stuhlmann, 1888, forming a species cluster in four large Brazilian floodplains. We also analyse the phylogeographic and evolutionary history of dispersal and vicariance events that might have led to the origin and present-day distribution of these lineages. Applying a universal COI molecular clock in a Bayesian approach, we provide preliminary age estimates of the evolution of this species cluster and try to correlate these to the hydrological history of the studied floodplains.

## COMBINING TROPICAL PALEOECOLOGY AND TREE RINGS TO RECONSTRUCT PAST ECOLOGICAL DISTURBANCES

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Ecological disturbances such as fire, grazing and human impact are important drivers of ecosystem dynamics in tropical regions. Fire is considered a key ecological process at the savanna-forest ecotone, with long-term fire variability largely responding to the centennial scale variations in the moisture balance. The extent to which prehistoric human impact left a legacy on present tropical ecosystems is instead still highly debated. Short (tree rings) and long-term (paleoecology) records can provide unique insights into the range of variability of disturbance regimes at both low and high frequency, together with the relative drivers of change.



Dendroecology approaches (tree rings measurements and stable isotopes) can provide high resolution, spatially detailed disturbance histories and stand scale dynamics of tropical forest, together with climate reconstructions. Charcoal records from lake sediments instead can offer a longer-term perspective over ecosystem dynamic, identify past ecosystem thresholds, how ecological processes interacted over time. Methodological approaches combining such different temporal perspectives can provide new insights for tropical disturbance ecology, and be informative for future biodiversity conservation and post-fire management in tropical areas.



## THE DYNAMIC RELATIONSHIP BETWEEN FOREST AND SAVANNAH IN CENTRAL AFRICA

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At Lope National Park, Gabon, the vegetation transition from forest to savanna has created a unique, dynamic ecotone and is a dominant force in the ecology of the flora and fauna of the region. The edge of the forest has moved across the landscape for the past 18,000 years in patterns driven mainly by climate, but modified in a multitude of ways by the actions of man.

We have carried out multi-disciplinary research on the post Pleistocene evolutionary ecology of the region for the past three decades. Work by a large group of institutions and individuals has produced a databank on the population ecology of the wildlife community, its species-level diversity and, for several taxa, underlying phylo-geographic patterns. The data on animal populations is embedded in a contextual databank including information on local climate and vegetation incorporating measures of structure, composition, diversity, biomass, productivity and reproductive strategies. Concurrently, research on anthropogenic impacts has elucidated the role of humans in the landscape. Fire, hunting, clearing of grass and trees, but also planting of trees and crops have all directly changed the landscape, and altered the resilience of both forest and savanna to climate change.

This presentation considers how the multiple strands of research on change over time at the Lope site can be brought together to understand how the present forest and savanna ecosystems were shaped over the recent evolutionary past, and what this can tell us about their trajectories for the future.

## ALTITUDINAL VEGETATION CHANGES ON THE DRY NORTHERN SLOPE OF THE MT. KILIMANJARO FROM THE LATE GLACIAL TO THE HOLOCENE

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Tropical mountain forests characterized by high species richness represent great ecological importance as sources of water and other ecosystem services for millions of people living in the tropics. However, in context of combined impacts of global warming and the conversion of natural to human-modified landscapes, understanding the long-term vegetation dynamics in Tropical mountain forests is urgently needed to assess future landscape dynamics.



Here we used pollen and phytolith analyses of palaeosoil profiles from montane forests of Mt. Kilimanjaro to reconstruct past changes of altitudinal vegetation belts. In addition to show the dynamics in altitudinal vegetation belt changes from the Late Glacial to the Holocene, our results highlight important composition changes of the main tree taxa and the C3 and C4 grasses. Comparison between different sites, located on the drier northern slopes and the wetter southern slopes allow to characterized ecosystem dynamics and their reaction on environmental changes, especially regarding precipitation and temperature. These results will contribute to a better understanding of modern and future ecosystem dynamics and to maintain and manage the high biodiversity in the East African biodiversity hot spots by governmental and non-governmental agencies.



## HISTORICAL DEVELOPMENT OF THE EAST AFRICAN VEGETATION FROM THE LATE MIOCENE

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East Africa contains a microcosm of most tropical African vegetation types, from the arid Sahelian vegetation to the bizarre cold and wet tropic-alpine vegetation, to more normal thicket, savanna and lowland rainforest. This vast range of vegetation types is not zonally organised, but in a complex mosaic, where many types are fragmented into small parts and separated from other small parts. This fragmentation is most likely the result of the remarkable environmental heterogeneity, including the tallest free-standing mountain in the world, a spectacular rift valley and a wide coastal plain. The consequence is an unusual juxtapositioning of vegetation types, often without the normal transition zones.

The reconstruction of Plio-Pleistocene vegetation changes in this region is immensely complex, influenced by (a) geomorphological evolution – uplift, rifting, volcanism; (b) changes in climatic controllers, such as the ITCZ and off-shore sea-surface temperatures, potentially leading to climates without modern analogs; (c) changes in the fire regimes driven by changing grassland distribution and composition and (d) changes in the biotic environment. Consequently, it seems unlikely that a modelling approach will be successful in reconstructing palaeo-vegetation for East Africa. Here we use the available fossil data to indicate potential vegetation points, and use this as starting point to speculate on the past distribution of vegetation types. This indicates a general linear increase in C4 grasses (interpreted as a spread of grassy savannas at the cost of a more woody vegetation), and more complex local variation.

## INTEGRATING BIOGEOGRAPHY, PALEOECOLOGY, AND PHYLOGENOMICS TO RECONSTRUCT THE EVOLUTIONARY ORIGINS OF THE AFRICAN RAND FLORA

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The Rand Flora is an enigmatic biogeographic pattern in which plant lineages from different families share a similar disjunct distribution across the continental margins of Africa and adjacent islands: Macaronesia-northwest Africa, Western African mountains, Horn of Africa-South Arabia, Eastern Africa, and South Africa. First described in the XIX century by the Swiss Botanist H. Christ, the pattern takes its name from the Germanic word “Rand”, i.e., rim or edge, since Rand Flora lineages are seemingly confined to the margins of the continent by inhospitable areas (environmental barriers), such as the northern Sahara Desert or the tropical lowlands of Central Africa. Several explanations have been proposed for this disjunction, ranging from vicariance of a Cenozoic macroflora by climate-driven extinction to long-distance dispersal events in more recent times.

Here, we explore the potential of integrating different sources of information, including spatial niche modelling, palaeoclimate models, novel biogeographic analytical tools, and next-generation-sequencing techniques to reconstruct the origins of this pattern at different phylogenetic scales, from species to populations to individuals. The interest on this pattern lies in the possibility to study the effects of large-scale, climatic extinction driven by the ongoing aridification trend that affects also the Southern Mediterranean region.



# SESSION 21

## HUMAN-MODIFIED TROPICAL FORESTS

Chair:

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Human disturbance in the tropics is leading to massive changes in biodiversity and major shifts in ecosystem biogeochemistry, altering key processes such as net primary productivity, ecosystem respiration, biogeochemical cycling and fluxes of reactive trace gases. Yet despite studies of land-use change impacts on biodiversity and ecosystem biogeochemistry of tropical forests, the links between these impacts have received less attention, challenging our ability to accurately model and predict the response of tropical ecosystems to current and future environmental forcings.

In this session, we will explore what is known about the linkages between forest degradation and biodiversity loss, and investigate the consequences of these concomitant phenomena for ecosystem processes and trace gas exchange. We will identify key knowledge gaps and discuss means of addressing them, including inter-disciplinary or multi-disciplinary modes of problem solving. Contributions are particularly welcome from those investigating plant-soil interactions; biosphere-atmosphere exchange; traits-based approaches to studying ecological processes; remote sensing approaches to quantifying biodiversity and ecosystem functioning; the role of fauna in modulating biogeochemical cycles and multi-trophic processes.

## S21-001 - HUMAN-MODIFIED TROPICAL FORESTS

### THE RELATIONSHIP BETWEEN TAXONOMIC DIVERSITY AND ABOVEGROUND CARBON STORAGE IS TAXON-SPECIFIC

Frederik Van de Perre<sup>1</sup>, Michael R. Willig<sup>2</sup>, Steven J. Presley<sup>2</sup>, Pascal Boeckx<sup>3</sup>, Hans Verbeeck<sup>3</sup>, Elizabeth Kearsley<sup>3</sup>, André De Kesel<sup>4</sup>, Petra Ballings<sup>4</sup>, Dries Van Den Broeck<sup>4</sup>, Myriam de Haan<sup>4</sup>, Bart Würsten<sup>4</sup>, Steven Janssens<sup>4</sup>, Olivier Lachenaud<sup>4,5</sup>, Patrick Grootaert<sup>5</sup>, Maurice Leponce<sup>5</sup>, Stijn Cooleman<sup>6</sup>, Steven Dessein<sup>4</sup>, Herwig Leirs<sup>1</sup>, Erik Verheyen<sup>5</sup>

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The preservation of forest carbon stocks is a key strategy in the battle against climate change. The UN-REDD+ program proposes to offer incentives for developing countries to reduce national deforestation rates and associated carbon emissions. These incentives could potentially mitigate climate change and at the same time conserve biodiversity. However, it remains uncertain whether preserving carbon stocks will automatically safeguard biodiversity. In many studies, biodiversity is positively (but weakly) associated with the amount of carbon stored in the ecosystem. This relationship is however geographically variable, and even reverses in some regions. Furthermore, most studies have evaluated relatively few taxa.



We analyzed the relationships between taxonomic diversity of a wide range of taxa (small mammals, birds, ants, flies, trees, lichens, slime molds and fungi) and aboveground carbon in the Yangambi Biosphere reserve (D.R. Congo). We used three different groups of taxonomic diversity metrics in our analyses: alpha diversity (species richness, Shannon and Simpson diversity), beta diversity (community dissimilarity), and species of conservation concern. The relationship between each of the diversity metrics and aboveground carbon was evaluated using orthogonal polynomial regression, including linear and quadratic components.

The effect size and shape of the associations between alpha diversity and carbon differed considerably among taxa. Only for trees highest diversity was found in high carbon forests. Furthermore, our results show that for most taxa, community composition differs more between forests, when these forests have larger differences in carbon stock. Our findings suggest that conservation of high carbon forest is necessary, but that effective conservation of regional biotas will require strategies that also conserve low carbon stock habitats.



## CARBON SEQUESTRATION, BIODIVERSITY AND SOCIAL STRUCTURES IN SOUTHERN AMAZONIA

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The globally relevant land use frontier of Southern Amazonia is extremely dynamic. Mato Grosso experienced an increase of 87% in cropland and 40% of deforestation from 2001-2004. This development is accelerating along the Cuiabá-Santarém highway and is associated with further major C losses and GHG releases.

The **main goals** of this multi- and interdisciplinary approach with Brazilian-German cooperation are viable C-optimized land management strategies mitigating GHG emissions and maintaining ecosystem services (ESS) under changing climate conditions. They are utterly needed to meet the goals set by Brazilian national plans (ABC) and international treaties such as REDD and the Kyoto protocol. **Three regions** along the land use frontier of Southern Amazonia were selected: Novo Progresso (Southern Pará): most active deforestation; Sinop (Northern Mato Grosso): young soy bean production; Cuiabá (Central Mato Grosso): established cultivation (>20 years) and adapted mechanised cropping (e.g. no till). Analyses focus on soil carbon (C) turnover, climate, ecosystem functions and socio-economic processes triggering land use change (LUC).

Within the project climate and socio-economic drivers of land use development are analysed to produce science-based and feasible recommendations for sustainable **“Land management strategies”**. For the **modelling of land use change** (LUC) and the development of land use strategies a cluster of internationally recognized model tools was used with regionalization for Southern Amazon. The model software developed by different groups of this project (ZALF, UFZ, CESR, University of Hohenheim) are either deterministic (agroecosystem model MONICA, GHG-modeling with CENTURY, CANDY and DNDC; soil erosion risk with EROSION-3D, SWAT for water balance; integrated regional land-use change with LandSHIFT) or multi-agent-based agro-economic modeling (MP-MAS), and allow simulation and assessment of scenarios for future land use practices under the conditions of climate change and GHG reducing land use strategies. Results how to set up regional adapted scenarios for modeling (4 “Carbiocial scenarios”) and simulation results of LUC for Southern Amazonia will be presented. Also consequences of LUC for ecosystem services as water balance in macro-catchments, soil-C-stock and erosion risk will be pointed out.

## NATURAL REGENERATION AFTER AGRICULTURE: CHANGES IN TAXONOMIC DIVERSITY IN THE TROPICAL DRY FOREST

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### Aims

Understanding the secondary forests capacity in retaining biodiversity has been recurring challenge among ecologists, mainly in tropical forests highly disturbed by agricultural use land. The Tropical Dry Forest are easily accessed by the human population mainly because of its structural simplicity. This results in forest mosaics, with areas with different abandonment ages by man, active areas and never used areas. We address two questions: (1) which regeneration potential of areas abandoned after intense agricultural use; and (2) what factors contribute to maintaining biodiversity in this landscape.



### Methods

We sampled woody species in 15 regeneration sites (4-70 years) and five mature forests and made chemical and physical analyzes of soil to know the soil changes over time. We used linear models and multivariate ordinations to describe the distribution and species composition between areas in regeneration and mature forests.

### Important Findings

The secondary forest showed rapid recovery taxonomic with initial areas having the same taxonomic composition that late and mature forests. There was an increase in the richness and diversity of species. The species with the highest abundance were also those with widest distribution. The soil has not changed over time.

The intense land use has led to a taxonomic and edaphic homogenization in the landscape. This configuration is common both for dry and wet forest. In this landscape with intense history of human use, natural environment limitations and severe socio-economic conditions, maintaining biodiversity is key; mainly maintaining of ecosystem services.



## TREE REGENERATION IN TUMBESIAN DRY FORESTS - EFFECTS OF FOREST COVER AND LIVESTOCK PRESENCE

Jorge Cueva<sup>1,2</sup>, Carlos Ivan Espinosa<sup>2</sup>, Hildebrandt Patrick<sup>1</sup>, Zhofre Aguirre<sup>3</sup>, Bernd Stimm<sup>1</sup>, Reinhard Mosandl<sup>1</sup>, Michael Weber<sup>1</sup>

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The Tumbesian Dry Forests of southern Ecuador and northern Peru cover an outstanding biodiversity with a high level of species endemism. However, they are strongly affected by human settlement including activities like agricultural expansion, selective logging and livestock farming, which is traditionally practiced by mainly using goats and cattle in few cases. Livestock farming is supposed to affect tree regeneration by grazing, seed dispersion or weed control and finally leading to forest degradation but the effects are not yet clear.

In order to assess the impact of livestock grazing on tree regeneration we used a stratified sampling design considering two vegetation types (deciduous and semi-deciduous dry forest) and three levels of stand density (sparse, semi-dense, and dense forest) based on a regional vegetation cover and land use mapping. In each stratum we installed 4 inventory clusters consisting of 3 plots (60m x 60m) for stand inventories (> 10cm DBH), summing up to a total number of 24 cluster (72 plots) or 25.92 ha in total. Regeneration of tree species was registered in 8 subplots (2m x 2m) within each plot (576 subplots in total; 2304 m<sup>2</sup>). 144 subplots of tree regeneration have been fenced in order to exclude cattle and goats grazing. We conducted one initial forest inventory as well as five repeated inventories of tree regeneration and assessed the impact of stand structure and grazing on the development tree of regeneration in terms of abundance, diversity, height growth, damages, and survival.

## IS GOLD MINING A SOURCE OF MERCURY EXPOSURE IN BATS FROM THE PERUVIAN AMAZON?

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Artisanal and small-scale gold mining (ASGM) is the largest anthropogenic source of mercury (Hg) to the environment. In the southeastern Peruvian Amazon, ASGM is estimated to have released up to 300 tons of Hg to the environment during the period 1995-2007 alone, and is claimed to be responsible for Hg concentrations above international guidelines in wildlife species related to aquatic systems. Here we investigated Hg exposure in bat populations and the possible relation to regional ASGM-Hg releases. For this, we analyzed fur Hg concentrations in bats collected at different distances from the major ASGM areas in Peru. We also examined the correlation between fur Hg concentrations and differences in feeding guilds, sex, reproductive stage, and body size.



Our findings in fur from 165 individuals of *Artibeus*, *Carollia*, and *Phyllostomus* indicate that bat fur Hg concentrations mainly respond to differences in feeding habits. Hg concentrations are significantly higher in omnivore bats than in frugivore bats. At least for *Carollia* and *Phyllostomus*, and for species *Carollia perspicillata* and *Phyllostomus elongatus*, our data indicate that populations in ASGM-affected sites have higher Hg concentrations as compared to populations in unaffected sites. Because Hg concentrations reflect Hg dietary exposure, this indicates that Hg emissions from amalgam roasting sites deposit locally and enter also the terrestrial food web. This study demonstrates that the location of ASGM activities (and consequent Hg point sources) increase wildlife Hg exposure; nevertheless, the overall Hg concentrations here reported are relatively low. Our findings are below the toxicity threshold at which neurological adverse effects have been recorded in rodents and mink (>10 µg g<sup>-1</sup>), and also below the mean baseline Hg concentration found in museum bat specimens from higher trophic levels collected in the Amazon basin in the 1920-30'. This emphasizes the importance of the feeding habits for Hg concentrations found in both bats and other animals.

**Merian Award Applicant**



## MANAGING OIL PALM PLANTATIONS TO MAXIMISE BIODIVERSITY, ECOSYSTEM FUNCTIONS, AND YIELD

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Oil palm agriculture has expanded rapidly across the tropics in recent decades, to meet the needs of a growing world population and increasing rates of consumption. The growth has caused widespread conversion of forest habitat to plantation monocultures, resulting in reduced habitat complexity, losses of biodiversity, and altered provision of ecosystem function. With demand for oil palm continuing to increase, there is an urgent need to determine how best to manage oil palm plantations in order to balance the competing needs of crop production, and biodiversity and ecosystem-function protection.

The Biodiversity and Ecosystem Function in Tropical Agriculture (BEFTA) Project in Sumatra, Indonesia, is a large-scale, long-term experimental project to investigate the effects of understory habitat management on biodiversity, ecosystem functions, and yield. Through a series of biodiversity surveys and ecosystem function experiments, we are determining how key ecosystem processes are mediated in oil palm plantations and what the effects of external factors such as rainfall and El Niño cycles are on the system. We are then considering how complexity of understory vegetation (including different levels of herbicide use and manual clearing) can affect these processes, and whether management-practice can provide a win-win for biodiversity and yield.

We found that there are complex interactions between ants, levels of herbivory and rainfall in oil palm plantations, suggesting a role for both ants and other predators in mediating caterpillar levels and herbivory damage. High levels of understory vegetation (in the plots with the lowest herbicide use and manual clearance) resulted in significantly higher diversity of ants and plants, but no indication yet of this harming yield. Experiments are ongoing, but results so far suggest that biodiversity and ecosystem function interactions are more complex than we might have imagined in highly modified oil palm landscapes. However, simple management tools – such as increased understory vegetation – may have the potential to provide environmental benefits without harming palm oil yield.

## MANAGING FOR PREDATORS: THE ROLE OF UNDERSTORY COMPLEXITY IN OIL PALM

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The spread of oil palm is a major threat to tropical biodiversity, but plantations can still contain a diverse mix of species. These include many predatory groups, some of which may be important for controlling pest species within plantations that can reduce yield and can result in the application of insecticides. Although some predatory species have been deliberately introduced into plantations or their populations manipulated to increase pest control, very little research has yet investigated the potential of wider-scale plantation management to benefit predatory species.



The Biodiversity and Ecosystem Function in Tropical Agriculture (BEFTA) Project has experimentally manipulated the understory habitat complexity in large replicated plots in mature oil palm plantations in Riau, Indonesia. By monitoring the predator communities before and after management in plots with reduced understory complexity (herbicide sprayed), enhanced complexity (no herbicide spraying), and intermediate complexity (business as usual plots with intermediate levels of spraying), we were able to assess the role of the oil palm understory in supporting predators in oil palm.

We found that higher levels of understory complexity can benefit a diverse mix of different predatory groups, including spiders, assassin bugs and frogs. In the case of spiders this can also lead to higher trapping rates and more complex communities. Our results have important implications for the development of more-sustainable oil palm management techniques.



## NECTAR-RICH PLANTS AS A MANAGEMENT STRATEGY FOR ENHANCING NATURAL ENEMIES OF HERBIVOROUS PESTS IN OIL PALM

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The expansion of oil palm in the tropics represents a significant threat to biodiversity. However better-managed plantations can still contain a diverse insect assemblage. Integrated Pest Management (IPM) practices are often used in oil palm plantations, where managers monitor pest species and only apply pesticides when pests reach a level where yield is affected. The objective of IPM is to preserve natural food webs and enhance the abundance of natural parasitoids and predators to control pest species.

A key strategy employed by IPM systems in oil palm is planting nectar-rich plants to attract parasitoid wasps, in order to control Lepidoptera abundance. Nectar is the main energy resource for adult wasps and enhances their longevity and fecundity. However, few studies have yet investigated the effectiveness of this strategy or the area over which individual plants have a measurable effect. In this study we investigate the distribution of nectar-rich plants across a typical plantation and experimentally test the efficacy of nectar-rich plants in supporting parasitoid numbers and controlling pest species and herbivory damage. We also investigate the optimum planting density and distribution of plants. As the project was only established in 2016, we will present preliminary results here.

We found parasitoids emerged more frequently from Lepidoptera pupae (21%) than larvae (3%), with the majority of the parasitoids being Hymenoptera (98%). This indicates that parasitoids of Lepidoptera are fairly common in plantations. The experimental component of this study will go on to investigate whether these parasitization levels can be enhanced by planting nectar-rich plants. We will also present data on the distribution of nectar-rich plants in plantations along with results from a recent study on the relationship between nectar-rich plants and major Lepidoptera families found in oil palm.

**Merian Award Applicant**

## SOIL BIODIVERSITY AND ECOSYSTEM PROCESSES ASSOCIATED WITH HABITAT COMPLEXITY, SOIL MANAGEMENT AND REPLANTING IN OIL PALM PLANTATIONS

Jake L Snaddon<sup>1</sup>, Hsiao Hang Tao<sup>2</sup>, Adham Ashton-Butt<sup>1</sup>, Resti Wahyu<sup>4</sup>, Jean-Pierre Caliman<sup>4</sup>, William A Foster<sup>3</sup>, Edgar C Turner<sup>3</sup>

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Oil palm plantations represent relatively complex agricultural habitats, with 25-30 year replanting cycles. This allows management practices to be used to restore and maintain biological processes to support soil physical and chemical fertility throughout the crop cycle. Here as part of the Biodiversity and Ecosystem Function in Tropical Agriculture (BEFTA) project we look across a number of studies at how soil invertebrate communities and associated ecosystem processes are impacted by habitat complexity, soil management practices and oil palm replanting in Riau, Indonesia.



For the core BEFTA project, the understory vegetation was manipulated in replicated plots resulting in reduced, normal and enhanced vegetation treatments. Here we examined ground dwelling arthropods using pitfall traps and soil biological activity through litter decomposition and bait lamina sticks. In a neighbouring site we examined the impact of four soil management zones: areas under 1) empty fruit bunch (EFB) application, 2) chemical fertilization, 3) pruned palm fronds, and 4) harvesting paths, on soil invertebrates and soil biological activity. To conclude, using a chronosequence of sites, we looked at soil invertebrate communities across a replanting event. Sampling soil monoliths from mature first-generation stands through to 6-year second-generation stands.

Our results show that differences in management have distinct effects on the soil biological activity and that practices such as EFB application and maintenance of understory vegetation can play an important role in supporting soil ecosystem functioning in oil palm plantations.



## THE ROLE OF ANTS AND TERMITES IN SUPPORTING ECOSYSTEM FUNCTIONING IN OIL PALM PLANTATIONS IN SUMATRA, INDONESIA

Amelia SC Hood<sup>1</sup>, Andreas D Advento<sup>2</sup>, Anak Agung K Aryawan<sup>2</sup>, William A Foster<sup>1</sup>, Edgar C Turner<sup>1</sup>

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The expansion of oil palm plantations is a primary cause of land-use change in Southeast Asia. Ants and termites are a highly important component of these ecosystems, playing roles as predators, herbivores, decomposers and drivers of soil properties.

We are assessing their importance in the ecosystem functioning of oil palm, using manipulative exclusion experiments. In particular, we are focusing on how their role changes throughout the process of replanting, and whether it is affected by different management strategies. Last year we set-up six exclusion and control plots at four study sites: one in a recently replanted site and three in mature plantations with different levels of understory vegetation complexity. To quantify ecosystem services we are taking measurements of yield, insect biodiversity, herbivory, soil properties, and decomposition rates. The implications of this study are both practical, as they affect plantation management, and theoretical, as they increasing our understanding of complex tropical ecosystems.

### Merian Award Applicant

## OPTIONS FOR REDUCING TROPICAL PEATLAND C EMISSIONS FROM OIL PALM AGRO-ECOSYSTEMS THROUGH SOIL SURFACE MANAGEMENT PRACTICES

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Southeast Asia (SE) is the only tropical region that is a net source of atmospheric C, attributed to both high rates of land-use change and disturbance of peat soils. Tropical peat soils have been estimated to make up ~ 11 % of global peatland surface area, whilst storing 88.6 Gt C, 15 – 19 %, of the total peatland carbon (C). Recent land-use change now sees half of tropical peatland area being management as industrial plantations, including oil palm plantations. Published soil respiration and peat oxidation CO<sub>2</sub> fluxes from this 'new' ecosystem vary widely, between 3.82 – 30 Mg C ha<sup>-1</sup> yr<sup>-1</sup>. Published net methane (CH<sub>4</sub>) fluxes suggest plantations are net sinks of CH<sub>4</sub>, at rates of -0.015 Mg C ha<sup>-1</sup> yr<sup>-1</sup>. It is currently uncertain how variations in management techniques can be employed to reduce peat oxidation emissions from agricultural peat soils. There is also a lack of data published on net CH<sub>4</sub> emissions from managed plantations, with data missing for CH<sub>4</sub> fluxes from drainage ditches.



Here monthly CO<sub>2</sub> and CH<sub>4</sub> measurements were taken for a year from different management areas on an oil palm plantation in Sarawak, Malaysia. The variations in surface management, such as bare soil harvest paths, frond piles and drainage ditches, allow for interpretation into how variation in the surface can alter both peat oxidation and methane fluxes. Similarly the natural variation in water table depth and climate data allows for an understanding in how managing the water table depth may affect CO<sub>2</sub> and CH<sub>4</sub> emissions. Combined, these data offer an opportunity to ascertain optimal management practices to enable long term soil health and reduce C emissions from oil palm plantations on peat soil.



# SESSION 22

## LEGACY SPECIMENS, FUTURE GOALS

### Chairs:

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Museum, herbarium and bibliographic collections represent a valuable legacy for tropical ecology. They are rich sources of data and material on the organisms they represent and are actively used by researchers, particularly in taxonomy. In recent years the push towards digitization of these resources has opened up new avenues for research. The digitization of biodiversity collections has included the imaging of the specimens; the transcription of specimen labels and the scanning of books. These new digital data, combined with the objects themselves are being used in research topics as diverse as ecophysiology, evolution, history of science, environmental history etc. Numerous environmental changes are occurring, including climate change, biodiversity homogenization, ocean acidification, pollution of the environment and the constant increase in human pressure on landscapes and land use. In this changing world biodiversity collections can provide a pre-industrial baseline for the tropics, which we can use to quantify change induced by modern human activity. Museums, herbaria and libraries are particularly rich in specimens and literature from the 18<sup>th</sup> and 19<sup>th</sup> centuries.

We propose a session to explore the possibilities of digitization and the legacy of biodiversity collections for tropical ecology. The session will bring together tropical ecologists with those people digitizing collections to explore the kinds of data that are available; their potential uses and the pitfalls of these data. Once collections are digitized many new communication possibilities are opened. Digitization will allow the linking of collections from many institutions and countries. It opens up the possibility to link information from diverse source. For example, databases of collectors, traits, medical uses and others can be linked together to reveal underlying patterns. Digitization will also improve the democratization of science, allowing everyone access to the same data and enabling now disenfranchised stakeholders to make use of these resources. Not only will this create new research opportunities, but it will also improve the efficiency of science.

This session will examine the multitude of uses of these data, particularly in tropical ecology, and the multitude of other potential origins of baseline information, including data from practitioners or impact assessments. It will bring together a wide range of stakeholders interested in biodiversity data, environmental change and biodiversity informatics. The session will investigate those areas of tropical ecology that will most benefit from collections data. We believe that this session will stimulate future research and collaboration between researchers in these fields internationally.

## DIGITALISATION OF HISTORIC INFORMATION ON ECOLOGY: CASE OF NATIONAL PARKS IN DR CONGO

Han de Koeijer<sup>1</sup>, Luc Janssens de Bisthoven<sup>1</sup>, Maarten Vanhove<sup>1</sup>, Jean-Pierre d'Huart<sup>2</sup>

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Parc National Albert, was established in 1925 as first national Park in Africa by King Albert I in the then Belgian Congo. It was renamed Virunga National Park after independence and is well known for its rich biodiversity, notably the emblematic mountain gorillas, its high variety of ecosystems and the threats to its existence by armed groups and economic activities (poaching, encroachment, oil-drilling). Virunga is one out of three national parks established in DR Congo during the Belgian colonial period.



The Royal Belgian Institute of Natural Sciences was instrumental in the management of the national parks during the colonial period. It was responsible for the scientific inventories of the parks. INPBC has published a series of more than 300 studies on the biodiversity of Belgian Congo between 1937 and 1960. Given his long affiliation with the INPBC, Dr. J. Verschuren of RBINS was responsible for the collections and the archives of the national parks and repatriated copies of many management reports to RBINS before the destruction of the administration in the post-independence turmoil. In 2003 the digitalisation of the archives and collections began with the support of summer work students. In 2015 most publications, photos and slides had been digitalised and a start was made with the management reports and with Dr. Verschuren's personal archives. All digitalised information has been published online and is available at <http://www.apncb.be>. The legal documents defining the official limits of the national parks during the colonial period are the only digitalised information not open for access.

The archives have been consulted regularly through the website and undoubtedly more so than in the previous 40 years. Photos from the archives have been used in several popular and scientific publications, for the visitor centre in Virunga NP as well as for studies in and around Garamba, Upemba and Virunga National Parks. A long term habitat monitoring project has started in the parks with the archives data as baseline.



## BIODIVERSITY BASELINES IN ENVIRONMENTAL IMPACT ASSESSMENTS

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Biodiversity is under threat from anthropogenic pressures, in particular in biodiversity-rich developing countries. Development cooperation actors, who traditionally focus on the improvement of socio-economic conditions in the South, are increasingly acknowledging the linkages between poverty and biodiversity, e.g. by referring to the ecosystem services framework. However, there are many different discourses which stress the need for biodiversity integration and which influence how biodiversity and development are and/or should be linked. Moreover there is a gap between the lip service paid to biodiversity integration and the reality of development cooperation interventions.

This study analyses how biodiversity discourses are reflected and shaped by environmental impact assessment (EIA) practice, and how these framings influence decision-making. The findings, based on an in-depth qualitative analysis of World Bank EIAs undertaken in West Africa, indicate the dominance of the 'utilitarian' and 'corrective' discourses, which respectively stress human use of nature and mitigation of negative unintended development impacts. Identifying and highlighting these discursive trends leads to increased awareness of the importance of biodiversity among all development actors in North and South. However, some discourses may lead to an overly narrow human-centred approach which downplays the intrinsic value of biodiversity. This study proposes recommendations for an improved integration of biodiversity in development cooperation, focussing on the need for systematic baseline studies in EIAs.

## DUSTY BASELINE: THE MERIT OF MUSEUM COLLECTIONS IN BIOLOGICAL INVASION STUDIES

Michiel Jorissen<sup>1,2</sup>, Antoine Pariselle<sup>3</sup>, Tine Huyse<sup>1,4</sup>, Emmanuel Vreven<sup>1,4</sup>, Jos Snoeks<sup>1,4</sup>, Filip Volckaert<sup>4</sup>, Auguste Chocha Manda<sup>5</sup>, Gyrhaiss Kapepula Kasembele<sup>5</sup>, Tom Artois<sup>2</sup>, Maarten Vanhove (speaker)<sup>2,4,6,7</sup>

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In most tropical regions, the Nile tilapia (*Oreochromis niloticus*, Cichlidae) has been introduced for aquaculture, making it one of the most widely-introduced species. Afterwards, it has become invasive in many places with detrimental effects on the local fauna. The literature reports a decline of indigenous cichlid species after the introduction of Nile tilapia in several African regions. It is a fast grower and aggressive species and can hybridize with indigenous cichlids. The effect of parasite co-introduction and possible subsequent parasite spillover and spillback remains, however, underexplored. Parasites can strongly influence the fitness and so the competitiveness of infected individuals and species. Therefore, it is important to monitor host-switching between native and invasive fish species.

The most prevalent gill parasites on Nile tilapia are Monogenea (Platyhelminthes). These are obligate fish parasites which have a direct lifecycle (no intermediate hosts), are species rich and generally host-specific. They mainly infect gills or skin of fish. These aspects make Monogenea ideal candidates for transfer because they only require a single host species in the invasive area, are easily transferred through skin contact or through eggs and since they are host-specific each host species hosts its own unique fauna of species, thus providing a distinguishable character between host species.

The goal of this research is to trace co-introduction of Nile tilapia parasites and subsequent host switching to indigenous cichlids. To trace this, the pre-introduction (or native) parasite fauna is reconstructed by sampling hosts stored in museum collections (baseline data). Contemporary samples from the same localities will be compared with the collected baseline data, which will allow for a reliable tracing of host switching events. We will present results from two ecoregions, Bas-Congo and Bangwuelu-Mweru, both within the Democratic Republic of the Congo and preliminary results of neighbouring ecoregions in central/southern Africa in which the host and parasite communities are explored and compared.



## TOWARDS LESS INVASIVE METHODS TO INVENTORY AND MONITOR WILDLIFE IN THE CONGO BASIN

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The establishment of the biodiversity inventory of a region requires making sometimes extensive specimen collections. Only after the taxonomic diversity of the main faunal components is sufficiently well known, ecological studies can be initiated. The transition between biodiversity inventory studies and ecological studies requires that traditional methodologies that mainly rely on specimen collections should gradually be replaced by less invasive methods. Such methods allow researchers, managers and conservationists to lower the impact of their studies on the populations of often already endangered species. Although such methods are well described for vertebrates, this does not seem to be the case for ecologically important invertebrates such as spiders, annelids, termites etc.

In this context, we intend to introduce and adapt existing methods to lower the impact of our projects in the region of Kisangani and protected areas in the Congo Basin (DR Congo). To this end we conducted a literature survey to compare different methodologies that are routinely used to collect biological data on various animal groups around Kisangani. Our study reveals that the number of animals trapped and killed over the past decade during studies on mainly terrestrial vertebrates, such as shrews, rats, birds, reptiles and amphibians is alarmingly high. With the presently used methods, thousands of animals are sacrificed during both short term and long term investigations. No less than up to 1,000 specimens are sacrificed for an average thesis. This is certainly an unacceptably high number!

Based on this observation, the future research projects of the 'Centre de Surveillance de la Biodiversité' will increasingly use less invasive methods such as banding (tracking study), the collection of feathers, droppings, wing skin (genetic research) for birds and bats, the use of photographs and videos (camera traps), the use of transmitters or tags in large mammals, capture-recapture-marking in small rodents and bats (toe clips) and photographs of amphibians to collect reliable biodiversity data without killing the studied animals.

## THE ROLE OF TROPICAL ECOLOGY IN EX-SITU PLANT CONSERVATION IN THE BOTANIC GARDEN MEISE.

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Ex situ plant collections play an important role in biodiversity conservation and studies related to plant ecology and evolution. The Botanic Garden of Meise holds 23000 accessions of nearly 18000 different taxa of worldwide origin and distributes around 1000 samples/ year worldwide. As there is an important demand for samples of rare and exceptional taxa and these taxa are often also important for conservation,



Botanic Garden Meise invests in programs to optimize the cultivation of these collections in respect to the niche diversity of the different taxa. Typically gardens with large ex situ collections cultivate these collections uniformly on a taxonomic or geographical level. For example all Aroids, Bromeliads or Begonias are kept in the same greenhouse under the same lighting and temperature and often on only a few potting mixes. Although, ex situ, this works fine for most species, rare and narrow niche taxa tend to get lost first.

Currently, in the 10000 taxa rich glasshouse collections, basic tropical ecology data collected from descriptions, databases and herbarium specimens of the different taxa are being encoded in the LIVCOL database. This includes data on biomes and (micro) habitats, habits, temperature, light, edaphic factors and soils. It is now easier to reorganize, cultivate and plant out collections based on an ecological rather than primarily on a taxonomic basis. In addition it is possible to print labels with these data available for the gardening staff. Currently around 2000 taxa have been encoded in the database with priority in groups with high niche diversity, research interest and importance for conservation.





# SESSION 23

## ECONOMIC VALUATION, CERTIFICATION AND CONSERVATION

### Chairs:

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Tropical forests are major pools of biodiversity. At a global scale, they fulfill multiple ecological functions and ecosystem services, such as carbon storage, mitigation of climate change and extreme weather conditions, and water cycling. The preservation of the remaining forested tropical landscapes is essential. Both locally and regionally, these forests provide direct benefits to forest dependent people in form of timber and Non Timber Forest Products. National and international industries also profit from these pools of biodiversity. Growing human demographic pressure as well as sheer economic interests of some players constitute important underlying causes of forest degradation and deforestation.

Therefore, a major challenge today is to reconcile environmental and socio-economical needs. A new economic paradigm - one in which material wealth is not delivered perforce at the expense of growing environmental risks, ecological scarcities and social disparities - may be the answer. The quite new concept of Green Economy can be seen as this new economic paradigm, driving growth of income and jobs, while reducing environmental risks and scarcities - in short, delivering sustainable development. For example, through the recognition and traceability of products coming from well managed resources, certification is regarded as a powerful tool to reduce negative impacts of forest management interventions, to ensure both economic benefits and the maintenance of the ecological functions of tropical forests over the long term.

The goal of this session will be to present some results from research project aiming at conducting tropical forest ecosystems valuation and assessing the benefits of tropical forest management interventions and certification on these ecosystem's environmental and economic values.

## TROPICAL FORESTRY: WHAT IS THE ROLE OF CERTIFICATION, WHAT EFFECTS CAN BE EXPECTED, AND HOW TO EVALUATE IMPACTS?

Marion Karmann<sup>1</sup>

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To introduce Session 23 of the congress, this talk will discuss the FSC certification standard requirements for an African forest management operation. It will address the challenges that forest management standards have balancing environmental, social, and economic interests in forestry.

Focusing on ecological issues, indicators and areas for expected positive change management will be analysed, and compared with examples of 'corrective action requests' from public reports, resulting from certification bodies' office and field audits and public consultation feedback. This talk will help researchers identify the background material of the certification scheme to attribute findings to the context of certification claims and call research.



## A LOOK AT INTACT FOREST LANDSCAPES AND THEIR RELEVANCE IN CENTRAL AFRICAN FOREST POLICY

Barbara Haurez<sup>1,2,3</sup>, Kasso Dainou<sup>1,2,4</sup>, Cédric Vermeulen<sup>2,3</sup>, Fritz Kleinschroth<sup>5,6</sup>, Frédéric Mortier<sup>5</sup>, Sylvie Gourlet-Fleury<sup>5</sup>, Jean-Louis Doucet<sup>2,3</sup>

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Tropical forests are important providers of natural resources and ecosystem services but their ecological functions are facing increasing human pressure, linked to economic development. The preservation of tropical forest ecosystems is interrelated with effective land use planning and identification of priority areas for conservation.

Initially defined by Greenpeace and the World Resources Institute (WRI) in 2000, Intact Forest Landscapes (IFLs) are large areas of forest minimally impacted by human activities. IFLs were identified by mapping industrial activities, road networks and infrastructure using remote sensing. Since 2014, when IFLs were recognized and adopted by the certification scheme Forest Stewardship Council (FSC), the IFLs have become integrated into forest management policies. In order to trace the history and evaluate the applicability of IFLs for forest management policy in the Central African context, we searched for documents related to the IFL method, and previous similar concepts.

The IFL method is simple and cost-effective and enables the monitoring of forest degradation at a global scale. However, the approach mainly considers forest cover and is imprecise at the local scale. For example, hunting, one of the main threats faced by Central African ecosystems, cannot be detected by satellite imagery and is therefore disregarded in IFL identification processes. In contrast, there are other considered anthropogenic activities, such as reduced-impact selective logging, which may be compatible with forest ecosystem conservation.

To better tailor the IFL approach to Central African forests, we recommend (i) the consideration of wildlife communities distribution in the analysis of disturbance, (ii) a thorough evaluation of the impacts of different human activities on forest ecosystems, and (iii) the integration of local stakeholders and governments in the design of land management strategies devised to address social, economic and environmental needs.

## SOCIO-ECONOMIC AND CONSERVATION IMPACTS OF FOREST CERTIFICATION AT LOCAL SCALE IN CENTRAL AFRICA

Richard Eba'a Atyi<sup>1</sup>

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Voluntary certification schemes help consumers to differentiate among goods and services that meet some social and environmental requirements, and provide access to niche markets to certified companies. Although certified forests and plantations are increasing in Central Africa, the existence of observable positive socioeconomic and environmental impacts of forest certification is still questioned.



The social impacts of FSC-certified Forest Management Units (FMUs) were assessed in the Congo Basin. It was found that certified FMUs: (i) provide better working and living conditions for workers and their families; (ii) have more inclusive and better governed institutions for negotiations between the local population and logging companies; (iii) have better managed and more effective benefit-sharing mechanisms; and (iv) adopt innovative ways of dealing with problems related to infringement of customary uses, which remains one of the most thorny issues that companies face in certified FMUs.

In addition to social impacts, FSC certification could have a positive influence on forest conservation. In Gabon, FSC-certified companies were observed to perform better than non-certified companies in almost all national legal requirements and international standards in wildlife management. However, assessing effectively the environmental impacts of forest certification appears to be complex as quality biodiversity and monitoring data are scarce for certified forests and even more difficult to find for non-certified FMUs. This is further complicated by the intrinsic complexity of characterizing biodiversity, and by the diversity of existing certified forest management practices.

In conclusion, although FSC certification seems to generate positive social and environmental impacts, consensual practical management activities for achieving specific, measurable biodiversity objectives are needed to better understand the benefits of forestry certification on biodiversity.



## SURVEY AND DIAGNOSIS STUDY OF CAPITAL ASSETS AND LIVELIHOODS STRATEGIES OF HOUSEHOLDS DEPENDING ON RESOURCES OF THE LUKI BIOSPHERE RESERVE (DRC)

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Poverty issues need to be addressed in a holistic way. This implies adopting an integrated approach for ensuring a multidimensional analysis. This research addresses multidimensional poverty analysis through the concepts of livelihoods and the capitals theory. Households' livelihoods opportunities are a set of space-time varying assets allocated between five categories of capital (natural capital, human capital, social capital, financial capital and physical capital). Depending on exploitable assets and related behaviours, households make choices to achieve a sustainable life balance.

The livelihoods approach provides an analytical framework for measuring categories of capital to move towards sustainable development.

In the protected areas context, such as the Luki Biosphere Reserve, people depend on natural resources or income. The Luki Reserve is consequently in the process of an environmental degradation. We have investigated the availability of assets in the Luki Reserve and made links with livelihood strategies by carrying out 330 household surveys. This study has been conducted on in 14 villages to collect data on the five capitals.

The application of the multidimensional livelihoods approach and capital theory allows to highlight an interdisciplinary manner to enhance the contribution of natural resources to tropical forests dependent households. This, including economic, valuation has the advantage to better understand the livelihoods choices and strategies of rural households.

## ESTIMATE THE ECONOMIC VALUE OF THE CAMEROON SEGMENT OF THE TRIDOM

Jean Hugues Nlom<sup>1</sup>

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This talk aims to estimate the economic value of the Cameroon segment of the Tri-national Dja-Odzala-Minkébé, also known as TRIDOM. The methodological framework used for that purpose is the well known Total Economic Value (TEV) which aims to give a price to all goods and services delivered by the nature and to avoid hence the *"tragedy of the commons"* as raised by G. Hardin (1968) in the exploitation of natural resources like forests. Some goods and services delivered by forests have market prices while others don't have. In that final case, economists have developed several techniques like travel cost method (TCM), contingent valuation method (CVM), hedonic price method, replacement costs and others.



In the specific case of our study, the estimation of the TEV is limited to timber, fuel wood, non-timber forest products, ecotourism, watershed protection and carbon storage. Results show that the TEV of Cameroon segment of TRIDOM is about US\$ 67.96 billion that is US\$ 3.09 per hectare. This amount is divided in direct use value (US\$ 1.31 billion), indirect use value (US\$ 66.65 billion) and option and existence values (US\$ 9 million). Indirect use value appears to be the most important category of value within TEV. That result proves a real potential concerning forest services while the involvement of Congo basin countries to carbon financial markets remain limited. Congo basin countries should then put in place mechanisms to develop payment for environmental services.





# SESSION 24

## INCLUDING LIANAS IN VEGETATION MODELS

### Chairs:

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Lianas (woody vines) are structural parasites and an important component of tropical forests. Recent research from the Neotropics has indicated that lianas are proliferating in abundance and biomass. Although the drivers behind this liana increase are currently not fully understood, liana proliferation itself can endanger the future of the tropical carbon sink as lianas reduce carbon sequestration and storage in these forests. As tropical forests play an important role in the global carbon cycle, this in turn may lead to increased atmospheric CO<sub>2</sub> concentrations, which may have serious implications for climate change. Understanding the mechanisms behind the increase in liana dominance relative to trees in tropical forests is therefore pertinent to better predict the fate of tropical forests in a changing climate. However, to be able to make future predictions of the consequences of changing liana impacts on the carbon balance, lianas need to be integrated into vegetation models from which they are currently absent.

This session will gather scientists to discuss the recent research developments in the field of liana ecology. We are particularly interested in bringing together liana ecologists, ecophysiologicalists and vegetation modellers to be able to integrate these different knowledge bases with the aim to:

- (i) Synthesize the current knowledge of the impact of lianas on ecosystem processes in tropical forests;
- (ii) Integrate current knowledge on the functional differences between lianas and trees;
- (iii) Propose potential mechanisms for the increase in liana abundance and biomass to incorporate lianas and their effects into vegetation models.

## PARASITE-HOST INTERACTIONS IN TROPICAL TREES: LIANAS DIFFERENTIALLY IMPACT POPULATION GROWTH RATES AMONG HOST TREE SPECIES

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Lianas are structural parasites of trees and reduce individual host tree growth, survival, and fecundity. Yet, the impact of liana infestation on individual tree species population growth rates remains unknown. This is essential as lianas are increasing in abundance across the Neotropics, which may have profound consequences for tree species composition if lianas differentially reduce host tree species population growth rates.



In this talk, I show how we used long-term data to evaluate the effects of lianas on the reproduction, growth and survival of 57 to 91 tree species from Barro Colorado Island, Panama. For a subset of 33 tree species with sufficient data across the entire life cycle, we build integral projection models to integrate the effects on growth, survival and reproduction across the life cycle and quantify the effect of lianas on population growth rates.

Liana infestation decreased tree growth, survival and reproduction, with strong effects on survival in fast-growing, light-demanding species and on reproduction in large-statured species. Population models show that on average, populations of trees with >50% of their canopy infested by lianas decline by 1.9% annually (or by 33% per decade). The reduction in population growth rates was greatest among fast-growing species, which showed higher sensitivity to liana infestation (~12.5% annual decreases).

Results demonstrate that lianas have strong differential effects on tree species population growth rates. Given that large proportions of trees are infested with lianas, our results indicate that increases in liana abundance are likely to alter tree species composition in Neotropical forests.



## IMPACT OF LIANAS ON INDIVIDUAL TREE GROWTH

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A strong competition exists between lianas and trees for both above- and belowground resources. It has been shown that lianas can limit the growth, recruitment, diversity and survival of tropical forest trees, which can have large consequences for tropical forest dynamics.

In this study, we investigate the effect of lianas on individual tree growth at the Gigante Peninsula in Panama. At Gigante, a liana removal experiment was carried out in 2008 in 16 0.64ha plots (8 removal plots and 8 control plots), with follow-up in 2011 and 2013. Accordingly, tree growth as affected by the presence of lianas was recorded in the control plots, while unaffected tree growth was monitored in the removal plots. We present a mixed effect model to predict individual tree growth while accounting for liana infestation, light availability, neighboring competition and wood density of each individual tree. This model is subsequently used to predict stand-level forest productivity both in the absence and presence of lianas, and model performance is tested against the liana removal plots.

## THE LIANA ASSEMBLAGE OF A CONGOLIAN RAINFOREST: DIVERSITY, STRUCTURE AND DYNAMICS

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This study analyses the diversity, composition, and dynamics of the liana assemblage of the Ituri rain forest in north-eastern DR Congo. In two 10-ha plots of the Ituri Forest Dynamics Plots 15008 liana individuals ( $\geq 2$  cm diameter at breast height) were found, representing 195 species, 83 genera and 34 plant families. Liana density decreased from 1994 through 2001 to 2007, with concomitant declines in basal area and above-ground biomass. Despite lower stem densities the species richness remained constant over time. Total liana recruitment rates decreased only slightly and mortality rates decreased significantly over the census intervals. Diameter growth and survival increased with liana stem diameter. In contrast to the generally found increase in liana abundance in the neotropics, the Ituri forest showed recent declines.

Interestingly, changes in overall liana community structure and composition were mostly driven by one species only: the superabundant *Manniophyton fulvum* collapsed between the first and the second census. The vital rates recruitment, growth and mortality shared a wide interspecific variation and most species had low to moderate rates. Species that grew fast tended also to recruit and die fast, but recruitment and mortality rates were not directly related, suggesting that species shift in absolute abundance over the 13 year period. Lianas are thought to globally increase in overall density, but information on species level changes in abundance and on the underlying vital rates that explain changes in liana density is scarce. The Ituri forest showed a pervasive change in liana population densities in the last decade. Many decreasing species are associated with disturbed habitats and are short-lived. Many increasing species are late successional and longer-lived. Increasing species have a slightly higher recruitment, decreasing species a higher mortality. This study suggests that changes in the liana community result from forest recovery from past disturbances. Rising atmospheric CO<sub>2</sub> level, the most widely suggested factor driving liana increase, was not a likely explanation for liana change: more species declined than increased, and increasing species did not have higher growth rates. This is the largest study of an African liana community and its dynamics, and I conclude that in the Ituri Forest local stand dynamics override more global drivers of liana change.



## INCREASING LIANA DOMINANCE MAY EXACERBATE THE LONG-TERM IMPACTS OF HYDROPOWER ON TREE DIVERSITY AND CARBON STORAGE IN THE TROPICS

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Flooding tropical forests for hydropower can create archipelagos of islands comprised of former hilltops. Tropical forest communities isolated on islands undergo rapid and sustained degradation; lianas are well-adapted to degraded habitats, and may therefore proliferate. Lianas compete with trees at all life stages both above- and below-ground, reducing tree recruitment and survival. Lianas store significantly less carbon than trees, and therefore altered liana-tree dynamics on islands could intensify loss of both biodiversity and carbon storage, representing an additional and currently unaccounted-for impact of dam creation. Using islands within the Balbina hydropower dam in the Brazilian Amazon, we explore community characteristics of sapling and mature lianas.

We find that liana saplings increase in dominance relative to tree saplings in small and highly degraded islands, and that mature liana density, dominance and biomass increase with island area. The diversity of liana communities remains relatively constant across islands and mainland plots, and liana community composition does not converge with that found in continuous forest as island area increases. Liana communities appear not to respond strongly to isolation on reservoir islands: we highlight that as liana communities thrive, remnant tree communities likely face additional stress from increasing liana-tree competition, further negatively impacting the biodiversity and carbon storage potential of reservoir islands.

## LIANA IMPACTS ON CARBON DYNAMICS IN TROPICAL FORESTS: RESULTS FROM A LIANA REMOVAL EXPERIMENT

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Lianas (woody vines) are a key component of tropical forests. Lianas use trees for structural support to access the canopy, and competition between lianas and trees can substantially decrease tree growth and survival, leading to a reduction forest-wide carbon uptake. Lianas have recently been increasing in abundance and biomass in Neotropical forests, which may alter the carbon balance and cycle of tropical forests. Tropical forests store and sequester vast amounts of carbon and currently contribute ~40% of the terrestrial carbon sink. The increase in liana abundance and biomass may reduce the capacity of tropical forests for carbon storage and sequestration and therefore impact the global carbon cycle. However, estimates of the impact of lianas on carbon dynamics of tropical forests are crucially lacking and it is therefore pertinent to investigate the effect of lianas on forest-level biomass dynamics.

We established a large-scale liana removal experiment in the Barro Colorado Nature Monument in Panama. The aim was to simulate a forest that is essentially liana-free to assess the forest-level impacts of lianas on carbon dynamics compared with unmanipulated control plots in which lianas were present. Five years after liana removal, lianas reduced net above-ground carbon uptake severely. Additionally, seasonal analyses showed that liana biomass growth is higher in the dry season, as has been shown in other research. However, in contrast, the impact of lianas on net above-ground forest carbon uptake is greater in the wet season compared to the dry season.

Our results particularly demonstrate the large impacts lianas have on ecosystem processes. In particular, they reveal large differences in carbon cycling between forests with and without lianas. Combined with the recently reported increases in liana abundance, these results indicate that lianas are an important and increasing agent of change in the carbon dynamics of tropical forests and may be partially responsible for the long-term decline in the carbon sink function of Amazonian forests.



## INTRODUCING LIANAS IN A DGVM, METHODS AND FIRST RESULTS

Manfredo di Porcia e Brugnera<sup>1</sup>, Marcos Longo<sup>2</sup>, Elizabeth Kearsley<sup>1</sup>, Hans Verbeeck<sup>1</sup>

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<sup>2</sup>Brazilian agricultural research corporation (EMBRAPA), Brazilia, BR

Lianas are an important component of tropical forests, commonly constituting up to 40% of the woody stems and about 35% of the woody species and contributing substantially to forest leaf biomass. Lianas compete strongly with trees for both above- and below-ground resources. Their indirect impact on the carbon balance, due to their influence on tree community dynamics (by increasing mortality and suppressing tree growth), is far larger than their direct contribution to biomass.

Currently tropical forests are experiencing large-scale structural changes, including an increase in liana abundance and biomass. This may eventually reduce the projected carbon sink of tropical forests. Despite their crucial role no single terrestrial ecosystem model has included lianas so far.

The goal of this work is to include lianas in a Dynamic Global Vegetation Model and to test it against experimental data. For the purpose we chose ED<sub>2</sub>, a model that occupies the midpoint on the continuum from gap models that contain individual trees, to area-based global models. ED<sub>2</sub> explicitly tracks horizontal and vertical heterogeneity in canopy structure making it very suitable to study liana impacts at a large scale. At the same time, the very inner structure of the model, that is its spatial implicitness, constraints the programming design of this new liana PFT.

In the first part of the presentation I will outline the current representation of lianas in ED<sub>2</sub> and the parametrization that has been used. I will provide reference to the available literature to justify the choices made for parameters and allometries.

In the second part I will show preliminary results where I compare the output of the model with the data collected in the sites of Barro Colorado Island (Panama) and Paracou (French Guiana). The data comes from both inventories and flux towers. I will focus mainly on plant density (demography) and GPP / evapotranspiration (monthly / daily fluxes). By comparing initialized runs and runs starting from bare ground and liana vs no liana runs I will assess the strengths and weaknesses of the current model version.

**Merian Award Applicant**

## A VIEW FROM ABOVE: USING AN UNMANNED AERIAL VEHICLE (UAV) TO INVESTIGATE SCALE AND PATTERN OF LIANA INFESTATION IN TROPICAL FORESTS, MALAYSIA

Catherine Waite<sup>1</sup>, Geertje van der Heijden<sup>1</sup>, Doreen Boyd<sup>1</sup>, Richard Field<sup>1</sup>

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Tropical forests are a major global carbon sink, storing ~30% of terrestrial carbon. However, recent increases in liana abundance are pervasively altering forest structure; reducing carbon accumulation and long-term storage by enhancing tree mortality and reducing growth by up to 84%. Also, by relying on trees for support, lianas allocate a higher proportion of biomass to foliage production over carbon-dense stems reducing net above-ground carbon uptake by as much as 76%/year. Despite this, lianas are chronically understudied in tropical forest censuses and while mapping and monitoring studies utilising satellite and airborne images have occurred, they are limited by relatively coarse spatial and temporal resolutions, cloud obscuration, and high costs. Resultantly, a relative dearth of data on the scale and impacts of recent liana proliferation exists. The use of UAV imaging provides a potential tool to map and monitor lianas at higher spatial and temporal resolutions than possible with plot-based censuses, while overcoming limitations associated with traditional airborne and satellite techniques.



Combining UAV and ground-based canopy censuses in two areas of Malaysian forest, this research will investigate whether canopy cover of lianas can be accurately distinguished using UAV imagery. It aims to assess the viability of UAVs for mapping and monitoring lianas in tropical forests while providing information on the extent and spatial patterning of liana infestation. This is crucial for analysing and quantifying lianas' effect on forest function, while helping uncover mechanisms behind their proliferation, as a continued increase may further reduce tropical forest carbon storage and sequestration, thus endangering the future of the tropical carbon sink. Preliminary results ( $r$  values = 0.68 to 0.83,  $n = 20$ ,  $p$  values = <0.001) indicate a strong, positive correlation between UAV-derived and ground-derived %liana canopy cover on an individual tree level. At this initial stage, these encouraging results suggest the UAV may indeed be an affordable, accessible new method for collecting data on liana canopy cover in tropical forests.

**Merian Award Applicant**



# SESSION 25

## ARTHROPOD ECOLOGY AND CONSERVATION

### Chairs:

Yves ROISIN, yroisin@ulb.ac.be

Maurice LEPONCE, Maurice.Leponce@naturalsciences.be

Arthropods are the most abundant and most diversified animals in tropical ecosystems. They are distributed among several guilds, such as predators, herbivores, fungivores and decomposers, showing various degrees of specialization. In addition, many species play an important role by interacting with plants, such as pollination, seed dispersal or protection against herbivores.

Whereas social insects dominate most terrestrial tropical habitats by their abundance and biomass, a multitude of non-social taxa occupy specific niches. In view of the considerable interdependence between arthropods, plants, and other inhabitants of the tropics, anthropogenic disturbances may produce dramatic effects on the ecosystems, affecting both their constitution and the services they provide. This session will explore various aspects of the ecology and conservation of arthropods in tropical ecosystems. It will pay special attention to the interactions between ants and other organisms, but will also address other interactions involving arthropods, emphasizing the need to take arthropods into account in conservation policies.

## THE CONSERVATION STATUS AND EXTINCTION RISK OF MALAGASY MILLIPEDES

Elena Rudolf<sup>1</sup>, Thomas Wesener<sup>2</sup>, Axel Hochkirch<sup>1</sup>

<sup>1</sup>Trier University, Trier, DE, s6elrudo@uni-trier.de

<sup>2</sup>Zoological Research Museum Alexander König, Bonn, DE

Madagascar is known for being one of the world's biodiversity hotspots with high endemism rates and a highly threatened flora and fauna. While the extinction risk is well known for the endemic vertebrate species, the threatened status of the invertebrate fauna is less understood. Within the framework of a current "charismatic mega-invertebrate" project of the IUCN, which aims to increase the portion of the invertebrates assessed in the IUCN Red List of Threatened Species, 145 endemic Malagasy millipedes of the orders Sphaerotherium (also known as Giant Pill-Millipedes) and Spirobolida (Spirobolid Millipedes) were examined regarding their extinction risk and knowledge gaps in respect of the conservation status were identified.

For the study, the available data on the distribution, ecology and estimated population size for each species was compiled from publications and unpublished information sources. Based on the estimated distribution range and the threats within this distribution range, the extinction risks of the species were assessed in accordance with the criteria of the IUCN Red List of Threatened Species. Those information were used to investigate the overall extinction risk of the examined species and the spatial distribution of the biodiversity richness as well as of the threatened species and the Data Deficient species.

The study shows that most of the examined species are restricted to forest habitat and therefore highly depend on the remaining forest cover of Madagascar. The majority of them is only known from a restricted forest area, often limited to an extent of less than 100 km<sup>2</sup>. Almost a third of the examined species are threatened by extinction, most of them even qualifying for the Critically Endangered category. Another 26 % of the species are Near Threatened, while for 19 % of the species not enough information were available to class the species into one of the IUCN categories. The major threats to the species were small-scale agriculture in the form of slash-and-burn agriculture (tavy) and logging activities within the remaining forests.

The study reveals the importance of taking invertebrates into account, when determining conservation measures, and shows the importance of further research in Madagascar to close the knowledge gaps concerning the Malagasy millipede fauna.



## WOLBACHIA: A PUPPET MASTER IN THE PARTHENOGENESIS OF THE NEOTROPICAL TERMITE *CAVITERMES TUBEROSUS*?

Simon Hellemans<sup>1</sup>, Nicolas Kaczmarek<sup>1</sup>, Yves Roisin<sup>1</sup>, Denis Fournier<sup>1</sup>

<sup>1</sup>*Evolutionary Biology and Ecology (CP 160/12), Université Libre de Bruxelles, Brussels, BE, sihellem@ulb.ac.be*



The Neotropical termite *Cavitermes tuberosus* conditionally uses sexual and asexual reproduction to combine the advantages of both strategies: workers, soldiers and dispersing reproductives are produced via normal sexual reproduction, whereas non-dispersing queens (*i.e.* neotenic daughters) are produced asexually through gamete duplication. Thelytoky can be encoded in the genome of *C. tuberosus*, or induced by maternally inherited bacteria such as *Wolbachia*, *Cardinium* or *Rickettsia*. By manipulating the reproduction of their hosts towards the female sex, reproductive parasites enhance their own transmission. We aimed at determining the presence and the potential impacts of reproductive parasites in *C. tuberosus*.

We collected 15 nests of *C. tuberosus* in a range of 120km in French Guiana and screened termites for bacteria infection using 16S rRNA polymerase chain reaction. All nests were positive for *Wolbachia* infection only. Almost all individuals within a nest, whatever the caste they belonged, were infected.

*Wolbachia* strain was identified in 15 nests by sequencing six standard genes. Phylogenetic analysis unambiguously evidenced that one single strain, belonging to supergroup F, infected all nests. Sequences shared 99% identity with the *Wolbachia* strain from the bedbug *Cimex lectularius*. This *Wolbachia* strain is known to be essential for the host's growth and reproduction.

Overall, our results suggest an intimate relation between the two partners. Whether *Wolbachia* masters the host' reproduction or supports the host's growth and survival, remains an open question

## THE MANY CONTROLLED BY THE FEW: RAIDING BEHAVIOUR IN THE TERMITE PREDATOR *MEGAPONERA ANALIS*

Erik Frank<sup>1</sup>, Karl Eduard Linsenmair<sup>1</sup>

<sup>1</sup>*University of Würzburg, Würzburg, DE, erik.frank@uni-wuerzburg.de*

There are no true central place foraging studies focused on obligate group raiding predators. This study tries to explain foraging behaviour in light of present theories using *Megaponera analis* as a model organism. *Megaponera analis* is a group hunting ponerine ant species, specialized on termites of the subfamily Macrotermitinae. The combination of laboratory and field experiments revealed an unprecedented amount of detail of their foraging behaviour, thus allowing us to test and confirm various central place foraging predictions. Remarkably most of these behaviours are not regulated collectively but by very few individual scout ants.



We found a clear positive relation between raid size and termite abundance at the foraging site thereby confirming predictions of the maximization of energy theory. Furthermore selectivity of the food source increased with distance, thus confirming central place prediction theory. We identified the driving factors for raid size variability, recognizing food source quality rather than distance or colony size as the main factor. The confirmation of these theories strongly suggests that scouts must be the main driver behind raiding choices and behaviour. Marginal value theorem is also confirmed by our results. Time spent at the hunting ground increased with distance and larger food sources were exploited longer. This raises the question on how the foraging time at the food source is collectively regulated in a group-hunting predator. Hunger decreased selectivity of the food source, while average raid size increased and more scouts left the nest in search of prey. These results suggest that foraging behaviour becomes more risk-prone under hunger, supporting hunger state prediction theory.

Remarkably most central place foraging behaviours in *M. analis* were not achieved by collective decisions but rather by individual decisions of scout ants. Thereby having 1% of the colony (10-20 scouts) deciding the fate and foraging efficiency of the remaining 99%.

**Merian Award Applicant**



## TO CHEAT OR TO CLEAN? MUTUALISTIC RELATIONSHIPS BETWEEN ANTS AND RATTAN PALM IN DANUM VALLEY, BORNEO

Maciej Barczyk<sup>1</sup>, Marcin Czarnoleski<sup>1</sup>, Krzysztof Miler<sup>1</sup>

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Ant-plant mutualism is a well-known element of many tropical ecosystems. Nonetheless, the knowledge about particular systems, including ants inhabiting climbing palms of southeastern Asia, is still scarce.

We examined the rattan palms *Korthalsia furtadoana*, which produce ant-housings (domatia), in tropical lowland forest of Borneo in Danum Valley Conservation Area. The domatia are used by several species of ants as the nesting space. Some of these species are supposed to provide protection to their host-palms. We surveyed 100 palm aggregations, evaluating the presence of ants in the domatia and the physical condition of leaflets in each case. Furthermore, we examined how ants react to artificially placed herbivores and epiphylls, which might be associated with the potential factors limiting the growth of plants in a dense tropical rainforest.

We identified three ant species inhabiting domatia: two species belonging to genus *Camponotus* and one to genus *Crematogaster*. Our results show that leaflets of rattans inhabited by ants, regardless of the species, are less damaged by herbivores and, moreover, are less overgrown by epiphylls, than leaflets of uninhabited rattans. However, when we compared the condition of leaflets between palms inhabited by different ant species, we found that although all three species seem to protect their hosts against herbivores, protection against epiphylls occurs only in *Camponotus*. We examined how ants react to artificially placed herbivores and epiphyll and showed how their peculiar behaviour correlates with condition of leaflets. Our findings shed a new light on the complexity of this poorly studied ant-palm system.

## ANT MOSAICS IN TROPICAL LOWLAND FORESTS: TAKE A LOOK AT A BIGGER SCALE

Ondřej Mottl<sup>1,2</sup>, Jacob Yombai<sup>3</sup>, Vojtěch Novotný<sup>1,2,3</sup>, Maurice Leponce<sup>4</sup>, Petr Klimeš<sup>1</sup>

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<sup>2</sup>Faculty of Science, University of South Bohemia, Ceske Budejovice, CZ

<sup>3</sup>The New Guinea Binatang Research Center, Madang, PG

<sup>4</sup>Operational Directorate Natural Environment, Royal Belgian Institute of Natural Sciences, Brussels, BE

The ant mosaics theory was established to describe the patchy structure of arboreal ant communities in forests systems and it is essentially built upon the concept of dominance hierarchies between ant species and the existence of negative and positive associations among them. It is documented from degraded ecosystems that dominant ant species create spatially non-overlapping territories. The question how the spatially excluded territories are created and if ant mosaics are prevalent also in primary forest is still relatively unclear and studies have struggled to bring an end to the debate.



Not only different forest type, but also the scale of observation and use of different statistical approach could contribute to the high variability of results among ant mosaics studies.

We have sampled dominant arboreal ants from a 9ha primary forest plot in Papua New Guinea to obtain data on spatial distribution of ant community on larger scale. We have randomly selected 25 canopy trees from each hectare (225 trees in total) and used a slingshot to install ropes with tuna-honey baits into the tree crowns. We have found 27 canopy ant species and also performed simple behavioural tests to determine colony boundaries. The extension of mapped territories ranged from a single tree to almost 1 hectare. This result suggests that the position of study plot on smaller scale (1 hectare or less) could provide different results based only on dominant colony in the selected plot.

In addition, we have done series of aggression tests between the 4 most abundant species. We have calculated Aggression Indexes for each species, which showed correlation with number of occupied baits and size of the colony. Those results suggest the behavioural importance of individual species on the ant mosaic.

Our results confirmed the existence of ant mosaics in a tropical primary forest and suggest that the size of study plot could affect the results of research done on spatial distribution of arboreal ants.



## THE SMELL OF RESINS: HOW AN AUSTRALIAN EUCALYPT ATTRACTS ITS BEE SEED DISPERSER

Sara Leonhardt<sup>1,2</sup>, Anna Baumann<sup>3</sup>, Helen Wallace<sup>2</sup>, Peter Brooks<sup>2</sup>, Thomas Schmitt<sup>1</sup>

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<sup>2</sup>University of the Sunshine Coast, Sippy Downs, AU

<sup>3</sup>None, NA, DE

Many bees provide an essential mutualistic service to plants, the pollination of their flowers. But bees can also disperse seeds of plants, a rare seed dispersal mutualism called melittochory. Australian stingless bees (Apidae: Meliponini) disperse the seeds of an Australian endemic eucalypt (*Corymbia torelliana*, Myrtaceae) by collecting resin from its fruits. We investigated whether the resin chemistry of *C. torelliana* may be particularly well adapted to attract the bees by studying the importance of resin compounds as olfactory cues in this bee seed dispersal mutualism.

We performed several choice tests with pure resin extracts, fractionated extracts, extracts enriched with *C. torelliana* resin compounds and with single compounds, to investigate whether the stingless bee species *Tetragonula carbonaria* relies on olfactory cues when searching *C. torelliana* resin and which compounds of the blend they use to identify it.

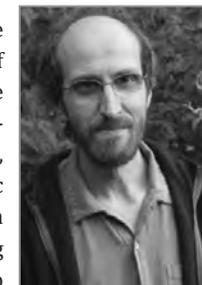
We found that olfactory cues were sufficient to attract bees, but that they only landed on filter papers with pure resin extract, whereas they did not land on papers with fractionated or enriched extracts, nor with single compounds. This behaviour suggests that, instead of relying on just a few specific volatile compounds, the bees use a complex mixture as recognition cue as well as relative compound proportions. Moreover, they hardly tolerate even slight changes of concentrations of single components. Such high cue specificity is unusual for insects seeking resources. In the case of Australian stingless bees, it does however ensure detection and identification of the resin of their mutualistic partner.

## SAWFLIES OF ETHIOPIAN AND ECUADORIAN HIGHLANDS IN A CHEMO-ECOLOGICAL PERSPECTIVE

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Sawfly (Hymenoptera, Symphyta) larvae feed on a diversified range of plants, and they are often attacked by natural enemies. Both of these inter-trophic relationships importantly rely on bioactive chemicals such as defensive compounds. However, chemo-ecological data are very fragmentary for tropical sawfly species, which is due at least to a lack of collection material and basic knowledge about biological traits. Here, sawflies were sampled in two countries, Ethiopia and southern Ecuador, by mainly focusing on biotopes situated at higher altitudes. The main aims were to update the species list for the countries, and whenever possible, to gather ecological data about species.



The identified specimens belong to the Tenthredinidae, Argidae and Pergidae. In Ethiopia, the most common sawfly genus was *Athalia* (Tenthredinidae). Numerous adults of *Athalia vollenhoveni* Gribodo, 1879 were found on one patch of *Ajuga integrifolia* (Lamiaceae), at an altitude of 3200 m. They used this plant as a copulation site, while the larvae have Brassicaceae as host plant, each sawfly stage exploiting particular plant metabolites in reproduction versus defence. In Ecuador, a population of larvae of *Lagideus podocarpus* Smith, 2016 (Pergidae) was discovered at an altitude of 2800 m, the larvae feeding on *Fuchsia vulcanica* (Onagraceae). A simple bioassay revealed that these larvae were efficiently defended against attacking ants. More generally, it is known that the larvae of Argidae and Pergidae contain toxic peptides which are harmful to invertebrates and even lethal to vertebrates. Further taxonomical and chemo-ecological research of sawfly species from tropical areas is promising in that it exemplifies the entomological chemo-biodiversity of biotopes which are, however unfortunately, often highly endangered.



# SCIENTIFIC POSTER SESSION - ABSTRACTS



S01-P01 - TRAITS AND FUNCTIONS IN THE TROPICS

## FOLIAR HERBIVORY AND LEAF TRAITS OF CONGENERIC TREES OF TWO CONTRASTING FOREST FORMATIONS OF THE MATA ATLÂNTICA BIOME

Aline do Nascimento<sup>1</sup>, Vitor Cyrino<sup>1</sup>, Dora Villela<sup>1</sup>, Marcelo Nascimento (speaker)<sup>1</sup>

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Environment and leaf quality are among factors that influence herbivory in plants. The aims of the study were: (1) to compare herbivory and leaf traits in rain forest (RF) 'restinga' (RES, or arboreal vegetation of coastal sandy areas) species; (2) to relate herbivory to leaf traits; and (3) to establish if differences in leaf traits are related to environment (dry vs wet) or phylogeny. The study was carried out in forest fragments at the União Biological Reserve (RF) and at the Caruara Reserve (RES) in the state of Rio de Janeiro, Brazil. Ten congeneric pairs of native species, five individuals per species, were marked and mature leaves (n=20 per individual) sampled in May and September 2013 and January and August 2015. Leaf area and rate of herbivory were determined and leaf C and N were analysed.



Herbivory was significantly higher in RF ( $7.2 \pm 0.24\%$ ) than in RES ( $3.2\% \pm 0.9$ ), 60% of RF species vs. 20% of RES species had herbivory > 5%. Leaf herbivory of congeneric pairs was similar (n = 2) or greater (n = 7) for RF species, except for *Eugenia*, which showed higher herbivory in RES than in RF (p < 0.05). Leaves of *Byrsonima*, *Cecropia*, *Ficus* and *Eugenia*, had always low damage (< 5%) in both RF and RES, while *Annona* showed leaf herbivory > 5% in both vegetation types. N concentration was significantly higher in RF ( $2.55 \pm 0.91\%$ ) than RES ( $1.92 \pm 0.87\%$ ) leaves and the C:N ratio was significantly greater in RES ( $29.1 \pm 13\%$ ) than in RF ( $20.2 \pm 8.4\%$ ) leaves. Leaf C:N was negatively and N positively correlated with herbivory. Our results indicate that environment and not phylogeny explains the patterns of herbivory and leaf traits at the study sites.

TUESDAY 16:00 - 18:30



## OBSERVING TREE WATER RELATIONS AND CLIMATIC VARIATIONS IN A MOUNTAIN RAINFOREST OF SE-ECUADOR

Brenner Silva<sup>1</sup>, Simone Strobl<sup>2</sup>, Jörg Bendix<sup>1</sup>, Erwin Beck<sup>2</sup>

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<sup>2</sup>Bayreuth Center of Ecology and Environmental Research and Department of Plant Physiology, Bayreuth, DE



In the biodiversity hotspot of SE-Ecuador, different behaviours have been observed in water regulation of individual trees. We simultaneously deployed a laser scintillometer for area-averaged measurements of above-canopy evapotranspiration and thermal dissipation probes (Granier) for sap flow measurements at selected tree individuals within the evergreen lower mountain forest. In addition, area-wide evapotranspiration has been estimated by remote sensing at crown level to investigate the change in evapotranspiration between a humid and a less-humid period.

A positive change was observed in almost half (48%) of the tree crowns within the measurement footprint of the scintillometer. This change which is in line with conditions of lower humidity was not observed in the other 52% of the crowns. At the same time, only 37% of individuals showed a coefficient of determination  $> 0.5$  between evapotranspiration and sap flow observations along a year of measurements. In this work we present the different tree water relations with observed meteorological conditions in the evergreen lower mountain forest of SE-Ecuador.

## RARE TREE SPECIES SUPPORT FUNCTIONAL DIVERSITY IN RESOURCE-ACQUISITION IN CENTRAL AFRICAN FORESTS

Elizabeth Kearsley<sup>1</sup>, Koen Hufkens<sup>2</sup>, Hans Verbeeck<sup>1</sup>, Marijn Bauters<sup>1</sup>, Hans Beeckman<sup>3</sup>, Dries Huygens<sup>1</sup>, Pascal Boeckx<sup>1</sup>

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<sup>3</sup>Royal Museum for Central Africa, Tervuren, BE

Tropical forests are characterized by a high biodiversity. In the context of identifying processes underlying the maintenance of species diversity, we examine the relationship between the rarity of tree species and their contribution to functional diversity (FD) at a central location in the tropical rainforest of the Congo Basin.

FD indices are assessed using a set of functional traits representing unique contributions to plant resource capture and growth, namely wood density, specific leaf area, leaf nitrogen content and leaf carbon isotope composition. Tree species covering a cumulative 95% basal area in 5 1ha plots are included in the analysis, with a total of 738 individual trees being sampled, covering 105 species. For each species, the contribution to FD is determined by assessing the extremity of species trait locations within the functional trait space and by quantifying the distance between functional characteristics of different species or functional distinctiveness. The relationship between these measures and the rarity of the species in the tree communities are determined.

Our main finding is that rare species support the trait combinations with the highest functional distinctiveness. Rare species however cover the entire range of low and high functional distinctiveness, contributing both unique and redundant functions. Common species only show a low contribution to FD but are crucial for aboveground carbon storage. We argue that within carbon sequestration initiatives, inclusion of both FD and biodiversity conservation is imperative not only for conservation purposes but also to sustain the stability of the ecosystem.



## HOW TO CRACK THE CAFFEINE CODE? DISCOVERING THE GENETIC DIVERSITY BEHIND CAFFEINE SYNTHESIS IN THE GENUS *COFFEA*

Yves Bawin<sup>1,2</sup>, Steven Janssens<sup>1,2</sup>, Erik Smets<sup>1,3</sup>, Brecht Verstraete<sup>1,2,4</sup>

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Caffeine is a well-known secondary metabolite that is independently produced by several flowering plants including *Camellia* (tea), *Theobroma* (cocoa), *Citrus* (lime and oranges), *Paullinia* (guaraná) and *Coffea* (coffee). Within these caffeine-producing plants, the caffeine is stored in different organs in order to deter herbivores and pathogens, to inhibit germination of competitors in their surroundings, or to attract pollinators. The caffeine synthesis pathway is mainly studied in commercial coffee species (*C. arabica* and *C. canephora*). Three *N*-methyltransferase enzymes (XMT, MXMT, and DXMT) participate in caffeine synthesis in these species, resulting in moderate to high seed caffeine levels in *C. arabica* and *C. canephora*, respectively. However, cultivated coffee species show only a snapshot of the total diversity in caffeine content present in the genus *Coffea*. The seed caffeine concentration of *Coffea* species varies between 0 and 2.5 % of the dry weight, with multiple species producing caffeine-free seeds. The mechanisms that cause the absence of caffeine in the seeds of some coffee species are still unknown.

Our study of the three nuclear genes that encode the three caffeine synthesis enzymes confirmed the occurrence of these genes in several coffee species. We also identified small deviations in the nucleotide and amino acid sequences of *C. canephora* and closely related species compared to the gene sequences of all other studied species, possibly explaining the high caffeine content in the seeds of these species. However, clear information about the genetic basis of caffeine synthesis in non-caffeinated species could not be obtained. We are developing a next-generation sequencing pipeline to retrieve the sequences of the caffeine synthesis genes and several related genes with high coverage in *Coffea*. By doing so, we aim to further uncover the genetic diversity underlying the remarkable variation in the accumulation of caffeine in this plant genus.

## USE OF MIOMBO-TREES FOR FUEL AND CONSTRUCTION IN CUSSEQUE (BIÉ, ANGOLA): SPECIES USED, BIOMASS ESTIMATES AND IMPACTS ON VEGETATION

Raquel Kissanga<sup>1,2</sup>, Luís Catarino<sup>2,3</sup>, Cristina Hanson<sup>2,3</sup>, Fernanda Lages<sup>4</sup>, Manfred Finckh<sup>5</sup>

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<sup>2</sup>Department of Plant Biology, Faculty of Science, ULisboa, Lisboa, PT

<sup>3</sup>CE3C, Centre for Ecology, Evolution and Environmental Change, Faculty of Science, ULisboa, Lisboa, PT

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The Cubango River Basin is rich in biodiversity and the livelihoods of thousands of people from Angola, Namibia and Botswana depend on it. About half of the Basin's population live in Angola and traditionally depend on many different plant species to satisfy their basic needs.



This study was developed in the context of the TFO project (The Future Okavango) in the three villages of Cusseque, where Miombo forests are the main vegetation type. The aim of this study was to investigate the woody plants species used by the population to build houses and for fuel, as well as to estimate the amount of biomass used. For that, we conducted semi-structured interviews and weighted and measured the volume of the trunks used for construction and fuel. The houses built in each village were counted and we calculated the respective area.

In total, 51 species were used in construction and 11 were referred to be used as fuel. The listed species belonged to 21 families, among which 12 species were herbaceous, 8 were shrubs and 30 were trees. However, it should be noted, that the use as fuel is hardly selective and many trees used for this purpose may not have been reported.

The houses built were classified as large, medium and small-sized, and the average biomass used in the construction of the walls of each house type was estimated to be 2,450, 1,750 and 1,050 kg, respectively. For this purpose the local populations used adult trees, obtained from neighboring forests that often were being cleared for cultivation.



We estimated an annual total consumption of 524.6 tons of woody biomass by 1085 residents, corresponding to 483.5 kg *per capita*. Of total wood consumption, fire wood amounted to about 1 kg *per capita* per day, or 411.2 tons of biomass annually spent by the population of the three villages (approx. 78% of the total). On the other hand, about 113.4 tons of forest biomass per year were used for construction of houses (approx. 22% of the total).

The wood used for fuel can be collected in an opportunistic manner, in the fields or on the way between the fields and settlements, while harvesting the logs for house building is preferably made in the forests. Although the values obtained are estimates, they allow outlining the impact the use of plants by resident communities has on Miombo ecosystems and help us to assess the sustainability of current land use systems.

### Merian Award Applicant

## COMPARATIVE PLANT FUNCTIONAL TRAITS AMONG TREES/SHRUBS AND GEOXYLIC SUFFRUTICES IN BIÉ PLATEAU-ANGOLA

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Two groups of woody plant species occur in central Angola, forming a diversity of species pairs of trees/shrubs and dwarf shrubs, so called geoxylic suffrutices. The pairs appear similar but differ strongly in life form and habitat. However, less obvious differences and correlations in selected plant functional traits between the life forms tree and dwarf shrub are very likely but yet unknown.



This study was therefore conducted to compare the following plant functional traits among pairs: Specific leaf area (SLA), leaf thickness (LTh), woody density (WD), and leaf concentrations of N (LNC), C (LCC), P (LPC), Ca (LCaC), Mg (LMgC) & K (LKC) and C:N ratio. The investigated trees/shrubs were *Cryptosepalum exfoliatum*, *C. pseudotaxus*, *Uapaca* sp., *Parinari curatellifolia*, *Syzygium guineense* & *Combretum zeyheri* and the corresponding geoxylic suffrutices were *C. exfoliatum* ssp. *suffruticans*, *C. maraviense*, *U. nitida* P. *capensis*, *S. guineense* ssp. *huillense* & *C. platypetalum*. The measurements were made in the surroundings of Cusseque, Bié Province, and samples were collected for chemical analysis. Data was analysed with comparative and correlation statistics such as ANOVA or PCA. The results showed significant differences between the pairs in most of the traits, some positively (e.g. SLA) or negatively (e.g. LMgC) correlated. We concluded that three traits were characterising the differences between the life forms best, namely LMgC, LTh & LCaC. According to PCA, the most similar trait in all pairs was SLA (mean contribution 35.62%) followed by LKC (20.07%), LCaC (15.53%) and C:N ratio (12.20%). The highest similarity in plant traits between geoxylic suffrutices and trees/shrubs was found in the pair *Combretum platypetalum* and *C. zeyheri* (16.09%) of which SLA represented about 49.6% of total similarity. We concluded that there are differences in plant traits among geoxylic suffrutices and trees/shrubs that are closely related and the best trait that allowed establishing similarities was SLA.



## COMPARATIVE PHYLOGEOGRAPHY AND POSTGLACIAL EXPANSION IN TWO DRY AFRICAN TROPICAL WOODLANDS SPECIES

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Zambezian and Sudanian savanna's are extensive across sub-Saharan Africa, ecologically important yet highly sensitive to global changes. Evolutionary history using intraspecific genetic variation, can provide valuable insight into how species have responded to past environmental and population changes and guide strategies to promote resilience to future changes.

Here, we examine the level and structuring of genetic diversity across the geographic range of two savannah woodland sister trees, *Azelia africana* (from the Sudanian area) and *Azelia quanzensis* (from the Zambezian area). We used variation in nuclear microsatellites DNA (nSSR) to study the Spatial Genetic Structure and phylogeography of these species with: 241 individuals for *A. africana* and 113 individuals for *A. quanzensis*, sampled across their natural range and herbarium. Individual-based bayesian clustering of nSSR genotypes identified two gene pools that correspond to the two morphospecies. There was no pattern of geographic structuring within each species. At the level of each species, the nSSR data revealed a weak correlation between genetic relatedness and spatial distance among individuals at large scale. Phylogeographic analysis using coalescent simulations indicated a more recent origin for the two species, suggesting range expansion in savannah of Sudanian and Zambezian regions, possibly during the Pleistocene period.

## PLANT DIVERSITY AND POPULATION DYNAMICS IN THE ARID SUCCULENT KAROO OF SOUTH AFRICA - 15 YEARS OF ANNUAL MONITORING

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The Succulent Karoo biome (80-250 mm pyr<sup>-1</sup>) is a renowned centre of biodiversity and endemism and one of few biodiversity hotspots in arid regions. The vegetation is dominated by leaf-succulent shrubs, which are accompanied by a high density of annuals and monocotyledonous geophytes. The biome is threatened by climate change, particularly increase in temperatures and changes in rainfall patterns. The impact that these changes will have on the diversity and species composition is poorly understood.

The BIOTA Southern Africa project (biota-africa.org) implemented 37 standardised long-term biodiversity monitoring sites, so called Biodiversity Observatories, along a north-south transect from northern Namibia to the Cape in South Africa. Nine Observatories are situated in the Succulent Karoo. The SASSCAL initiative (SASSCAL.org) extended the network of long-term monitoring sites in southern Africa and continues the annual vegetation monitoring. The Observatories are 1 km<sup>2</sup> in size and subdivided into a grid of 100 hectare plots. Within 20 randomly-selected hectares per Observatory nested plots of 100 m<sup>2</sup> and 1000 m<sup>2</sup> in size were monitored annually from 2001 until to-date. The annual monitoring comprises the species inventory and cover per species (100 m<sup>2</sup> and 1000 m<sup>2</sup>) as well as the abundance of individuals per species (100 m<sup>2</sup>). Environmental variables, like topography, soil surface structure, soil chemical and physical parameters were assessed as potential drivers of species composition and diversity. Standard weather variables (rainfall, air temperature and rel. humidity, wind direction and speed) were recorded by an automatic weather station next to each Observatory.

The poster will present the first results of 15 years of annual vegetation monitoring in the lowland Succulent Karoo (Soebatsfontein). A main focus is the response of cover and abundance per species and species richness per plot to the seasonal and inter-annual rainfall patterns.



## A SOCIO-ECOLOGICAL OBSERVATORY FOR THE SOUTHERN AFRICAN WOODLANDS

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Understanding the response of southern African woodlands to global change is the long-term goal of SEOSAW. These woodlands are the largest savanna in the world (3M km<sup>2</sup>) and support the livelihoods of >150 million poor people, but key ecological and social processes are not well understood. This knowledge gap arises because existing data have not been synthesised, nor analysed with state of the art methods. As a result, we currently have no reliable way to understand the future of the ecosystem under global change.

Shifts in vegetation structure in the woodlands have been hypothesised to result from a multitude of processes and could threaten future provision of ecosystem services to rural and urban people. Global change is also predicted to increase the carbon stored in African woodlands. However, there is currently no regional network of observations to evaluate if such changes are underway, and little testing or validation of model predictions against relevant data. Indeed, such models are generally based only on understanding and validation from South African national parks, or other continents, neither of which represent the woodland's functional ecology or social context.

SEOSAW will address this by synthesising data from across the region, and making it easily accessible for regional analyses and modelling efforts. It will also develop a set of standardised data collection methodologies and new collaborations to improve future observations. SEOSAW is an open partnership of 18 research groups (so far!), currently working on 2269 plots spread across the region.

## PERMANENT PLOT: A NOVEL REFERENCE TOOL FOR SUSTAINABLE MANAGEMENT OF THE MIOMBO FOREST IN UPPER-KATANGA

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The Miombo of Katanga has been the subject of studies dealing mainly with phytosociology and floristics (Duvigneaud 1958, Schmitz 1971); Malaisse and his collaborators published preliminary data on functional ecology (Malaisse 1978). However, little data exists on the structure of stands, their growth dynamics and their functioning. Nowadays, in Upper Katanga, no study has yet been carried out in permanent plots. This situation did not allow good management of miombo woodland because the definition of the adapted silvicultural routes for this ecosystem was never carried out efficiently.

This oral presentation aims to show how permanent plots can play an important role in the management of miombo (now degraded) by combining interdisciplinary approaches such as forest ecology (functional traits), silviculture, structure (tree distribution, species coexistence) and the growth and demography of miombo trees.

Recall that the Upper-Katangese landscape is scattered with high termite mounds, sheltering a particular flora. The functioning of this flora is very different from that of the adjacent environment; That is, the forest matrix. Other types of ecosystems can also be mentioned; These are the gallery forest, the dense dry forest, etc. During our presentation, we will also show how to study the ecology of the Upper Katanga forest through a permanent system, taking into account all its extremely complex biological diversities, ultimately proposing a decision-making plan for its sustainable management.



## THE PLANKTONIC COMMUNITY AND PRIMARY PRODUCTIVITY OF OWALLA RESERVOIR, OSUN STATE, NIGERIA

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This study investigated the planktonic community and primary productivity of Owalla Reservoir, Osun State, Nigeria. Seven (1, 2, 3, 4, 5, 6, 7) Sampling stations were used. At Stations 1 and 3, only surface water samples were collected for primary productivity and total plankton, while water samples were collected from three levels of water column (surface, mid-depth and close to the bottom) of the reservoir at stations 2, 4, 5, 6, 7. Plankton was examined under the light compound microscope at: x40 and x100 magnifications. Primary productivity was determined using

Oxygen Method. Physico-chemical parameters were also determined. The data obtained were statistically analysed.

About 137 species of phytoplankton and 39 species of zooplankton were obtained. The flora comprised 76 Chlorophyta, 16 Cyanophyta, 31 Bacillariophyta, 8 Euglenophyta, 3 Dinophyta, 2 Rhodophyta and 1 Haptophyta. The horizontal pattern of variation showed an increase in the mean abundance of most of phytoplankton groups from inflow to the dam area. Also, vertical variation showed a decrease in the mean abundance of most of phytoplankton groups from surface to the bottom of the reservoir. Seasonal variation in the mean abundance of phytoplankton and zooplankton species showed that most groups had their highest mean abundance during the dry season. Copepoda decreased towards the dam site while Crustacea increased towards the dam site while Rotifera had their highest mean abundance at the mid basin. Crustacea and Copepoda showed significant decrease ( $P < 0.05$ ) down to the reservoir bottom in contrast to the Rotifera which increased towards the bottom of the reservoir. This was also observed with Copepoda and Crustacea which both showed a decrease towards the dam area. Seasonal variation indicated that all the groups had their mean abundance highest at the surface both during dry and rainy seasons. Temperature and turbidity of Owalla Reservoir during the study period were in the range of 25.2 - 32.0°C and 0.37 to 121.2 NTU respectively. Alkalinity, DO, BOD, Conductivity and pH showed the highest mean values in all stations at the surface of the reservoir ( $42.4 \pm 1.24 \text{ mg CaCO}_3/\text{L}$ ,  $7.3 \pm 0.39 \text{ mg/L}$ ,  $3.13 \pm 0.26 \text{ mg/L}$ ,  $95.4 \pm 3.81 \mu\text{Scm}^{-1}$ ,  $7.39 \pm 0.04$  respectively); while Alkalinity, Acidity, BOD had highest mean values at the dam site. The Seasonal variation in the chemical parameters showed that Alkalinity, Acidity, DO, BOD and pH showed higher mean values during rainy season than in the dry season. The study concluded that Owalla Reservoir is rich in phytoplankton and zooplankton which will support aquatic organisms and fishery production.

Merian Award Applicant

## LOTIC ECOSYSTEMS IN THE MAB RESERVE OF YANGAMBI (DR CONGO): EXPLORATION OF THE DIATOM BIODIVERSITY

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Diatom diversity from the Man and Biosphere Reserve of Yangambi, located in Tshopo Province (part of the formerly Oriental Province) and bordering the Congo River, have never been the subject of any investigation till recently. The first samples for diatom analyses were taken in the North-Western part of the Reserve during the Belgian-Congolese Boyekoli Ebale Congo 2010 expedition. Sampling from the Lobilo River in the South Western part was done in 2012 and 2013 in the frame of a Belgian research project (COBAFISH) financed by the Belgian Science Policy. In 2015 a more detailed sampling plan and monitoring was established covering nine rivers and streams as PhD thesis topic of the second author (VLIR-UOS project).

Preliminary results of the diatom analyses are given for a selected number of rivers: Lobilo, Isalowe and Bosambila. The studied samples were all taken near the bridges over the rivers on road R<sub>408</sub> Kisangani-Isangi. The sampling site of the Lobilo is located at 5 km from its mouth, while the sampling site of the Isalowe and Bosambila was within about ten meters from their entrance into the Congo River. Additionally a sample taken near the source of the Isalowe was also investigated. First results of the diatom flora in these three acid rivers (pH 5.5-5.9) revealed a diversity of more than 80 species belonging to 31 genera. *Eunotia* was the dominant genus and represented by large species diversity among which *E. cf. rhomboidea*, *E. zygodon* and several taxa described new to science (e.g. *E. fuseyi*, *E. leonardii*, *E. rudis*). Besides a large number of cosmopolitan species (e.g. *Encyonema silesiacum*, *Eolimna minima*, *Frustulia crassinervia*, *F. saxonica*, *Gomphonema affine* var. *rhombicum* *Navicula cryptocephala*) pantropical species such as *Encyonopsis frequentissimum* and Tropical African species such as *Cavinula lilandae* were sporadically observed in all samples with exception of the Isalowe source. The species composition and presence of numerous cosmopolitan species point to an organic pollution. Indeed, the studied samples, with exception of the Isalowe source, were all taken downstream close to the mouth into the Congo River and have been exposed to human impact. Notwithstanding the rivers flow in a Reserve, they are running through small villages and are subject to the impact of local artisanal palm oil production.



## INVASIVE *EICHHORNIA CRASSIPES* HAS NOT ACTED AS NOAH'S ARK FOR SOUTH AMERICAN OSTRACODS (CRUSTACEA) IN THE CONGO RIVER (AFRICA)

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The common water hyacinth (*Eichhornia crassipes*) is a free-floating aquatic plant native to South America, but presently widely introduced on other continents, including Africa. *Eichhornia crassipes* is very common in the catchments of both the Congo (Africa) and the Amazon (South America) Rivers. We compared the ostracod communities (Crustacea, Ostracoda) in the *E. crassipes* pleuston from both river catchments. We also compared the ostracod communities from the invasive *E. crassipes* in Congo with those associated with stands of the native African macrophyte *Vossia cuspidata*. Here we test if the water hyacinth has acted like "Noah's Ark" and has introduced South American ostracods into the Congo River Basin.

We found 26 species of ostracods associated with *E. crassipes* in the Amazon and 41 ostracod species in the Congo River catchments, namely 32 ostracod species in *E. crassipes* and 27 in *V. cuspidata*. No South American invasive ostracod species were found in the Congolese pleuston. Diversity and richness of Congolese ostracod communities was higher in the invasive (*Eichhornia*) than in a native plant (*Vossia*). The highest diversity and abundance of ostracod communities were recorded in the Congo River. Species compositions were significantly different in both catchments, but there were no significant differences in the variability of the composition of species of ostracods (beta diversity) within these catchments. It appears that local ostracod faunas have adapted to exploit the opportunities presented by the floating invasive *Eichhornia*.

## WHAT AFFECTS THE RICHNESS OF THE ODONATA SPECIES? WE DO!

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The conditions constraining the species richness and dispersal of Odonata are understood only in a limited manner.

The Kasenda Cluster of Crater Lakes in the Albertine Rift (Western Uganda), exhibits a spectrum of isolation, size and degree of human impact; presenting us with an opportunity to examine the importance of these variables in determining the occurrence of odonates.



We carried out a study into the habitat conditions and established a complete faunal list of odonate species for 15 crater lakes. The study examined models of potential predictors of Odonata species richness and discusses their predictive ability and biological meaning.

To determine the most informative model, a variety of general linear models was carried out and ranked accordingly to AIC and  $R_2$  values. A set of six models showed highest potential in explaining Odonata richness and proved usefulness in predicting presence of particular odonate species.

The variable having the most predictive power and potential biological meaning was determined to be anthropogenic pressure, measured as a percentage of land use within the confines of the lake rims, however various different ecological and environmental factors – such as depth of the caldera, or diversity of macrophytes in the lake, proved to have a meaningful impact on the diversity of odonates.



## HYBRIDIZATION AND SPECIES DELIMITATION OF *SYMPHONIA* (CLUSIACEAE) IN MADAGASCAR

Katharina B. Budde<sup>1</sup>, Sanna Olsson<sup>2,3</sup>, Paloma Torroba-Balmori<sup>2</sup>, Stéphan Rakotondrasana<sup>4</sup>, Andriamalala Rakotondrara<sup>4</sup>, Isabel Sanmartin<sup>3</sup>, Myriam Heuertz (speaker)<sup>1,2</sup>

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The tropical tree genus *Symphonia* (Clusiaceae) comprises 17-24 species. It has a curious distribution: while the most widespread species, *Symphonia globulifera*, occurs in the tropical rain forests on the African mainland and in the Neotropics, all other *Symphonia* species are restricted to the island of Madagascar. The origin of the genus is still unknown but might either be found on Madagascar or the African mainland. Dick & Heuertz (2008) revealed that *S. globulifera* colonized the Neotropics by sweepstake dispersal from Africa. However, it is unclear why the genus only radiated in Madagascar, an analogous case to the lemurs. A possible explanation might be the ecologically very diverse and rugged topography of the island with a mosaic of distinct habitats where ecological specialization might have driven speciation. Hybridization between several species of the genus seems to occur and allele sharing might play a role for ecological adaptations. A first step towards the study of evolutionary mechanisms is the delimitation of species in the *Symphonia* complex on Madagascar.

Morphological characters of this genus seem insufficient to differentiate between *Symphonia* species in the field. Here we compare different approaches based on morphological characters, ITS ribotypes, psbA-trnH plastid sequences, and transcriptome derived microsatellite markers (SSRs). While ribotypes and plastid haplotypes are unable to delimit species, high-throughput sequencing and microsatellite markers give more hope to resolve the relationships within the genus. Particularly, the combination of 20 SSR genotypes from nearly 500 specimens with uncertain determination and herbarium vouchers in a Bayesian clustering approach seems promising.

## A FAREWELL TO CLONING: DISENTANGLING DOUBLE PEAKS AND DELINEATING SPECIES AMONG DIPLOID INDIVIDUALS

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The chromatograms obtained by Sanger-sequencing nuclear markers in diploid individuals often contain double peaks indicative of heterozygosity. Except in the trivial case when only one double peak is present, it has long been considered impossible to find out the haplotypes of diploid individuals without cloning PCR-amplified DNA regions, which is an expensive, tedious and error-prone process.



To fill this gap, I developed two programs that allow phase determination from direct sequencing of nuclear markers: Champuru (<http://seqphase.mpg.de/champuru/>) for length-variant heterozygotes (the chromatograms of which contain lots of double peaks) and SeqPHASE (<http://seqphase.mpg.de/seqphase>) for the other cases. Knowledge of the nuclear haplotype sequences of a group of individuals makes it possible to delineate reproductively isolated gene pools (i.e., species) using a graphical, intuitive approach called “haplowebs”. When haplowebs are obtained from several independent nuclear markers (be it a handful of loci using Sanger sequencing or thousands of RADseq markers using next-generation sequencing), combining the outcome of these analyses into a single “conspecificity matrix” allows fast and reliable multilocus species delimitation.



## EVOLUTION IN THE AFRICAN-NEOTROPICAL GENUS *GUIBOURTIA* (FABACEAE, CAESALPINIOIDEAE), COMBINING NGS PHYLOGENY AND MORPHOLOGY

Félicien Tosso<sup>1,2</sup>, Olivier J. Hardy<sup>2</sup>, Jean-Louis Doucet<sup>1</sup>, Kasso Dainou<sup>1</sup>, Esra Kaymak<sup>2</sup>, Jérémy Migliore<sup>2</sup>

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Tropical rain forests support a remarkable diversity of tree species, but few studies have investigated how and when this diversity arose. The genus *Guibourtia* (Fabaceae, Caesalpinioideae), characterized by two South American and 13 African tree species growing in various tropical biomes, is an interesting model to address the role of biogeographic processes and adaptation to contrasted environments on species diversification. Combining whole plastid genome sequencing and morphological characters analysis, we studied the timing of speciation and diversification processes in *Guibourtia* through molecular-dating and revisited the intra-generic taxonomic classification.

All species except *G. demeusei* and *G. copallifera* appear monophyletic. Dispersal from Africa to America across the Atlantic Ocean is the most plausible hypothesis to explain the occurrence of Neotropical *Guibourtia* which diverged c. 11.8 Ma from their closest African relatives. The diversification of the three main clades of African *Guibourtia* is concomitant to Miocene global climate changes, highlighting pre-Quaternary speciation events. Plio-Pleistocene climate oscillations appear to have more impacted the intra-species diversification of lineages, and especially the recent divergence within the clade comprising *G. coleopserma*, *G. tessmannii*, *G. pellegriniana*, and *G. leonensis*. The three main clades identified differ by their reproductive characters, which validates the three subgenera previously described: *Pseudocopaiva*, *Guibourtia* and *Gorskia*.

## TAXONOMIC REVISION OF THE GENUS *GREENWAYODENDRON* IN AFRICAN TROPICAL FORESTS BASED ON MORPHOLOGY AND GENETIC MARKERS

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Combining genetic and morphological markers is a powerful approach to decipher species delimitation, especially for tropical species complex. *Greenwayodendron* is an emblematic genus of tree taxa exclusively but widely distributed from West to East African rain forests. One of the most abundant tree species in the Congo Basin forest is *Greenwayodendron suaveolens*. Four taxa are currently recognized: *G. oliveri*, *G. suaveolens* subsp. *suaveolens* var. *suaveolens*, *G. suaveolens* subsp. *suaveolens* var. *gabonica* and *G. suaveolens* subsp. *usumaricum*. Previous genetic studies suggested that the taxonomic delimitation of the genus should be revised because the two varieties *gabonica* and *suaveolens* are likely to be two distinct species. The objective of this study is thus to propose a new taxonomic delimitation of the genus *Greenwayodendron* by combining both morphological and molecular characters. We relied on 842 silica-dried vouchers that were genotyped using microsatellite markers. We identified and characterized genetic clusters using a Bayesian clustering algorithm. In parallel, morphometric analyses of 250 herbarium specimens were undertaken. The spatial genetic structure of the populations of *Greenwayodendron* from Central and West Africa shows the existence of four genetic clusters that can be distinguished using morphological characters (leaf size and hairiness, flower and fruit size). Furthermore, genetic clusters from Central Africa can occur in sympatry, which implies reproductive barriers and strongly supports the hypothesis that they correspond to distinct species. Hence, genetic markers combined with morphological characters appear as key tools to perform taxonomic revision in complex taxa, as here for the *Greenwayodendron* genus.



## HOW WELL DO VEGETATION MODELS SIMULATE MID-HOLOCENE AMAZONIA?

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Most climate models simulate drier conditions for Amazonia over the next century. Moisture availability affects tropical forest productivity more than any other climatic variable, therefore the projected changes in precipitation represent one of the biggest climatic threats to Amazonia and the ecosystem services it provides. The effects of short-term droughts in the region are relatively well understood. Ecological monitoring projects showed that the 2005 and 2010 Amazonian droughts caused an increase in tree mortality and, in the short-term, the region switched from a carbon sink to source. However, the effects of a longer-term drier climate are less well understood. Vegetation models have been used to simulate what effect a future drier climate might have on forest ecosystems, with most predicting some degree of forest dieback. However, huge uncertainty exists over the scale of any such dieback.

To gain a better insight into the uncertainties surrounding the future vegetation model simulations, we aim to take a palaeomodelling approach. This involves running these models for a past period where climatic conditions were similar to that projected for the future, and for which we have sufficient palaeovegetation data. This gives us an opportunity to assess model performance outside the present day climatic range for which they may have been tuned. The mid-Holocene (MH, ca. 6,000 years ago) is a period when Amazonia's climate was significantly drier than present. We use a number of dynamic global vegetation models (DGVMs), driven by the climate models in the Paleoclimate Modelling Intercomparison Project (PMIP3), to produce a large ensemble of MH vegetation simulations. A multiproxy synthesis of MH palaeovegetation data has been compiled in order to carry out a model-data comparison exercise. This enables us to assess how well the models can simulate MH vegetation, and ultimately how well we can expect these models to simulate future vegetation in a drier climate.

## FUTURE VEGETATION PATTERN IN BIODIVERSITY HOTSPOTS IN INDIA UNDER CHANGING CLIMATE

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India is one of the 12 mega biodiversity countries of the world. It represents 11% of the world's flora in about 2.4% of the global land mass. The rapidly increasing human population in biodiversity hotspots in India and changing climate put pressure on these sensitive eco-regions. Recent studies have revealed a net loss of 35.3% of forest area in the Western Ghats from the 1920's to 2013. Forest pattern in biodiversity hotspots may change under future climate scenario which has given rise to the urgency to study and project the future vegetation distribution.

In this study, we studied past, current and future vegetation distribution of three biodiversity hotspots in India; Eastern Himalaya, Western Himalaya, Western Ghats, based on different IPCC scenarios for years 1900, 2016 and 2100. We used the adaptive dynamic global vegetation model (aDGVM1). The model simulates the past vegetation distribution to be dominated by forests, C4 grassland and woodland. Fire played a significant role in vegetation distribution as it supports savannas and reduces forest cover. In presence of fire 16.6 % and 26.5 % of the area is occupied by savanna and C4 grasses respectively whereas less area is occupied by forest (27%) and woodland (13.7%). The model projects that future climate scenarios favor C3 grasses to outcompete C4 grasses in Western and Eastern Himalaya due to increasing concentration of atmospheric CO<sub>2</sub>. Forest in the lower Himalaya shifts further northward and changes to woodland in Western Ghats. With more favorable future condition for C3 plants, the area covered by forest or C3 grassland increased substantially under elevated CO<sub>2</sub>. These shifts imply changes in vegetation structure such as taller trees along the Himalayas and Western Ghats by the end of 2100.

We conclude that increasing atmospheric CO<sub>2</sub> concentration and rising temperature have a huge impact on the vegetation distribution in these three biodiversity hotspots. The prediction results can play an important role in alerting scientists and decision makers to potential future risks by developing proactive strategies to reduce climate change impacts on biodiversity.



## MODELLING PAST AND PRESENT DISTRIBUTIONS OF TROPICAL AFRICAN BIOMES AND SPECIES USING A DYNAMIC VEGETATION MODEL

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In the framework of the AFRIFORD project (Genetic and paleoecological signatures of African rainforest dynamics: pre-adapted to change?, <http://www.ulb.ac.be/facs/sciences/afriford/>), we used the CARAIB dynamic vegetation model to simulate past and present distributions of tropical African vegetation at the biome and species levels to better project and understand future dynamics. We studied individual species (*e.g.*, *Azelia africana*, *Pericopsis elata*, etc) for which we determined climatic requirements and gathered specific traits.

To perform palaeovegetation reconstructions, we used outputs of snapshot climate simulations (*e.g.*, CNRM-CM5, FGOALS-g2 and MRI-CGCM5 global climatic models) from the PaleoModelling Intercomparison Project (PMIP3, <https://pmip3.lsce.ipsl.fr/>) for the mid-Holocene (6 ka) and the Last Glacial Maximum (LGM, 21 ka). These global climatic outputs were downscaled at a 0.45° spatial resolution over Equatorial Africa using the MAR regional climate model (RCM). For current conditions, the RCM was nested in different historical climate datasets.

We compared modelled species distributions with species occurrences from different databases for present and with palaeorecords for past periods. MAR regional climate simulations notably allow CARAIB to reproduce the Dahomey Gap separating the Upper and Lower Guinean forests in West Africa in present biome distribution. The vegetation model also simulates LGM rainforest distribution in agreement with hypothetical glacial rainforest refuge areas inferred from palaeorecords.

## SIMULATION OF RESOURCE-EFFECTIVE MANAGEMENT STRATEGIES IN TROPICAL FORESTS: DEVELOPMENT OF AN INNOVATIVE TOOL FOR DECISION-MAKING

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On a global scale, highest deforestation rates occur in tropical least developing countries. As a consequence of human-induced climate change and land-use change, the forest ecological balance is disturbed, so that the permanent provision of their ecosystem services is not guaranteed and losses in biodiversity and forest resources occur. The study goal is to evaluate long-term responses of forest growth regarding management strategies for selective logging in the context of climate change.



The dry tropical montane forest of Munessa in south-east Ethiopia is a prominent example of deforestation in the sub-humid tropics, where climatic change have been observed during the recent years and where 5<sup>th</sup> IPCC Assessment Report envisages future changes. To evaluate possible consequences for the local forest ecosystems, we used the individual-oriented forest simulation model FORMIND. We parameterized the model utilizing field observation data including a forest inventory, dendrochronological, and climate measurements. By testing different parameter settings for selective logging and climate, we analysed explicit simulation scenarios focusing on aboveground biomass dynamics and species richness. Our climate change scenarios were modelled on the regional findings of the 5<sup>th</sup> IPCC Assessment Report.

We found that the model reproduces well aboveground biomass productivity under current climate conditions. Variations in precipitation cause ecological shifts in the conditions for tree growth. Biomass and species richness both increase with mean annual precipitation, with the effects stabilizing over time. Our results emphasize the impact of the duration and frequency of periods of water limitation on forest growth. As a next step, we intend to evaluate the effects of a wider range of management strategies on long-term forest growth dynamics by implementing an updated version of the management module.



## TROPICAL IMPORTANT PLANT AREAS - A CASE STUDY FROM GUINEA

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Kew has been active in Guinea since 2005 with NGO Guinée Ecologie and has promoted the creation of the National Herbarium in 2009. With our partners and the Guinean Ministry of the Environment, Water and Forests and the Office of Guinean Protected Areas, we launched a Darwin Initiative funded project to identify Tropical Important Plant Areas in Guinea in April 2016. For historical reasons, Guinea lacks fundamental baseline data for its native flora.

Floristic survey data collected over the past 10 years, augmented with data from historical herbarium records, show that Important Plant Areas in Guinea do not correlate well with the established protected areas. The data indicates such areas exist in the sandstone hills of Kindia, the Kounounkan mountain range, the Fouta Djallon and Guinée Forestière. Despite some of them being Forêt Classées (timber protection reserves), they are not effectively protected and often being cleared or degraded by a growing population.

The data collected is used for IUCN Red Listing and for producing a Plant Red Data book for Guinea, with support of a GBIF grant enabling repatriation of historical data from European herbaria. Guinea is being heavily impacted by a growing extractive sector: Plant conservation in Guinea is in the earliest stages and the mining and forestry industries are able to exploit areas unchecked due to the lack of knowledge and the paucity of IUCN assessments. We aim to engage school children and neighbouring communities to encourage conservation of local biodiversity and associated indigenous knowledge. In addition we are building capacity at university level for plant conservation in Guinea by increasing understanding of native plant biodiversity and its distribution, and provide tools to identify, monitor, and conserve it effectively.

## FROM SCIENCE TO ACTION - TOWARDS A SCIENCE/ POLICY INTERFACE IN DEVELOPMENT COOPERATION

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Biodiversity is nowadays on the agenda of many different actors with extremely different interests: scientists at universities and museums, different NGOs, political actors on all levels, serious private and economic players and unfortunately also manifold illegal actors. The utilization of biodiversity versus biodiversity conservation is one of the most striking challenges of our time, a strongly debated hot topic with no simple answers. Consulting firms, like GFA Consulting Group GmbH, are somewhere in between those different actors: working on behalf of development agencies such as GIZ or KFW to pursue mainly political goals, they have to deal mainly with governmental and private actors. Unfortunately, there is currently a lack of exchange between the scientific community/ knowledge and the more practical and political approach of consultants. However, for the successful conservation of biodiversity it would be desirable to facilitate an exchange between scientists and the consulting sector; scientists could work as specialized experts for consulting firms, sharing their knowledge and gaining access to manifold research possibilities and new funding options.



The presented poster will try to outline these possible linkages and describe options for a science policy interface aiming at biodiversity conservation.



## SANGHA TRINATIONAL FOUNDATION - A CASE STUDY FROM THE CONGO BASIN: CHALLENGES AND CHANCES OF CONSERVATION TRUST FONDS

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Trust Funds for conservation are a highly promoted and frequently used tool for the sustainable financial support for protected areas and biodiversity conservation efforts in general. The Sangha Tri-National Trust Fund (FTNS), established in March 2007, is aiming at the long-term financial support of conservation activities, eco-development and cross-border cooperation within the forest complex called Sangha Tri-National (TNS). FTNS is governed by an independent board and an executive office and has signed cooperation agreements with the concerned ministries for Forests and Protected Areas in 2008 in the three partner countries. Since 2010, FTNS is recognized as a foreign Fund authorized to exercise in Cameroon.

The TNS is an outstanding treasure due to its mainly undisturbed ecosystems and impressive biodiversity, home of many endangered emblematic species like forest elephants, lowland gorillas and chimpanzees. The TNS complex is a UNESCO World heritage site since 2012. Located in the North-western Congo Basin in the transboundary region of Cameroon, Central African Republic and Republic of Congo, it encompasses three contiguous national parks: Lobéké National Park (Cameroon), Dzanga-Ndoki National Park (Central African Republic) and Nouabalé-Ndoki National Park (Republic of Congo) with a total surface of 7,500km<sup>2</sup>. The parks are embedded in a much larger forest landscape, sometimes referred to as the TNS Landscape, including a buffer zone of 1,788 km<sup>2</sup>, established in recognition of the importance of the broader landscape and its inhabitants.

Many international NGOs, like WWF and WCS, do work in the TNS region since decades, injected serious long term investments and supported the creation of FTNS actively. Nevertheless, challenges for FTNS to protect TNS are huge; especially logging and poaching are mayor problems and the financing mechanisms of a trust fund became more difficult in times of low interest rates and international financial crises. GFA Consulting Group is advising and supporting FTNS and its efforts on behalf of KfW Development Bank.

## PROMOTING SUSTAINABLE LAND USE SYSTEMS IN SUB-SAHARAN AFRICA THROUGH PARTICIPATORY RESEARCH APPROACHES AND ENHANCED STAKEHOLDER INTERACTIONS

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Deforestation, forest degradation and the related decline in biodiversity continue to be major issues in tropical countries. In sub-Saharan Africa (SSA), the drivers of deforestation come mostly from outside the forestry sector. For example, natural forests are under pressure from smallholder cultivation practices and charcoal production for everyday needs. The selling of charcoal also provides an income for resource-poor farmers, underlining the link between food and non-food biomass production and deforestation.



The research project BiomassWeb has the overall objective to contribute to sustainable land use management and food security in SSA. It employs the value web approach which allows identifying synergies and trade-offs between the food and non-food uses of different crops, and provides a conceptual framework for incorporating a wide range of stakeholders and disciplines. BiomassWeb aims to ensure that research results will lead to actual changes on the ground by interacting with non-science stakeholders from the project start through transdisciplinary research and outreach approaches. These include (i) participatory field research in Ghana, Nigeria and Ethiopia, (ii) transdisciplinary workshops, (iii) demand-driven research and development activities, and (iv) the initiation of a pan-African expert network.

Three years of practical experience in collaborating with different stakeholder groups showed that participatory research can contribute to capacity-building and innovation at the local level but requires time, open-mindedness and flexibility from the scientists. Besides, the transdisciplinary workshops proved a successful tool in reaching out to decision makers in the land use sector. Finally, recommendations will be given for enhancing fruitful interactions between science and non-science stakeholders in the fields of biodiversity conservation and sustainable land use management.



## THE MARISCO METHOD: A KNOWLEDGE MAP AND ADAPTIVE NAVIGATION SYSTEM FOR TROPICAL BIODIVERSITY CONSERVATION

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Biodiversity in tropical countries is experiencing challenges that are increasing both in number and criticality. In addition, the environment for biodiversity conservation policy and action is becoming ever more “VUCA” - volatile, uncertain, complex, and ambiguous. Notwithstanding, biodiversity conservation is expected to draw up strategies and deliver measurable outcomes. The conservation management planning method MARISCO (adaptive Management of vulnerability and RiSk at COnservation sites) is underpinned by a strong philosophy and theoretical platform that includes ecosystem and complex systems theories, as well as non-equilibrium thermodynamics. It represents a visualised, systematic and participatory process designed for collecting, ordering and documenting both knowledge and non-knowledge related to biodiversity, threats and drivers of change, as well as the conservation management for a given site. MARISCO can facilitate adaptation to climate change, but only if it is integrated into a broader concept of ecosystem-based climate management and ecosystem-based sustainable development.

MARISCO has been successfully tested and evolved with partners of different contexts of development cooperation in a number of countries and sites throughout the tropics and subtropics (Malaysia, Namibia, Guatemala, Colombia, Ecuador, Peru, Brasil). MARISCO thus affirms and demonstrates that even in the face of uncertainty and risk it is possible to plan for adaptive management.

Visit the site: <http://www.marisco.training/>

## NATURAL COAGULANTS OBTAINED FROM SEEDS OF *MORINGA STENOPETALA* AND TUBERS OF *MAERUA SUBCORDATA* COULD PURIFY TURBID WATER INEXPENSIVELY AND SUSTAINABLY

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Inadequate water quality services and sanitation to the rural poor are among the most serious challenges facing developing countries. At present, about 780 million people are without access to improved sources of drinking water, mainly in Sub-Saharan Africa. Hence, improving drinking water quality at a household level is believed to be effective in fighting water borne diseases. One way of providing clean and potable water for people in need is through plant based coagulants. Natural coagulants, especially those from *Moringa oleifera* Lam., have been employed since ancient times (200B.C.) in the treatment of drinking water. Local communities in Ethiopia also use natural coagulants to treat turbid water at a household level for their drinking and domestic purposes. *Maerua subcordata* and *Moringa stenopetala* are the two plant species used by local people in Ethiopia which appeared to be effective and efficient for purification of low to high turbid surface water.



Using parts of these plant species for water treatment do not pose any harm to the plant and the environment. For instance, once the tubers of *M. subcordata* are removed, remaining patches of tubers regenerate. As the removal of the tubers does not damage the plant in the long term, this is an ecologically sound means of obtaining a source of natural coagulants. The natural coagulants from the two plant species was extracted using 0.5 M sodium chloride (NaCl) solution and deionized water. At 0.5 M, using the salt solution extraction, the turbidity removal efficiency of *M. subcordata* and *M. stenopetala* was 96% and 90.3%, respectively, whereas using the deionized water extraction; it was only 71% and 60% respectively. The turbidity of the treated water was below the level of WHO permissible drinking water guideline (< 5 NTU). The extracts also showed magnificent efficiency on disinfection of indicator bacteria such as *E. coli* and faecal coliforms. However, it was difficult to attain 0 cfu/100 mL which is above the drinking water guideline in terms of microbes. Plant based coagulants can be obtained in low cost and serve as water treatment agent in improving access to improved water supply in rural areas and in refugees during emergency for most countries in the developing world.



## MURKY MANGROVES AND CATCHY CORALS - THE DISCOURSES OF ATTRACTIVENESS OF COASTAL ECOSYSTEMS

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Perception of ecosystems, as for many other natural or man-made features, is usually translated into a description and discourse which highlights particular traits. When these traits take over in the discourse and a shaded and varied depiction of the system becomes oversimplified, this becomes a cliché or caricature. As discourses enable or constrain particular types of actions, and define acceptable and desirable management, they have a direct relevance for conservation.

We sample descriptions of the mangrove ecosystem in the literature and compare this selectively to how other coastal systems are described. Mangroves are usually used to set a scene of threatening, impenetrable and dark forests. They are pictured as hostile to human settlement, harbouring disease (vectors) or they are home to hostile indigenous people, the only ones capable of finding their ways through them. Coral reefs are admittedly dangerous for those venturing near them (ships), yet they protect the pristine coast or island environment behind them against intruders. By themselves corals are bright, have clear water, brightly coloured fauna and they are by their general appearance attractive. These features are translated in the way corals are pictured and presented. We present samples or world literature and popular literature and media on mangroves and coastal features. We discuss whether the perception and discourse could play a role in willingness to protect, and on prioritisation for conservation.

## CONTRIBUTIONS OF TRADITIONAL KNOWLEDGE TO FOOD SECURITY OF A SMALL FISHING COMMUNITY IN THAILAND

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In many countries, local communities have sound traditional knowledge related to food security. Also in small-scale fishing communities in developing countries, the latter people are capable of utilising their knowledge which is based on long-established experience and practice to contribute to their livelihoods and guarantee food security for several generations. Traditional knowledge systems are based on accumulation of knowledge, observations, testing and learning through trial-and-error, and are passed on to future generations orally or by shared practical experiences.

In this research, we investigate how local people use traditional knowledge to maintain their food security and livelihoods through sustainable use of food resources. The study was conducted at Bu Boi, a small fishing community in southern Thailand. We obtained field data through Participatory Rural Appraisal (PRA), combined with a number of other data collection research techniques: semi-structured interviews, participant observation, focus group discussions and field walks. Our findings demonstrate that traditional knowledge could contribute to food security through four mechanisms: (1) traditional knowledge guiding food gathering, (2) traditional rights linked to the access of food resources among resource users, (3) food preservation, and (4) food resource management and protection. The yield from their traditional knowledge can maintain their food security and livelihoods within the small fishing community. This useful information can be used to strategically plan and design guidelines concerning food security, component of scientific research about conservation and resource management.

### Merian Award Applicant



## EVALUATION BETWEEN ARTISANAL, SEMI-INDUSTRIAL AND INDUSTRIAL LINEFISHERIES IN THE EXPLOITATION OF FISHERY RESOURCES IN THE SOUTH SAVE, MOZAMBIQUE

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The present study was evaluated the interaction between fisheries: artisanal, semi-industrial and industrial linefisheries in the exploitation of the fisheries resources on the Southern Mozambique of South Save River, thought of analysis of the similarity degree of specie captured in both fisheries. The purpose of the study was to assess the aspect of integrated evaluation pertinence of exploitation state extent that currently these fisheries are addressed independently.

The historical data for artisanal, semi-industrial and industrial linefisheries were the period from 2009 to 2013, and were obtained by the Fisheries Research Institute, which were complemented by samples of artisanal fishing, in the centre's Maritime and Costa do Sol – Maputo and Maputo Province, Farol de Inhaca during the months on July, August and December in 2013, to increase length furcula data of the monitored species and lacked their data for evaluation.

The value of the coefficient of Jaccard was 0.260 for artisanal to 0.154 of Maputo province vs. Semi – industrial and industrial linefishing in the Southern Mozambique of South Save River, during the period from 2009 to 2013.

This dissimilarity on composition of catches is due to the different types of habitats of the southern coast of Mozambique, which are accessible to artisanal linefishing because the that fishery was practiced in inshore, coastal waters associated with estuaries, mangrove forest, sea grass rugs, and the semi-industrial and industrial linefishing was practiced offshore, in coral reefs on the open sea of with the coral reefs and rocky bottoms. Despite the high dissimilarity a total number of 75 species occur in common on the artisanal, semi – industrial and industrial linefisheries, 9 of which have proved to be important in terms of ratio in volume of both sectors namely: *Cephalopholis sonnerati*, *Cheimerius nufar*, *Chrysoblephus puniceus*, *Epinephelus albomarginatus*, *Epinephelus guaza*, *Epinephelus tauvina*, *Lethrinus lentjan*, *Leitrinus nebulosus* and *Scomberomorus commerson*.

It is impossible to perform a specific assessment of the exploitation of all resources accessible for linefishing due to it is high adversity. It is suggested that the more important specie in common, the evaluation should be specific considering the impacts of both sectors artisanal and semi- industrial and industrial.

## VEGETATION STRUCTURE AND CARBON STOCKS OF TWO PROTECTED AREAS WITHIN THE SOUTH-SUDANIAN SAVANNAS OF BURKINA FASO

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Savannas and adjacent vegetation types like gallery forests are highly valuable ecosystems contributing to several ecosystem services including carbon budgeting. Financial mechanisms such as REDD+ can provide an opportunity for developing countries to alleviate poverty through conservation of its forestry resources. However, for availing such opportunities carbon stock assessments are essential. Therefore, a research study for this purpose at two protected areas (Nazinga Game Ranch and Bontioli Nature Reserve) in Burkina Faso was conducted.



Similarly analysis of various vegetation parameters was also applied to understand the overall vegetation structure of these two protected areas. For estimating above ground biomass, existing allometric equations for dry tropical woody vegetation types were used. Compositional structure was described by applying tree species and family importance indices. The results show that both sites collectively contain a mean carbon stock of  $3.41 \pm 4.98 \text{ Mg C ha}^{-1}$ . Among different savanna vegetation types, gallery forests recorded the highest mean carbon stock of  $9.38 \pm 6.90 \text{ Mg C ha}^{-1}$ . This study was an attempt for addressing the knowledge gap particularly on carbon stocks of protected savannas. It can serve as a baseline for carbon stocks for future initiatives such as REDD+ within these areas.



## ECOSYSTEM MANAGEMENT CAN MITIGATE VEGETATION SHIFTS INDUCED BY CLIMATE CHANGE IN WEST AFRICA

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The welfare of people in the tropics and sub-tropics strongly depends on goods and services that savanna ecosystems supply, such as food and livestock production, fuel wood, and climate regulation. Flows of these services are strongly influenced by climate, land use and their interactions. Savannas cover c. 20% of the Earth's land surface and changes in the structure and dynamics of savanna vegetation may strongly influence local people's living conditions, as well as the climate system and global biogeochemical cycles. In this study, we use a dynamic vegetation model, the aDGVM, to explore interactive effects of climate and land use on the vegetation structure and distribution of West African savannas under current and anticipated future environmental conditions. We parameterized the model for West African savannas and extended it by including sub-models to simulate fire management, grazing, and wood cutting.

The model projects that under future climate without human land use impacts, large savanna areas would shift toward more wood dominated vegetation due to CO<sub>2</sub> fertilization effects, increased water use efficiency and decreased fire activity. However, land use activities could maintain desired vegetation states that ensure fluxes of important ecosystem services, even under anticipated future conditions. Ecosystem management can mitigate climate change impacts on vegetation and delay or avoid undesired vegetation shifts. The results highlight the effects of land use on the future distribution and dynamics of savannas. The identification of management strategies is essential to maintain important ecosystem services under future conditions in savannas worldwide.

## AN INDEX FOR PRIORITIZING CONSERVATION AREAS IN SAVANNAS OF SUB-SAHARAN AFRICA

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Savannas and grasslands constitute around 40% of the land surface worldwide, and dominate the terrestrial tropics. These ecosystems shelter one-fifth of the global human population who rely directly on them for their livelihood and are home to the largest megafauna populations on Earth. While they sustain crucial ecosystem services, they, however, have attracted little conservation interest compared to tropical forests. As an example, in terms of perceived biodiversity values, savannas have been eclipsed by tropical forest. Although tropical forests harvest highest tree species richness, savanna diversity is important in terms of grasses, mega-herbivores and carnivores.

Our goal here is to compare forest and savanna diversity and endemism, and to build an index of global change threat to identify areas that need to be classified as conservation priorities. We gathered information about species richness and endemism for vascular plants and vertebrate taxa for all sub-Saharan Africa at the WWF Ecoregion level. The endemism and richness data for vascular plants are from White (1983) and Kier et al. (2005), and endemism and richness for vertebrate of from Jenkins et al (2013). In order to assess current and future status of each ecoregion, we gathered information about protected areas, population density and agricultural areas. We performed a multivariate analysis of these three variables for each ecoregion, and used the coordinate of each ecoregion within the two-first axes space of the analysis as an index for current ecoregion status (i.e. the more agricultural areas and the less protected areas mean higher risk for biodiversity loss). We then used future scenarios of population and agricultural areas to simulate future risk for each ecoregion. Preliminary results highlight that savanna areas are at very high risk for biodiversity loss due to a dearth of protected areas and because some mesic savannas are targeted for future biofuel production.



## PHYTOSOCIOLOGICAL STRUCTURE OF DAMBOS ECOSYSTEM IN THE NIASSA NATIONAL RESERVE (NNR), NORTHERN MOZAMBIQUE

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Niassa National Reserve (NNR) is the most extensive conservation area in Mozambique and the third largest in Africa, encompassing 42,000 Km<sup>2</sup> of miombo woodland. Due to the importance of the dambos formation in the maintenance of forest, fauna and aquatic diversity in the miombo woodlands, in 2015 we assessed the vegetation structure and composition of dambos in the NNR. Six dambos were selected using Google earth, MODIS satellite images and exploratory visit in the site. The field data was collected using fixed area and systematic sampling process in two stages: the first, consisted in transects lines of 100 x 10m, laying perpendicular to the dambos flow, whereas the second stage consisted in use systematic sub-transects.

In total 5.8 hectares were sampled, summing up 109 inventoried wood species in the main dambos transects. The most common species were *Vitex doniana*, *Burkea africana*, *Syzygium cordatum* and *Annona senegalensis*, while the most dominant species in the Importance Value Index (IVI) were *Vitex doniana*, *Pseudolachnostylis maprouneifolia*, *Annona senegalensis* and *Syzygium cordatum*. The diversity index was 3.55, the Simpson's dominance index was 0.05 and the heterogeneity index (H) was 2.99, indicating high diversity and heterogeneity in the NNR dambos.

## EFFECTS OF GENERALIST HERBIVORES AND RAINFALL IN A SEASONALLY DRY TROPICAL FOREST IN BRAZIL

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Herbivory by large mammals, either wild or domestic, is an important driver of changes in plant communities. Its effects may be more pronounced in seasonal environments with strong variation and unpredictability of resource availability such as the dry tropical forests as it is the case of the Brazilian Caatinga, one of the semi-arid regions most populated of the world and forest-dependent for their livelihoods. The extensive creation of goats is one of the main economic activities where people still raise free-ranging goats. These introduced generalist herbivores are well adapted to the seasonal conditions showing both browsing and grazing feeding behavior.



In this work, we investigate the relation between these herbivores, Caatinga vegetation and annual rainfall. We wanted to know whether goats present any mechanism of habitat selection in the landscape respecting vegetation structure and a functional profile of diet. We remotely (using GPS) assessed the habitat selection and home range. The goats forage nearby the houses and preferably in open areas with less dense vegetation. The goats had not shown any functional profile for any of the measured attributes. After a year of goats exclusion, we were able to detect a small but significant negative effect of goats on herbaceous aboveground biomass between treatments and time (through the year). We also observed a difference in the number of species of herbaceous plants; however, no difference was observed for the number of individuals. In the absence of a functional profile we can suppose that other factors such as seasonality in the availability of resources could be a greater limiting factor and criterion of selection.



## INFLUENCE OF HABITAT MODIFICATION BY LIVESTOCK ON PÁRAMO BIRD ABUNDANCE IN SOUTHERN ANDES OF ECUADOR

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Livestock grazing on natural grasslands is widespread with negative consequences to biodiversity. In the High Andes, páramo grassland is a distinctive ecosystem where the influence of livestock grazing on páramo birds is poorly documented. We assessed the influence of habitat modification of páramo grassland due to livestock grazing on bird habitat guilds in the southern Andes of Ecuador. We recorded birds occurring along transects in three localities, each with different levels of grazing pressure.

We found a decrease in abundance of páramo specialists in homogenous altered páramo grassland which we suggest may represent a loss of key habitat features necessary for their survival.

## POTENTIAL DISTRIBUTION OF THE ANDEAN CONDOR REVEALS PRIORITY CONSERVATION SITES IN THE SOUTHERN ANDES OF ECUADOR

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Andean Condor populations are in decline. In Ecuador, the majority of monitoring has been concentrated in the north of the country. To address this, we performed a distribution model for the southern Andes of Ecuador.

Our findings highlighted that the elevation as well as the climatic seasonality are important variables. Thus, higher elevation localities have greater habitat suitability. However, mid-elevation zones (~ 2000 masl) are also places to consider. Within this framework, concentrated conservation activities should be in the vicinity of Nabón, Girón and Saraguro. These localities have not been evaluated in detail previously.



## A REVIEW ON THE THREAT AND VULNERABILITY TO CULTURAL EXTINCTION OF SUNDERBANS MANGROVE FOREST, SOUTH ASIA

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Coastal countries are suffering from the adverse consequences of climate change making the people as climate refugees. Sea level rise, unexpected flooding and storms make all the coastal countries to concern about their protection and land loss. Mangrove ecosystems are natural defences which provide numerous goods and services. They are at risk due to the natural and man-mediated influences worldwide. Therefore, many coastal countries enquire to conserve mangroves forest to ensure its sustainability. India and Bangladesh are highly populated and lots of people depend on mangrove resources to sustain their livelihood. The Sundarbans is the largest unit mangrove forest in the world which declared as a World Heritage Site by UNESCO, bordering Bangladesh and India. About 2 million people are directly dependent on the resources including timber, fishes, crabs, shrimps, honey, nipa palm and thatch. During the cyclone Aila (2009), SIDR (2007) and Tsunami (2004), the extensive mangrove cover minimized the negative effects. But ongoing overexploitation of resources, frequent tropical cyclones, salinity intrusion and flood threaten the ecosystem as well as the local community. The government established laws and policies to reduce the pressure from the local population but the implementation is inactive. Local societies are morally attached with Sundarbans and severely affected by the ongoing stochastic disturbances in the environment. From a pragmatic perspective, linkage of sustainable forest management and appropriate types of property and user rights of the locals is paramount. Forcing them to accept alternative occupations, may lead to loss their own culture and traditions resulting local cultural extinction.

Therefore, in decision making process community participation has a key role to ensure the sustainable development of the ecosystem. Mangrove restoration, awareness programs, capacity building for the stakeholders are necessary to assure win-win situation to develop of both mangrove ecosystem and its communities.

## HOW WILL SALT AFFECT THE ACQUISITION OF NITROGEN AND PHOSPHORUS OF MANGROVE SPECIES?

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Due to tidal inundation patterns in highly diverse ecological settings, tropical mangrove ecosystems are exposed to fluctuating salinities and a large variation in nutrient availability, in particular nitrogen(N) and phosphorus(P). Environmental stress caused by high soil salinity, fluctuating salinity and low nutrient availability impose several physiological constraints on mangroves such as ionic imbalance and osmotic stress.

Growth and maintenance processes require a variety of different chemical elements. Moreover the ratio of elements is structurally and functionally important to regulate homeostasis and internal water balance. In order to grow in a saline environment, halophytic species have developed various salt strategies; the exclusion of salt, root ultra-filtration, accumulation of osmoprotectants or salt in their vacuoles. To regulate internal water balance through osmoprotectants, mangroves require relative larger quantities of N to carbon(C).

It is postulated that variation in stoichiometric homeostasis and C:N:P ratio in plants reflect the adjustment to the local environmental factors and resources. For mangrove species this has not yet been elucidated. Important information is still lacking about variation of C:N:P stoichiometry in mangrove species and their stoichiometric regulation as a result of fluctuating environmental salt concentrations. Although several studies indicated that variation in salt concentrations and nutrient availabilities influence growth performance of mangroves, it remains unclear how these gradients interact across a mangrove forest, and how this is related to stoichiometric regulation of leaf tissue of mangrove species.

Assuming that leaf C:N:P ratios in mangroves reflect their nutrient status, we hypothesized that these ratios vary along a salinity gradient. Secondly, we hypothesize that salt will affect the acquisition of nitrogen and phosphorus. The outcomes of this study provide a better understanding of mangrove stoichiometric homeostasis.



## TO EACH HIS OWN: THE DIVERSITY OF BURROW ARCHITECTURE OF MANGROVE CRABS AND ITS ECOLOGICAL CONSEQUENCES.

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Among the diverse invertebrate mangrove community, semi-terrestrial brachyuran crabs play a key role in maintaining a healthy mangrove ecosystem. The creation and maintenance of crab burrows highly affects the mangrove sediment topography and biogeochemistry. Such continuous burrow related activities enhance sediment oxygen fluxes, carbon sequestration, nutrient bioavailability and reduces sulfates considerably. Young mangrove plants, which are particularly sensitive to sulfates, display a greater growth performance in the presence of burrowing fiddler crabs.

The bio-engineering potential of different burrows is known to relate to its shape and dimension, and its morphology is strongly species-specific and highly variable, even within each mangrove crab family.

Thus, in order to analyze the ecological role of different burrowing crab species on the health of the mangrove ecosystem, knowledge on the structural characteristics of their burrows must be unveiled first. In this work, we present preliminary burrow morphology data on several Hong Kong crab species belonging to the Sesamididae, Varunidae and Ocypodidae families, of which some never recorded, obtained through burrow casting techniques and 3D reconstructions. Burrow morphology characteristics, such as shape, burrow opening, complexity, volume and surface area were correlated with crab species, carapace size, multiple occupancy and sediment features. Our results show that the family of the Ocypodidae typically construct J-shaped one-entrance burrows, while burrow architecture showed to be much more variable and structurally complex in the other families. The present study confirms the need for a deeper understanding of burrow architecture characteristics of mangrove crabs, in order to better assess the role of such structures on the overall mangrove ecosystem functioning and their impact on sediment biogeochemistry.

## THE HEARTBEAT OF MANGROVE SEEDLINGS: DENDROMETRY AND ANATOMY OF ON-TREE DEVELOPING AND ESTABLISHING *BRUGUIERA GYMNORRHIZA* SEEDLINGS

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Mangrove trees are remarkably well adapted to the tropical intertidal environment. Aerial roots and salt excluding mechanisms at the root and leaf level are one of the important mechanisms that help them surviving the highly dynamic mangrove environment. The formation of viviparous hydrochorous seedlings is another adaptation. All mangrove species belonging to the pantropical family Rhizophoraceae are viviparous. This means that their seeds germinate without a dormancy period, while they are still attached to the parent tree. The resulting mangrove seedlings form the mangrove dispersal units or propagules.

Like most plants, adult mangrove trees exhibit diurnal reversible stem diameter patterns, which are caused by diurnal fluctuations in internal water storage tissues. During on-tree development, viviparous Rhizophoraceae mangrove seedlings receive water, minerals and carbohydrates from the parent trees. Yet, little is known on the diameter dynamics of these developing conspicuous structures (reflecting fluctuations in internal water content), let alone on the same plants after abscission during establishment. We registered the diameter dynamics of on-tree developing and post-abscission establishing *Bruguiera gymnorrhiza* (L.) Sav. seedlings at high spatial (micrometer) and temporal (minutes) resolution by use of point dendrometers, and simultaneously recorded the variation in environmental conditions. The developing and maturing seedlings elongated, but lost in diameter in a stepwise manner towards abscission. Complementary anatomical observations, based on the combination of several techniques, provided context for understanding the seedling diameter fluctuations and contribution of the seedling to its own carbon balance. Establishing seedlings started exhibiting diurnal diameter fluctuations, typical of adult trees, upon the opening of their first leaf pair.



## LIKE A DRONE COME TRUE: COMPARISON OF SATELLITE AND DRONE IMAGERY FOR MANGROVE MAPPING IN SETIU WETLAND, MALAYSIA

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Drones have been emerging as a potential ecological monitoring and mapping tool. This study compared the utility of drone and satellite imagery in mapping mangroves, specifically in terms of image quality, cost, efficiency, and classification accuracy. The field surveys were carried out in Setiu Wetland, Malaysia, with mangrove forests as one of its major constituents. Drone imagery was collected using DJI Phantom II with SJ4000 Cameras, and satellite imagery was originated from Pleiades Satellite.

Classification methods using object-based and pixel-based approaches were tested for their mapping accuracy. In general, classification using drone imagery gave better results. The highest accuracy was obtained using the object-based approach with manual rule-set classification, with Overall Accuracy of 93.9% and Specific Accuracy of 97.0%.

Drone imagery has several advantages over satellite imagery, including higher spatial resolution and availability of Digital Elevation Model. Satellite imagery has higher radiometric resolution. Drone has higher temporal resolution as it can acquire the image on cloudy days, provides an advantage in tropical humid. In terms of user cost, satellite imagery is lower compared to drone imagery; however, in a long-term monitoring, drones will be cheaper as only the initial cost is high. Coverage area of drones is smaller. Data of drone imagery is 230 times larger than satellite imagery, thus the processing time is six times longer. Object-based classification could reduce the processing time.

Although drone provides better imagery than the satellite, in term of efficiency it is only adequate for long-term monitoring of a small area. Future development of drones, such as improvement of battery longevity will increase the coverage area; improvement of waterproof ability will allow drones to fly even under the rain and increase the temporal resolution. In the future, drones potentially will become an integral tool in remote sensing and ecological monitoring of mangroves

**Merian Award Applicant**

## FLYING DRONES OVER MANGROVES: MONITORING OF THE MATANG MANGROVE FOREST RESERVE IN PENINSULAR MALAYSIA

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The use of Unmanned Aerial Vehicles (UAV) offers the possibility to acquire imagery information for ecosystem monitoring faster, cheaper, more localized and at a higher resolution than any space-borne image. We investigate the use of UAV in combination with forest inventory data to retrieve biophysical properties of mangroves (*e.g.* species composition, height, land cover). Our study was conducted in the Matang Mangrove Forest Reserve (MMFR), located along the northwest coast of Peninsular Malaysia. This reserve has been under silvicultural management for charcoal and pole production since 1902. Although the monitoring in MMFR has traditionally been undertaken using standard forestry practices (*i.e.*, plot-based measurements), in this study we explore the use of UAV (Phantom 3 Professional quadcopter) RGB stereo images for retrieving mangrove canopy height and cover and floristic composition.

For 9 forest sites (in areas that had been recently clear-felled, in forests aged 7, 15 and 30 years and in undisturbed forest), Phantom 3 Professional RGB images were acquired at a spatial resolution of 12 megapixels. Information about the species composition, diameter (D130) and height was collected in 20 plots in the same areas where the drone imagery was acquired. Whereas 5m × 5m plots along a transect were considered for 7 and 15-year old mangrove stands (due to dense nature of the young vegetation), 10m × 10m were chosen for 30-year and undisturbed (matured) mangrove stands. Based on a preliminary analysis of ground measurements, the tree height varied from 9.3 ± 1.7m (D130: 4.9 ± 1.3cm) in 7-year old, 12.8 ± 3.6m (D130: 9.3 ± 3.3cm) in 15-year old, to 19.4 ± 7.8m (D130: 15.4 ± 7.3cm) in 30-year old mangroves, and 14.0 ± 8.7m (D130: 11.0 ± 7.9cm) in the undisturbed forest. Though the use of UAV in mangrove ecosystems is still limited, this study highlights the advantages and disadvantages of using UAV imagery to support monitoring activities in these ecosystems.



## QUANTIFYING THE IMPACT OF LIANAS ON THE VERTICAL FOREST STRUCTURE - A TLS APPROACH

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Lianas are an important component of tropical forests, commonly constituting up to 40% of the woody stems and about 35% of the woody species. Lianas compete strongly with trees for both above- and belowground resources. Tropical forests are currently experiencing large-scale structural changes, including an increase in liana abundance and biomass. Despite the large amount of data currently available on lianas, there are no quantitative studies on the influence of lianas on the vertical structure of the forest.

The main objective of this study was to evaluate the contribution of lianas to forest structure using a terrestrial laser scanner before and after liana removal. We used Riegl VZ-400, which is a full waveform LiDAR scanner that has been successfully used in the recent years for studying different forest structure parameters such as biomass, tree height, etc. We established two small plots of 10 by 10 m each (one removal plot and one non-manipulated control plot) in a lowland tropical seasonally moist secondary forest on the Barro Colorado Natural Monument, Panama.

We manipulated lianas by cutting them at the base in the removal plot, leaving the control plot untouched so that we could account for the effect of natural phenological variation over time. We scanned both plots 2 weeks and 4 weeks after liana cutting to quantify the effects of lianas on forest structure.

We generated a 2.5D raster, with a resolution of 50 cm representing the maximum height at which the laser pulse exits the canopy in each grid, for both the pre-cut and post-cut scans. We also compared the laser-derived vertically resolved gap fraction estimates and the vertical distribution of the vegetation elements after cutting to the pre-cut scans in removal and control plots. Our results indicated that lianas contributed a substantial amount to the vertical structure of the forest.

## MONITORING CHANGES IN RANGELAND AND DRY FOREST LANDSCAPES WITH REMOTELY SENSED DATA

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LTS International has been working on projects covering large areas of rangeland and dry forest ecosystems, particularly within Sub-Saharan Africa, over the last 20+ years. As a result of these projects, there has been an increasing need for spatial information to be collected and used for the purposes of detecting and monitoring environmental changes over time.



Particularly, satellite technologies have been used to develop two remote sensing tools:

- RaVeN produces recordings of change in pasture quality in remote rangeland ecosystems based on multi-sensor imagery. This semi-automated tool combines optical (Landsat and MODIS) and radar (Sentinel-1) satellite imagery to map vegetation cover and measure attributes of pasture quality. This process enables RaVeN to spatially map areas of productive grassland, while identifying areas covered by other vegetation species, such as the invasive and inedible *Prosopis*, which may prevent these areas to be used for livestock grazing.
- FoRAST is an innovative tool for detecting and measuring forest degradation using satellite radar technology, which was developed through a partnership between LTS and the University of Edinburgh (UoE) in 2013-2015. FoRAST combines long-wavelength radar data and ground-based aboveground biomass measurements through linear regression and uses this model to map aboveground biomass (change) over time.

As a result of this work, LTS has been contracted by the World Bank to carry out the Satellite Monitoring for Forest Management project to develop satellite, and ground-validated, methods to address challenges related to monitoring tropical dry forest ecosystems and forest degradation assessment. The work will involve the European Space Agency (ESA), acting as a key project partner and advisor, providing in-kind support in the form of data, tools, and technical support. LTS, in partnership with UoE, will implement the work in Mozambique, Zambia and a third, yet unknown, country, from 2016-2018.



## EDGE EFFECTS ON THE NECROMASS AND HETEROTROPHIC RESPIRATION STOCKS IN SEASONALLY DRY BRAZILIAN ATLANTIC FOREST FRAGMENTS

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Tropical forests act as carbon sinks, removing CO<sub>2</sub> from the atmosphere and keeping the carbon stored in biomass. This carbon is slowly release to the atmosphere by the process of decomposition of dead organic matter. The plant necromass is an important part of this cycle and its stocks can be altered by human impacts on the tropical forests. The aim of this study was to quantify the stocks of fine and coarse necromass, and estimate its heterotrophic respiration rates comparing the edge and the interior of five fragments of different sizes of lowland Seasonal Dry Atlantic forest in Rio de Janeiro State, Brazil.

We tested the hypothesis that the necromass stock is higher and the heterotrophic respiration is lower in the edge than in the interior of the fragments. Five forest fragments of different sizes were selected, one biggest and more preserved fragment of 1200ha; and four neighbours' smaller fragments of 13ha, 35ha, 49ha, 55ha. Sampling was carried out during the rainy season (October 2012 to March 2013), in two transects at the edge and two at the interior in each fragment. The coarse necromass was sampled by the LIS (Line Intersect Sample) method and the fine necromass by 50 x 50cm quadrats. The heterotrophic respiration was measured using a portable closed-chamber infrared CO<sub>2</sub> gas analyzer system.

There was no difference on the stocks of coarse and fine necromass between the edge and interior of the fragments. The largest fragment had the lowest stock of fine necromass, while one of the smallest fragments showed the highest stock of coarse necromass. The necromass respiration was positively related with its moisture, and differed significantly between the areas of edge and interior, being higher in the interior. The values of fine and coarse necromass stocks are within the range for the Atlantic Forests. The necromass moisture was the factor that best explained the variations in the rate of heterotrophic respiration. Therefore, the edge effect changed the functioning of the studied seasonal dry forest in relation to the CO<sub>2</sub> release, diminishing the heterotrophic respiration of the necromass.

## BEHAVIOURAL ADAPTATIONS OF AN ENDANGERED UNGULATE IN RESPONSE TO TROPICAL FOREST DEGRADATION IN SABAH (MALAYSIA, BORNEO)

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Timber harvesting in Sabah (Malaysia, Borneo) has caused severe degradation of forests, reducing leaf cover which essentially reflects heat and governs ambient temperatures, and leaving behind extensive networks of logging roads that facilitate encroachment. The rare Bornean banteng, which occupies the forests of Sabah, must endure repetitive habitat disturbance and survive in forest with a drastically altered vegetation structure. To understand the impacts of logging and the expression of thermal stress, non-invasive camera traps and non-parametric bootstrapping were used to investigate banteng behavior, habitat use and ambient temperature in three degraded forests with varying regeneration ages.

Forest with the shortest regeneration time (6 years) had the highest temperatures in open areas. In forest with 17 years of regeneration the temperature peak was 3.5°C lower. Banteng responded negatively to temperature in these forests, limiting energy-demanding activities in exposed areas during hot hours but foraging extensively along abandoned logging roads where hunters frequented. In the most regenerated forest (23 years), banteng did not respond negatively to temperature, and they were active throughout the day switching from exposed areas to dense canopy when temperatures peaked.

Thermal stress is highest in forest that is most degraded, and banteng mitigate this by adapting behaviours, energy allocation and use of the forest. They benefited by exploiting degraded grassy areas but increased foraging in these areas increased their vulnerability to hunters. Ambient temperature is not a measure of sustainable forest management however logging negatively alters the climate for many years, which in-turn negatively affects large mammals.



## ACOUSTIC VARIABILITY OF A NATIVE HAWAIIAN THRUSH IN A FRAGMENTED LANDSCAPE

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Acoustic behavior used for communication is important to understand because it transmits different types of information such as species and kin recognition, mate attraction, and territorial defense and acquisition. In oscine passerine birds, songs are culturally learned and passed down from one generation to the next, and when individuals from a population disperse they can spread their song cultural to other populations. Fragmented habitats may alter natural patterns of cultural transmission because the non-habitat matrix surrounding the fragments can discourage dispersal of birds, thus affecting the transmission of songs. This can result in different fragments having different songs through female choice, which creates reproductive barriers between populations because females may prefer mates whose songs they recognize.

On Hawaii Island, naturally occurring habitat fragments, called kīpuka, are islands of forest created by lava that flowed through a continuous forest leaving isolated forest patches of varying sizes. We hypothesized that the size and degree of isolation of these patches can affect different aspects of bird populations, including their acoustic behavior. In this study, we characterized the acoustic diversity of the ōmao in different kīpuka and we studied how fragmentation can affect the transmission and diversity of songs. The ōmao (*Myadestes obscurus*) is a native Hawaiian thrush found only on Hawaii Island and very little is known about their vocalizations.

We found that larger kīpuka had a greater acoustic variability than smaller kīpuka and as distance increased between the kīpuka there was a decrease in shared songs. The results from this study indicated that fragmentation is likely influencing acoustic communications in the ōmao.

## CONSERVING BIODIVERSITY IN FRAGMENTED FOREST ECOSYSTEM IN THE PHILIPPINES

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The forest vegetation along altitudinal gradient had been studied in a number of mountains on Philippine islands, such as Mount Pulag, Mount Akiki, Mount Mayon, the Aborlan Guba System (Palawan), Mount Makiling and Mount Tabunan. In these mountain forests, lower elevation dominants encroach in upper slopes displacing original dominants destroyed by farming causing fragmentation. There is a sustained biodiversity loss at the local level not documented by the IUCN and the country's environment bureau. Hence, assessment of the conservation status of species needs to be done by every village as well. Based on experiences with our ongoing studies, we incorporate the IUCN status, the country and we add more items such as, species frequency value and presence of disturbances (agricultural farm, mining operation residences, etc.). Then we assign weights to these set or criteria before we finally determine the conservation status of local species which should then be protected by the local government through a policy.



To further minimize severe biodiversity loss, we advocate restoration and rehabilitation efforts such as establishment of biodiversity corridors, sustained community biodiversity education, including offering an open online course in conserving socioecological production landscapes for kids, youth and adults at the University of the Philippines Open University, since the internet seems to play a crucial role in meeting the environmental challenges of the 21<sup>st</sup> century.



## PREDATION RATES AMONG CATERPILLARS IN RESPONSE TO HABITAT TYPE, LEAF DAMAGE AND ROLLING BEHAVIOUR

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Resources limitation (bottom-up control) and predation (top-down control) are the key factors determining the abundance and composition of herbivorous insects communities. Nevertheless, predators seem to play the main role, while restriction of resources has rather marginal importance. Anyway, experimental evaluation and quantitative measurements of those factors remain rare.

In selectively logged tropical forests, habitats are differentiated by access to the light. In places where the biggest trees were removed, there is more light and vegetation on lower forest layers is more abundant. Hence, those habitats may be more suitable for foraging of herbivorous insects as it was clearly documented that herbivorous insects prefer young leaves. Against, such open spaces are readily available for foraging of birds and other predators. Most herbivorous insects use specific self-defence strategies to avoid predation. For example some caterpillars wrap leaves around their bodies to form a physical refuge. However, some predators may be sensitive to this type of behaviour and actively search for rolled leaves. It is also suggested that damages made by herbivorous insects to plants can be another lure for predators.

We aimed at testing the following hypotheses: predation rate is higher in gaps than in closed-canopy forest; predation on exposed caterpillars is higher than on semi-concealed caterpillars; predation on caterpillars on damaged leaves is higher than on undamaged ones. We used plasticine caterpillars exposed on leaves in selectively logged tropical rain forest in Danum Valley (Borneo). Our experiment was designed to resemble specific trophic system: *Kopsia pauciflora* as the host plant on 1<sup>st</sup> trophic level, Tortricidae caterpillars on 2<sup>nd</sup> and their predators on 3<sup>rd</sup>.

According to our results canopies seem not to be a barrier for predators considering that the probability of the attack was similar in gaps and closed canopy forest. Overall number of attacks, however, was lower in case of all the predators when the caterpillar was rolled. It shows that leaf rolling might not only decrease the probability of attack but it is also an advantageous strategy against any type of predator. Although, our results indicate that artificial damages do not change the probability of prey capturing.

## DYNAMICS IN CLONAL DIVERSITY AND CLONAL GROWTH STRATEGIES AS A RESPONSE TO SEDIMENT GRADIENTS IN TROPICAL *CYPERUS PAPYRUS* SWAMPS

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Understanding the dynamics of clonal modules (ramets and genets) and growth strategies of plants in both space and time to environmental gradients is central to explore species adaptation and processes regulating population structure and differentiation.

In this study, we assess the spatial and temporal dynamics in clonal growth, diversity and structure of an emergent macrophyte, papyrus (*Cyperus papyrus*) in response to sediment regimes by comparing morphological traits and genotype data using 20 microsatellite markers. A total of 1140 ramets were studied from six permanent plots of 18 x 30 m each in three papyrus swamps (Ethiopia) with discrete sediment regimes (high vs. low) for 2 years.

In each swamp plots under a high sediment regime revealed a significant and high clonal diversity ( $D = 0.13$ ;  $R = 0.97.0$ ;  $\beta = 4.91$ ) compared to plots of low sedimentation ( $D = 0.99$ ;  $R = 0.07$ ;  $\beta = 0.87$ ). Overall, in these metrics, significant temporal difference was not observed. Ramets under high sediment regime were clumped and more dense than spreading and sparse ramets in the low sediment regime suggesting a shift of clonal growth strategy from phalanx to guerrilla. Additionally, the aggregation index confirmed that clones in high sediment regime were spatially clumped ( $AC = 0.60-0.80$ ), with intermediate to no intermingling of the ramets ( $DC = 0.21-1.00$ ) when compared to the low sediment regime. In conclusion, a higher level of sedimentation leads to an increased occurrence of the phalanx over the guerrilla strategy; an increased ramet density and genet size; and a higher genotypic diversity through seedling recruitment. The findings of this study serve as a guideline for restoration measures.



## UNDERSTANDING ANURAN RESPONSES TO RAINFOREST FRAGMENTATION AND OIL PALM AGRICULTURE IN THE LOWER KINABATANGAN WILDLIFE SANCTUARY, SABAH, MALAYSIA.

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Destruction of habitat and the elimination or interruption of wildlife corridors can have a major impact on plant and animal species. Across the globe, forest harvesting and shifting cultivation practices have degraded forest quality, but commercial logging and agriculture, in particular for oil palm (*Elaeis guineensis*), are now the major causes of forest and biodiversity loss, especially in the tropics of Malaysia and Indonesia in Southeast Asia. Just the state of Sabah in Malaysia holds 109 species of Anura (frog and toads), representing more than 73% of the total species in Borneo, with a degree of endemism of approximately 17%. Anura belongs to the most threatened class of vertebrates with over 41% of species at risk of extinction either by habitat loss and degradation, climate change and chytridiomycosis.

This study addresses the genetic and ecological consequences of forest fragmentation and oil palm monoculture in Anurans in the Lower Kinabatangan Wildlife Sanctuary in Sabah, an area where habitat fragmentation due to oil palm plantations has occurred during the last 30 years. Within the context of this study, an initial assessment of anuran diversity in the Lower Kinabatangan Wildlife Sanctuary was carried out by sequencing a fragment of the mitochondrial DNA (cytochrome oxidase subunit I and 16S ribosomal RNA genes) on 16 species. The observed patterns of phylogenetic diversity observed along this study area are part of the development of an Anuran management plan for species sustainably, and will contribute to the understanding the effects of fragmentation in this hyper diverse region of the world.

## CHANGING HUNTING PRESSURES AND WILDLIFE RESPONSES AND THE EFFECTIVENESS OF SECONDARY CONSERVATION ACTIONS IN THE DJA LANDSCAPE, CAMEROON

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Hunting for meat is likely to be one of the greatest threats to the survival of wild animal populations in the tropics. Mammals represent >80% of all bushmeat coming out of tropical forests, and in African rainforests, over half of all mammal species feature among hunters' game. The majority of investigations in recent decades have found that bushmeat hunting in African rainforests is unsustainable.

This study took place in the Dja Landscape, Cameroon, with the aims to assess temporal trends in bushmeat hunting dynamics: hunting pressure, methods of hunting and bushmeat offtake composition; to identify the drivers of bushmeat harvesting; and to assess the impact of conservation efforts and help refine conservation strategies of the Cameroonian association, APGS (of Antwerp Zoo CRC). Surveys were carried out in 4 study periods: November 2002-October 2003; March-June 2006, March-June 2009 and February-December 2016. We applied descriptive and multivariate analyses to the data.

We found gun use to dramatically increase over the years, and snare hunting to decrease. We found the frequency of primates in the offtake to increase, and rodents to decrease slightly. We found more hunters in later years, but with a lower per capital offtake. We found hunting to depend on the profession of the villager, his physical ability, his social obligations, ecological factors and economic incentive. As a result of this intensifying hunting we also found animal abundance in the forest to decrease, but species richness remained stable both in the bushmeat offtake and in the forest, even until present day, suggesting a certain stability of the ecosystem. We also found no great apes in the offtake since 2002. This may be due to the presence and sensitisation of CRC/APGS. However, external factors (cheap motorbikes, demand from the cities) tend to override conservation efforts. To halt wildlife population loss, conservation efforts must be holistic to address to root causes of hunting.



## ASSESSMENT AND CONSERVATION OF GENETIC DIVERSITY IN CAPTIVE AND WILD PRIMATE POPULATIONS

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The Golden-headed lion tamarin (Ghlt) is an endangered primate species, with a mandate from the Brazilian government for a genetically and demographically self-sustainable captive population with the primary role of population insurance. The secondary roles are conservation education, research and fundraising. Assuming Ghlt founders are unrelated, the world captive population is large enough (about 520 individuals) to ensure conservation of 90% of gene diversity (GD) of the wild population for 100 years. The current GD of the world captive population is 98% and 96% in the European (EEP) population. However, when taking into account founder relatedness (as estimated by molecular markers), this EEP estimate is reduced to about 86%. Using the same genetic markers, we also assessed GD in wild populations. Overall, the results suggest that these populations have a relatively low GD and high population genetic structure, raising questions about the actual functional landscape connectivity.

Results suggest that captive animals may have originated from cross-breeding, resulting in relatively high GD compared to the wild. The continued loss of habitat makes it desirable to continue managing the self-sustainable world captive population as an insurance population. Future genetic research will further optimize this management in captive as well as wild populations.

## METABARCODING: DEVELOPMENT OF GENETIC TOOLS FOR THE STUDY OF THE HERBIVORE DIET OF *PAN PANISCUS*

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In the context of an eco-ethological study taking interest of a bonobo community in the southern part of the lake Tumba landscape (DRC), the diet of these primates has been described through visual analysis of the content of bonobo faeces. This previous work allows us to test the possibilities offered by new technologies of sequencing (NGS) in the case of diet study. As described in other works treating of diet analysis using metabarcoding, we amplified by PCR the P6 loop of the trnL. This sequence amplified from bonobo faeces (n = 196), is a short, variable DNA plastidial sequence. After sequencing through the use of an Illumina Miseq platform, the sequences were submitted to several bioinformatical filtering steps and then were confronted with two kinds of reference dataset: a global one based on sequences coming from EMBL and a local one, based on sequencing of the local flora.



The results permitted the identification of nearly 130 consumed plant sequences. The metabarcoding approach, even if it allows a much higher detection threshold than visual technique, does not perform well in term of identification. Indeed, 74% of the sequences were assigned above the genus level. However, the results in this case can be improved with some work on the reference database.



## INTRASPECIFIC RESOURCE COMPETITION WITHIN A TROPICAL BIRD SPECIES (*RAMPHOCELUS COSTARICENSIS*)

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Food availability can drive competition and dominance aggression among individuals. In the Neotropics fruit resources are distributed patchily so competition among frugivores can be intense. Even within a single species, there may be competition and dominance hierarchies among different age and sex classes. Many tropical bird species are monomorphic in plumage, but the Cherrie's Tanager (*Ramphocelus costaricensis*) shows strong sexual dichromatism and presents an opportunity to examine intraspecific competition because sex and age classes can be distinguished by plumage. Initial observations led me to hypothesize that among Cherrie's Tanagers there is a dominance hierarchy at food sources where males displace female-like individuals.

To test my hypothesis, I set up 12 banana feeding stations throughout the Wilson Botanic Garden of Las Cruces, Costa Rica. Feeding stations were set up near trees for refuge from predators. Each time a Cherrie's Tanager visited the feeding station I recorded its sex class based on plumage. Randomly, I took two 30 minute video footages at the feeding stations.

Due to the low quality of the recording, I grouped both female and juveniles as "female-like" because I could not clearly differentiate the plumage between both. For intraspecific interactions, I recorded agonistic behaviors, displacement, total time each individual spent at the feeding station and the time until displacement. My results support Alexander F. Skutch (1954), that Cherrie's Tanagers remain placid most often while feeding at the station in groups unless birds were too close to one another. Individuals spent approximately the same amount of time at the feeding stations and hardly displayed aggressive behaviors between male and female-like individuals. Although I did not color band the birds individually, low aggressive interactions within Cherrie's Tanager may reflect the role of kin selection to increase inclusive fitness. Therefore individuals support a relative's offspring, as a means of passing on genes for the next generation.

## SPATIAL PATTERN OF RIPARIAN VEGETATION AND DIVERSITY ALONG HUMAN DOMINATED HIGHLAND STREAMS SOUTH-WESTERN ETHIOPIA.

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Riparian vegetation performs important ecosystem functions since it maintains regional biodiversity and provides a range of environmental services such as nutrient control, bank stabilization, shading effect and water quality improvement. However, anthropogenic activity and change in land use are factors that modify the riparian species composition and diversity. Understanding plant species distribution patterns along modified landscape is fundamental to managing ecosystems, particularly when habitats are fragmented due to intensive human land-use pressure.

To assess the patterns of riparian vegetation in human dominated streams, plant community composition, species richness and diversity patterns were analysed along 18 streams in the Gilgile Gibe catchments southwestern Ethiopia, using 50m<sup>2</sup>- plots established on both sides of the streams at 100-m intervals. Two-Way Indicator Species Analysis (TWINSPAN) was used to classify plant communities whereas Pearson correlation and forward multiple regression were used for analysis.

A total of 107 vascular plant species belonging to 49 families were recorded. Species richness and diversity were lower in agricultural streams with the narrow riparian zone, compared to forested streams with the wider riparian zone. Six plant communities were identified using TWINSPAN along the study streams; *Salix subserrata* - *Hygrophila schulli* community, *Cyperus papyrus* - *Maytenus arbutifolia* community, *Eucalyptus grandis* community, *Cordia africana*- *Albizia gummifera* community, *Phytolacca dodecandra* - *Pennisetum polystachion* community and *Ficus vasta* - *Syzygium guineense* community. Species richness was positively correlated with land use ( $r=0.66$ ,  $p < 0.01$ ) and riparian width ( $r= 0.74$ ,  $p < 0.01$ ). Riparian width explained 55% of the variation in species richness, and was the best predictor (standardized partial regression coefficients  $b'=0.743$   $p=0.001$ ).

This study shows the impact of anthropogenic activities on riparian vegetation and highlights the importance of sustainable management strategies that are compatible with its conservation and restoration. Owing to the high degree of forest fragmentation, conservation concepts must consider a multi-site approach.



## REGENERATION DYNAMICS IN FLOODPLAINS: PLANT SPECIES GUILDS IN THE KILOMBERO FLOODPLAIN, TANZANIA

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Floodplains are ecosystems offering a wide spectrum of habitats for plant and animal species due to a long gradient between dryland and wetland. They are also sustaining several ecosystem services and ecological functions, especially in arid and semi-arid bioclimates or during dry seasons. Due to fertile soils and water availability, floodplains are largely used for agriculture or in the focus of agricultural development strategies. This represents a critical threat for biodiversity and functions of floodplain ecosystems. Fallow periods may however help to counteract some of these losses. In our work, we aim at evaluating regeneration capacity after human induced disturbance events. This study was undertaken in the RAMSAR-protected Kilombero Floodplain near Ifakara, Tanzania. This area is at the transition from hot arid steppe to tropical savanna bio-climates, with a distinct hot dry season. The economic activities are mainly based on rice cultivation, while natural vegetation patches are still present. Experimental plots were arranged along a hydrological gradient from nearby the Kilombero River up to the surrounding drylands. In those plots we studied the regeneration of biomass and plant diversity after disturbance events, simulating fallows following crops. We further identified guilds representing plant species sharing similar strategies in the recovery dynamic under different land uses.

We found big differences in regeneration dynamics along the studied hydrological gradient. During the rainy season, there is a strong growth in drier positions, reaching to about 4000 gm<sup>-2</sup> dry weight of aboveground biomass which completely dies during the dry season and is eventually burned. In wetter positions, inundation during rainy season is the main factor hampering regeneration while plant growth is not interrupted in the dry season. Also plant species guilds are contrasting along the hydrological gradient in both, natural and anthropogenic vegetation. The results obtained in this project can be potentially applied in models of recovery dynamics as well as in bio-monitoring.

## DIATOMS FROM THE CONGO AND ZAMBEZI BASINS: A GUIDE TO THE GENERA OF TROPICAL AFRICA

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The diatoms are a group of algae which are unique in that they construct their cell wall from biogenic silica. They compose about 40% of most attached algal communities and are found from terrestrial, moist sub-aerial to fully aquatic habitats. Diatom research has historically been well established in Central Africa but more commonly directed towards the phytoplankton of large bodies of standing water. Recently there has been considerable international research interest on using diatoms as indicators of water quality as the community structure of these organisms is closely linked to changes in pollution status. Usually diatoms attached to a solid substrate and originating from rivers and streams are used for this purpose. Diatom taxonomy has undergone considerable changes during the last three decades with many new diatom genera being established. The advantage of this is that these diatom genera are now more narrowly defined and thus more ecologically relevant in terms of establishing water quality conditions.

A new volume in the series *Abc Taxa* sets out to introduce researchers to the latest concepts in collection and preparation methodology as well as diatom taxonomy and nomenclature. This is achieved by illustrating and discussing methodological concepts and providing a fully illustrated glossary. For the French speaking the terms of the glossary as well as the glossary itself were translated. Ninety one diatom genera, those most commonly occurring in the Congo and Zambezi catchment region, were discussed. A brief description with an indication of the morphologic characteristics, plastid structure (if available) and ecology was given for each of the genera. Digitally generated drawings were added to illustrate the distinguishing characteristics for each genus. All genera are illustrated by means of numerous photographs taken with a light microscope and/or scanning electron microscope. It is hoped that this new volume will aid researchers in the effective establishment and use of diatom based methods for river quality monitoring.



## DEVELOPMENT OF A CORAL REEF RESILIENCE INDEX (CRRI): A MANAGEMENT AND CONSERVATION TOOL APPLICABLE FOR CARIBBEAN CORAL REEF ECOSYSTEMS

Edwin Hernández-Delgado<sup>1</sup>, Sonia Barba Herrera (speaker)<sup>1,2</sup>

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Coral reefs worldwide are in severe decline due to a combination of local human stressors, and large-scale climate-related stressors, such as sea surface warming. However, for most locations, there is often a general lack of information regarding the actual status and resilience state of coral reef ecosystems. Timely information is critical for coral reef managers and decision-makers to implement sustainable management measures. The main objective of this project was to develop a Coral Reef Resilience Index (CRRI) and provide a GIS-coupled decision-making tool for reef managers applicable for Caribbean coral reef ecosystems. The CRRI is based in a 5-point scale parameterized from quantitative documentation regarding benthic assemblages. Separate sub-indices such as the Coral Index, the Threatened Species Index, and the Algal Index also provide specific information regarding targeted benthic components. This case study was based on assessments conducted in 2014 on eleven reef sites located across three geographic zones (inshore [ $<4$  km], mid-shelf [4-8 km], outer shelf [8-20 km]), and three depth zones ( $<5$  m, 5-10 m, 10-15 m), along the southwestern shelf of the island of Puerto Rico, Caribbean Sea.

Results showed a significant spatial and bathymetric gradient ( $p < 0.05$ ) in the spatial distribution of CRRI values that indicated higher degradation of inshore coral reefs, in comparison to mid-shelf and offshore sites. Mean global CRRI within inshore reefs ranged from 2.78 to 2.87, ranking them as fair. Mean CRRI within mid-shelf localities ranged from 2.97 to 3.17, ranking them between fair and good. CRRI ranged from 3.07 to 3.16 within outer shelf localities, ranking them as good. The coral and algal indices also showed declining trends towards inshore reefs, and the threatened corals index showed a general cross-shelf poor state, with the exception of two localities. CRRI has provided an important and solid management and decision-making tool for Caribbean coral reefs.

### Merian Award Applicant

## IMMUNE AND PHYSIOLOGICAL RESPONSE OF CORAL WITH DIFFERENT LIFE STRATEGIES TO STRESS: A FIELD-BASED APPROACH

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Coral reefs worldwide are continuously threatened by biological (e.g. disease), physical (e.g. hurricanes) and anthropogenic factors (e.g. run-off due to unplanned coastal development). It is known that sedimentation can limit the amount of light available for photosynthetic activity of *Symbiodinium sp.*, a unicellular algae that lives within coral tissue and provides up to 90% of its energetic requirements. Likewise, high temperatures can induce symbiont expulsion, resulting in what is known as coral bleaching. Thus, corals that thrive under either condition would be expected to be energetically limited and stressed. Such stressors can induce a metabolic imbalance in coral at a physiological level where overall protein concentration and symbiont density can decrease; and at an immunological level such as the increase in reactive oxygen species (ROS), which can induce apoptosis, necrosis and DNA damage.



For coral to acclimate to stressful conditions it likely redistributes its available resources towards traits beneficial for survival such as immune system. However, it is generally understood, corals show different life history strategies. Some corals invest most of their energetic budget towards rapid growth but at expenses of reproduction and maintenance (immunology and physiology), while others divert more energy for maintenance thereby lowering rates of growth. Such life-history trade-off has been the base to classify corals as “competitive” species that invest more energy towards growth making them more susceptible to stress and “stress-tolerant” species, which invest more in immune system allowing them to thrive under suboptimal conditions. Based on this classification it could be expected that the response to changes in environmental conditions would differ between differential life-history strategies.

Nevertheless, information regarding immune response considering different life-histories is limited. With the aim of understanding if in fact there is a difference, here, we will present the preliminary results of a study directed at answering the following questions: (1) do constitutive levels of immunology differ spatio-temporally between life-strategy? (2) is there a variation in constitutive levels during day-time? and (3) does the response to an experimentally induced stress relates to constitutive levels?



## LOCAL AND REGIONAL DIFFERENCES IN FISH COMMUNITY STRUCTURE ON THE MESOAMERICAN BARRIER REEF

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The importance of coral reefs as centres of biodiversity is well recognised, however, the scale at which specific structures relate to fish diversity patterns remains poorly explored. This study investigates the relative importance of geomorphological reef zones versus entire reef systems in influencing fish communities across three isolated but degraded Caribbean atolls. We compare shallow water (< 5 m) reef fish communities at 90 sites among and within atolls and across five geomorphological reef zones to assess their relative effects on both taxonomic and functional fish diversity.

Overall, diversity levels varied more among reef zones than among atolls and atolls differed most in terms of their lagoons. The latter finding may reflect local levels of degradation and resilience capacity of atoll lagoons that have been subject to a coral-algal phase shift and suggests that lagoonal fish assemblages serve as indicators of ecosystem health. Among atolls, fish richness and abundance were highest at the largest, least isolated and least protected atoll and lowest at a smaller, more isolated atoll that is protected from fishing but is periodically exposed to river plumes. This indicates that biogeographic effects of isolation and area in tandem with environmental factors linked to geomorphology (e.g. wave exposure, water residence time) affect fish communities and have the potential to enhance or counteract the effectiveness of marine reserves.

Further, we identify areas of high productivity, which are currently not accounted for in reserve protection schemes. Here we show that taking into account reef zone facilitates the detection of diversity patterns and aids in prioritizing sites for conservation. Further, we find both biogeographic and geomorphological factors may override reserve protection effects and our findings underpin the usefulness of geomorphological proxies of fish diversity for spatial marine conservation.

### Merian Award Applicant

## WAI ULI CORAL MAPPING AND MONITORING: INTEGRATING WESTERN AND NATIVE HAWAIIAN SCIENCES

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The purpose of this project was to establish a monitoring method of healthy and unhealthy coral in a specific area and create a reliable pathway to observe them over a long period of time. The methods started with setting 50 meter transect lines to determine the coral species diversity of the site. Then a working definition of unhealthy was set, specifically looking at growth anomalies on *Porities* species. The cultural components integrated for this project were recognition of Hawaiian place name, use of spatial environmental observations, and incorporating opening and closing chants on data collection days.



With the characterization of the site instituted, twelve coral heads were selected for monitoring, six healthy and six unhealthy. Each coral were measured for their circumference and diameter. For mapping purposes, compasses were used starting from shore to determine the degree direction from one coral to the next and a GPS unit was used to mark each one. From this data, an aerial map of the site was created pinpointing the exact locations of all twelve corals. With this pathway established, continued monitoring of coral is health is the on-going outcome of this project. Corals are visited three days of the month, once in the morning and once in the evening, and checked for changes in health. On-going incorporations to find correlations between coral health and other factors include collecting data on the invertebrate exosymbionts presence and environmental observations with attention to moon phases and tides. Future goals for this project are integrating community involvement in the monitoring process and successfully applying this monitoring methodology to another site.



## DIVERSITY TURN IN LAND USE SCIENCE: TRANSDISCIPLINARY RESEARCH IN THE VANILLA LANDSCAPES OF NE MADAGASCAR

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Madagascar's remarkable biodiversity is threatened by rising demands from global markets. Vanilla is one of the main exported commodities of Madagascar and the world's second most expensive spice, due to its highly-labor intensive production. We report on the transdisciplinary research project "Diversity Turn in Land Use Science" which investigates the ecological, social and economic impacts of vanilla cultivation in North-Eastern Madagascar. Eventually, the project aims to provide recommendation for sustainable land-use practices and facilitate the social and economic empowerment of farmers. Within the project scope, the ecological sub-projects focus on the impacts of vanilla cultivation on biological diversity and associated ecosystem services, assess the importance of landscape context to bird conservation, and examine the diversity and use of trees in the agricultural landscape.

We collect data focusing on gradients from high to low land-use intensity. First, we investigate crop and associated wild plant diversity, pollinator communities and host-parasitoid relationships in and around the different vanilla cultivation systems located in home gardens and at tropical rainforest margins. Second, we study the landscape- to regional-scale impacts of different types of vanilla cultivations as well as alternative land-uses on biodiversity conservation using birds as a model. For this purpose, the integration of landscape models, plot-based field studies and household surveys will be used. Third, we study the diversity and use of trees inside and around vanilla cultivation systems. We collect inventory data as well as interview-based data on the use of trees and linked to UAV-generated 3D landscape models. We present first insights from field surveys and aim to encourage general feedback on the project design and research ideas in this early phase of the "Diversity Turn in Land Use Science" project.

## BIODIVERSITY AND ECOSYSTEM FUNCTIONING IN FALLOW SYSTEMS IN THE CENTRAL CONGO BASIN

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Shifting cultivation and agricultural systems have been blamed for causing deforestation and associated losses in ecosystem services such as carbon sequestration in biodiversity conservation. On the other hand, it is also acknowledged that in many cases these systems are superior to permanent cropping systems in providing ecosystem services. However, substantial variation exists between systems, with increasing population densities and resulting changes in management affecting the functioning of the system and the associated services. Vegetation regrowth is a crucial process in that sense, but the successional dynamics of secondary vegetation in the tropics vary widely and these trajectories remain highly unpredictable. Especially in Central Africa, information on vegetation succession and biomass re-growth is scarce.



The aim of this study was to improve the understanding of driving factors of biomass accumulation and biodiversity of woody species diversity in secondary forests in a fallow system in DR Congo. Data on vegetation and carbon storage, environment and management practices were collected in 96 fallow plots located in three shifting cultivation sites. Using this dataset, we (1) calculated annual biomass increments and biodiversity indicators, (2) determined the relative role of management practices, landscape configuration and soil properties on biomass regrowth and biodiversity resilience and (3) assessed which community functional properties were responsible for the observed changes in ecosystem functioning.

Results indicate that in the 3 sites, ecosystem functioning and associated ecosystem services vary widely, with each additional agricultural cycle resulting in a deterioration of annual biomass increment rates and species richness. Community weighted means of pioneer traits were associated with increased biomass growth, while no support was found for an effect of functional diversity on ecosystem functioning.

### Merian Award Applicant



## HELP FROM ABOVE - BOOSTING YIELD AND CONSERVATION VALUE IN CACAO PRODUCTION BY DOING NOTHING?

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Apart from pressures from changing environmental conditions and increases in pest incidence, cacao production has been shown to be limited by cacao pollinator abundance. Cacao pollinators can occur in several habitat types such as the water holding leaf axils of tank bromeliads (Bromeliaceae). Epiphytic bromeliads can naturally occur in cacao plantations of the new world, but are often removed by the farmers who falsely assume them to be parasitic.

By comparing plantations with and without bromeliads and experimental manipulations, this research focusses on uncovering the potential positive effects of maintaining bromeliads within cacao plantations on the potential yield, and on general insect biodiversity associated to bromeliads.

## SUBSTITUTION OF THE MOST IMPORTANT AND DECLINING WILD FOOD SPECIES IN SOUTH-EAST BURKINA FASO

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Wild plant species are important nutritious supplements to otherwise nutrient poor diets of rural populations in West Africa. Consequently, a decline of wild food species has a direct negative impact on the nutritional status of local households. In this study, we firstly investigated the preferred wild food species in south-east Burkina Faso, their perceived change in abundance as well as their contribution to wild food income. Secondly, we studied how these species might be substituted in times of species shortfall. Thirdly, we investigated the impact of socio-economic variables on the substitution choice. We conducted 155 household interviews in two villages and found 21 wild food species.

With a contribution of almost 70% to wild food income, *Vitellaria paradoxa* and *Parkia biglobosa* were economically most important. All species were considered declining to some degree. The wide range of cited substitutes for the ten most important wild food species indicates a great knowledge on alternative plant species in the area. For the majority, the substitution choice did not depend on socio-economic characteristics. Cited as surrogate for several important wild food species, the native tree *Balanites aegyptiaca* was the most important substitute species. Many valued wild food species were substituted with other highly valued wild food species and therefore the decline of one species can lead to a shortfall of another substitute. Thus, even though our results suggest that people are able to counteract the decrease or absence of wild food species, growing decline of one species would concurrently increase the pressure on other native food species.



## UTILIZATION AND CONSERVATION OF AN INDIGENOUS-UNDERUTILIZED FRUIT TREE SPECIES: *XEROSPERMUM NORONHIANUM* (SAPINDACEAE)

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*Xerospermum noronhianum* (Blume) Blume, locally known as *ké* (leech's longan) is a multipurpose fruit tree species of high economic importance, native to the limestone forests of Vietnam. This species along with lychee (*Litchi chinensis* Sonn) belong to the Sapindaceae family. The fruits of *X. noronhianum* are edible, with a sweet and pleasant taste, resembling those of *Nephellium lappaceum*, another Sapindaceae species that yields the commercially important Rambutan tropical fruit. The fruit of *X. noronhianum* is too small to be of any commercial value, but the species is a source of medicines against diarrhea, stomach pains and Alzheimer disease. Recently, *ké* has emerged as a high-priority species for domestication in Vietnam after a national survey and ranking of non-timber forest products. Information on the level of genetic variation and the extent of genetic diversity within and between natural and managed populations is needed to develop strategies for domestication and to define units of *in situ* conservation as natural gene pools or forest gene banks for this species. Microsatellites (SSRs) provide an ideal tool to investigate genetic variation pattern. However, given the time-consuming and expensive process of isolating SSRs, it is advantageous to utilize primer sequences already identified in other closely related species.

We investigated the transferability of 14 lychee (*L. chinensis*) Simple Sequence Repeat (SSR) loci to *ké* (*X.noronhianum*). Ten primer pairs were found to be transferable (71.4%), whereas seven revealed polymorphisms (70%). The relatively high frequency of cross-transferability observed in this study is rather unexpected as *ké* belongs to the Sapindoideae subfamily, while lychee, pulasan and longan belong to subfamily Nephelaeae, and are therefore more closely related. However, this study showed that the SSR markers developed in lychee are a good source of molecular markers for *X. noronhianum*. Domestication and development plan of *ké* for integrating livelihood strategies with gene conservation is discussed.

## QUANTITATIVE ETHNOBOTANY TOWARDS CONSERVATION OF FOOD TREE SPECIES OF WARI MARO FOREST RESERVE IN THE SUDANIAN ZONE OF BENIN

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At present, the importance of local knowledge in biodiversity conservation is recognized worldwide coupled with the importance of food tree species to supply balanced feeding and nutrition in developing countries. In this study, we present an assessment of diversity and variation of food tree species used by local socio-cultural groups in the surrounding of Wari- Maro forest reserve, a degraded forest in the Sudanian zone of Benin. We aimed to identify the conservation priority of locally important food tree species.

Ethnobotanical surveys were conducted with 149 people inhabitant in villages in the surrounding of the forest to understand local knowledge of useful tree species. Floristic vegetation surveys were conducted within the forest to assess the ecological availability of food tree species. A quantitative ethnobotany approach combined with multivariate statistical analyses was applied to investigate utilization patterns of food tree species, and to highlight priority food tree species for conservation.

In total, 79 useful woody species were investigated among which 23 tree species were reported as food tree species. Differences in local knowledge on food tree species were observed among socio-cultural groups. Among the used food tree species, *Blighia sapida*, *Dialium guineense*, *Spondias mombin*, *Annona senegalensis*, *Borassus aethiopum* and *Vitex doniana* are prioritized for conservation in this area. Our study provides an example of an approach combining ethnobotanical and ecological tools to understand variation and utilization patterns and infer conservation priority at local which are required to develop sustainable management and conservation strategies.



## IMPROVED PLANT GENETIC BIODIVERSITY THROUGH THE ORGANIZATION AND PROMOTION OF AGRICULTURAL SHOWS AND SEED FAIRS

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Plant genetic resources for food and agriculture are the biological basis of food security. The Democratic Republic of Congo (DRC) is among the world's richest countries in terms of biodiversity, and the sustainable management of resources is a priority for ensuring food security. However, the state of diversity of PGRFA (Plant Genetic Resources for Food and Agriculture) is very low due to the weakness of the agricultural sector in the DRC, with a significant loss of old varieties that have disappeared in areas of conflict. In addition, the lack of international technical cooperation in agriculture in the DRC, the loss of gene banks, the halting of development programs and research, and bad weather have all contributed to declines in State structures for research, seed multiplication, and extension (INERA, 2009).

Current extreme weather events, including temperature increases, the scarcity of rain, the drought of certain vulnerable agricultural areas, the proliferation of pests and other insects have precipitated major challenges, both for food self-sufficiency of the population and the promotion of local agriculture generating investment income.

In many developing countries, agricultural fairs including seed fairs have been traditionally a center of the informal system of local markets, which offer enormous opportunities to many agricultural trades. In recent years, seed fairs and agricultural shows are increasingly structured and thus become the overall expression of the rural world. They have become both an opportunity and a place to meet and exchange ideas, knowledge and know-how for the rural populations of the region, particularly in the fields of agriculture, environmental management, biodiversity and climate change.

Through these experiences and seed fairs, *in situ* support of small farmers is emphasized. They learn that resources in general and plant genetic resources in particular, have a life cycle: they come into existence, provide a variety of helpful services, and then die and disappear, either physically or from the perspective of their users. The small rainforest vine, *Gnetum africanum*, illustrates this life cycle of a resource that is born, lives and dies. Thus, the seed fairs and agricultural shows are quite suitable for raising awareness of the importance of agriculture in terms of cultural heritage and diversity of income sources to contribute to the fight against food insecurity, the fight against poverty and the preservation of biodiversity.

### Merian Award Applicant

## CONSERVATION OF FRESHWATERS IN OIL PALM PLANTATIONS

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Freshwaters provide essential services for people, perform key ecosystem functions, and support very high levels of biodiversity, but are heavily threatened by land use change. In Southeast Asia, expansion of oil palm agriculture to meet increases in global food demand is posing a substantial threat to freshwater ecosystems. Conversion of natural habitat for plantation establishment as well as fertiliser use during plantation management can potentially affect flow, water temperature, sediment inputs, and levels of nutrients and organic matter in freshwaters, with substantial impacts on biodiversity and function. However, research into the impacts of oil palm on freshwaters and possible strategies for conservation – including maintenance and restoration of riparian buffer strips – has been limited.



We studied oil palm, logged forest and pristine forest streams at the Stability of Altered Forest Ecosystems (SAFE) Project in Sabah, Malaysia, and assessed the impacts of habitat disturbance on hydrology, macroinvertebrate biodiversity and ecosystem function. We found that oil palm and disturbed forest streams were significantly different from pristine forest streams in terms of a range of environmental conditions and in community composition of macroinvertebrate taxa. Preservation of forested riparian buffer strips in oil palm plantations helped to retain more 'forest-like' conditions and assemblages, but did not offer full protection for all conditions, suggesting that additional management strategies are needed.

Our ongoing research in Sabah, Malaysia, is considering the importance of buffer strip width and forest quality for maintaining a suite of environmental conditions and taxa both within stream and within the riparian buffer. Upcoming research at the Biodiversity and Ecosystem Function in Tropical Agriculture (BEFTA) Project in Sumatra, Indonesia, will experimentally test different strategies for restoring riparian buffer strips in oil palm plantations.

## LATE QUATERNARY VEGETATION AND ENVIRONMENT RECONSTRUCTION BASED ON POLLEN AND DINOFLAGELLATE CYSTS IN EASTERN SOUTH AMERICA

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Pollen, spores and dinoflagellate cysts of the marine sediment cores GeoB 2107-3 and GeoB 6211-1 located in the South Atlantic Ocean off southern Brazil have been studied by to reconstruct the vegetation as well as the environmental changes during the last glacial and Holocene period. The aim is to understand the interactions between vegetation and ocean and the role of climate dynamics on the vegetation over long time periods.



The results show that during glacial times, grassland was the dominant vegetation in eastern South America. Tropical rainforest was markedly reduced, indicating cold and dry climatic condition. During glacial times, due to the low sea level, grassland and patches of subtropical forest covered the exposed continental shelf. Araucaria forest on the highland was frequent during early glacial times and rare during mid- and last glacial maximum (LGM) period. *Nothofagus* pollen and dinoflagellate cysts indicate that the Malvinas Current which derived from the sub-polar front had a markedly stronger influence particular during the LGM period. During Holocene period, the expansion of Atlantic rainforest and tree ferns indicate humid and warm climate condition. During the late Holocene, the Araucaria forest expanded on the highland. Dinoflagellate cysts indicate the increase of the sea-surface temperature in the South Atlantic Ocean during the Holocene. The results suggest that changes in the South Atlantic Ocean had a strong influence on the vegetation dynamics in South American continent during last glacial and Holocene times.



## HOLOCENE VEGETATION RESPONSES TO CHANGING ENSO REGIMES IN THE SOUTHWESTERN ANDEAN CORDILLERA, ECUADOR

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Ecosystems in the Ecuadorian Andes support an exceptionally high botanical biodiversity and endemism. The presence of many endemic and specialized species make these ecosystems fragile and vulnerable to climate change. Temperature and precipitation in the Ecuadorian Andes are strongly affected by the El Niño – Southern Oscillation (ENSO). The future frequency and magnitude of ENSO in a world with global climate change is still highly uncertain and topic of intense debate. Hence, future impact of the ENSO on the fragile ecosystems of the high Andes remains uncertain. The consequences of variations in ENSO activity for regional hydrology and vegetation composition can be assessed by studying past environmental changes from long sediment records under changing ENSO regimes. One of the most detailed continuous records of past long-term El Niño dynamics from a terrestrial setting is the Laguna Pallcacocha record from Cajas National Park, Ecuador. Previous analysis revealed hundreds of El Niño-driven light-coloured inorganic, clastic laminations, in the dark organic lake sediments which reflect increased frequency of El Niño events during the past 5000 years, with millennial-scale oscillations. While used worldwide as a key record of ENSO variability, the direct effect of increased rainfall events on the regional vegetation has not been investigated.

We present the first Holocene pollen record from Laguna Pallcacocha that reveals clear responses of vegetation to phases of high ENSO frequency. Especially, the *Alnus* genus, occurring in the montane forest belts, is clearly responding to increased frequency of El Niño events during the past 5000 years. Additionally, an ultra-high resolution pollen analysis of the last century allows to calibrate interannual changes in pollen deposition to regional precipitation and temperature variability forced by ENSO. This analysis helps to bridge the gap between long-term vegetation and annual-scale responses to ENSO variability.

## 600 CAL YR BP OF ARAUCARIA FOREST AND GRASSLAND DYNAMICS IN THE SERRA DA BOCAINA NATIONAL PARK, SOUTHEASTERN BRAZIL

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The Serra da Bocaina National Park, with an area of 104.000,00 km<sup>2</sup> is located at the border of the states of São Paulo and Rio de Janeiro in Southeastern Brazil. The region is one of the first areas occupied by European during the Brazilian colonization. The original vegetation was composed by Montane Atlantic Forest, Araucaria Forest and High Elevation Grasslands. However, more or less 400 years of land use changed the landscape, ecosystems and species composition. The immigrants prepared the land basically putting fire and cutting all the vegetation, first for coffee plantation and afterward for cattle. Nowadays, there are also some exotic species such as *Pinus* spp.. The National Park embraces a large gradient of elevation, from the sea level to more than 2.000 m. As a result of several geomorphological domains, it presents different reliefs, microclimates, hydrography, soils, ecosystems and landscapes, as well as ecologic refugees, endemic and endangered species; increasing the importance of the area for conservation.



To study past vegetation dynamics and how humans changed the vegetation, a sediment core from a swamp was cored in a contact area between Araucaria Forest and Grassland, near São José do Barreiro, São Paulo State at 1.539 m elevation (S 22°44'02.0"/ W 044°38'39.4"). The 228 cm long record represents the last 600 cal yr BP. The upper most part of the sediment (76-0cm) is characterized by the presence of roots and organic material, with a reddish and yellowish brown colour. From 228 to 76 cm the record is quite sandy with silt and mostly greyish. The record provides important information on mountain vegetation dynamics, human impacts and climate change. The tree pollen types found are characteristics of Upper Montane Araucaria Forest, such as *Podocarpus*, *Weinmannia*, *Alchornea*, *Myrsine* and *Myrtaceae*, however, the *Araucaria* pollen type is low represented. Also, *Poaceae* and *Cyperaceae* are quite abundant. The presence/ absence of characteristic pollen taxa of Araucaria Forest, Atlantic Forest and Grassland are discussed in the light of the past, current and future scenarios enabling the planning of strategic actions of management for conservation the ecosystems and their biodiversity.



## COMPLEMENTARY IMAGING TECHNIQUES SUPPORT DETAILED IDENTIFICATION OF CENTRAL AFRICAN CHARCOAL

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Identification of ancient charcoal fragments is a valuable tool in reconstructing past environments and determining natural and anthropogenic disturbances, and for understanding past cultures and societies. Although in Europe such studies are fairly straightforward, utilising charcoal records from the tropics is more complicated due to the species-richness of the natural vegetation. Comprehensive databases have greatly aided identification but identification of charcoal from the tropics often still relies on minute anatomical features that can be difficult to observe due to preservation or lack of abundance.

This poster illustrates the relative potential of different imaging techniques and discusses how they can provide optimal visualization of charcoal anatomy, such that specific difficulties encountered during charcoal examination can be evaluated and fine anatomical characters can be observed enabling high level identification of charcoal taxa. Reflected Light Microscopy is often used to quickly group large numbers of charcoal fragments into charcoal types. Scanning Electron Microscopy and High-Throughput X-ray Computed Tomography are employed to observe fine anatomical detail. Finally, X-ray Computed Tomography at very high resolution has proved successful for imaging hidden or 'veiled' anatomical features that cannot be detected on exposed surfaces but need three-dimensional volumetric imaging.

Furthermore, we present first results from a large charcoal database aiming at untangling past linkages between fire regimes, vegetation shifts, climate change and human disturbances. We applied the complementary imaging techniques presented above to visualize anatomy in detail, describe the charcoal types and end up with state-of-the-art identifications. Our database now contains charcoal fragments from several sites within the Congo basin. Identification results from all these sites together will provide an alternative for palynological and sedimentological long-term records, which are lacking from this region due to a scarcity of stratified lakes or wetlands.

## FROM THE AMAZON TO THE ANDES: UNDERSTANDING CLIMATE ADAPTATION ALONG A TROPICAL ELEVATION GRADIENT

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In order to survive predicted global climate change, many species will need to adapt, acclimate, migrate, or face extinction. We investigate potential mechanisms of adaptation, utilising an Amazon to Andes elevational gradient in Peru, ranging from 500-3500 m asl, and encompassing unique and highly threatened tropical montane cloud forest (TMCF). Such a large gradient offers an ideal situation to study climate adaptation, while TMCFs are centres for endemism, whose fundamental climate sensitivity means they can act as an early warning system for climate change impacts.



Our study focuses on Miconieae, a diverse neotropical tree lineage, utilising phylogenetic and trait analyses to uncover evolutionary and elevational trends in functional traits such as leaf thickness, SLA and LDMC. We elucidate the features that allow this lineage to occupy a large elevational distribution and what the implications of observed evolutionary trends may be for the future of this vulnerable and highly biodiverse region.



## VARIATION OF TREE FINE ROOT ARCHITECTURE ALONG A TOPOGRAPHICAL GRADIENT IN AN ECUADORIAN TROPICAL MONTANE FOREST

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In montane forests of southeastern Ecuador, topography contributes crucially to the outstanding diversity of these ecosystems. The small-scale heterogeneity in forest structure and species composition is an outcome of a considerably stronger nutrient limitation at the upper slope, induced by down-slope fluxes of soil resources. The ability of plants to acquire nutrients and water has been proposed to be directly related to fine root architecture. Depending on resource availability, fine roots display branching patterns suitable to different degrees for space exploration or efficient nutrient transport. We therefore expect the nutritional gradient of montane forest slope soils to be reflected in tree fine root architecture.

We sampled fine root systems from 180 trees (10 in each six plots at upper, middle and lower slope position) in a lower montane forest (at ~2000m asl) in southeastern Ecuador. The roots were scanned and analyzed for differences in a set of architectural and morphological traits between the slope positions. Prospectively, it is planned to link the sampled fine root traits with leaf and wood traits of the same trees in order to gain further insights into below- and aboveground trait coordination and the effects of topography and related resource availability on tree resource economic strategies.

### Merian Award Applicant

## USING MODERN POLLEN DATA TO CHARACTERIZE ALTITUDINAL CHANGES OF TROPICAL MOUNTAIN RAINFOREST IN NORTHEAST BRAZIL

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Although the Northeast Brazil is mainly characterized by a semi-arid climate that corresponds to the driest area of Brazil, a sub-humid climate persists in small mountainous areas close to the coast. Such very local climatic conditions enable the development of a highly diversified mountainous rainforest surrounded by the Caatinga. Because such rainforests are characterized by small areas with specific vegetation and microclimatic conditions, their potentials to sustain tropical biodiversity are generally underestimated within the future scenarios of climate change. In order to characterize the different communities and distributions of these rainforests we analyzed the modern pollen rain in soil samples along an altitudinal gradient that we compared with botanical data from different mountainous area from Northeast Brazil.



We identified several ecological successions characterized by significant changes in rainforest assemblages whose distribution depends on water availability. In addition, to test their potential to sustain future tropical biodiversity we compared our calibration of pollen rain with fossil pollen data. Despite the high sensitivity of rainforest to climatic variability evidenced by our study, the rainforest persisted and responded to past climate changes by recruiting key species among its highly diverse stock. Consequently our results based on modern and fossil pollen data illustrate long-time perspective on ecological processes response to climatic changes of mountainous rainforests from Northeast Brazil.



## ALTITUDINAL TRENDS IN THE COMMUNITIES OF GEOMETRID MOTHS ALONG A COMPLETE RAINFOREST ALTITUDINAL GRADIENT IN NEW GUINEA

Pagi Toko<sup>1,2,3</sup>, Vojtech Novotny (speaker)<sup>1,2</sup>, Sentiko Ibalim<sup>3</sup>, Simon Segar<sup>1</sup>, Scott Miller<sup>4</sup>

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Geometrid moths are one of the highly diverse model taxon, frequently used to study the response of tropical herbivore communities to environmental factors, including elevation. The geometrids are in the minority of insect taxa exhibiting an unimodal response of alpha diversity to elevation, with species diversity maximum at mid-elevations. This contrasts with more widespread unimodal decrease in diversity typical for many other insect taxa, including butterflies or ants. The mid-elevation maximum of diversity was found also in our data, comprising >1,000 species of geometrids at Mt. Wilhelm.

Here we discuss the environmental variables, trophic interactions and phylogeny as potential drivers behind this pattern, and focus also on the importance of molecular vs. morphological species concepts when studying highly diverse tropical taxa along altitudinal gradients.

## NUTRIENT UTILIZATION BY ANTS ALONG A COMPLETE ELEVATIONAL RAINFOREST GRADIENT IN PAPUA NEW GUINEA

Jimmy Moses<sup>1,2</sup>, Vojtech Novotny<sup>1,2</sup>, Tom Maurice Fayle<sup>1,2,3</sup>, Petr Klimes (speaker)<sup>1</sup>

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Tropical mountains provide an ideal setting for macroevolutionary and macroecological studies, but also offer the opportunity to expand experimental studies of nutritional ecology of animals in natural ecosystems, which have mainly been conducted in laboratories. Since nutrients are not distributed evenly and thus limit communities in different environment, we may expect variable trends in feeding preferences of ants along tropical rainforest gradients. However, only few studies have documented such changes in nutrient requirements along tropical mountains and those did not study complete natural rainforest gradients.

We used such a complete elevational gradient (Mt. Wilhelm, 200m – 3700m a.s.l.) to study the trends in macronutrient requirements in ground-dwelling communities. In particular, we focus on the changes in nutrients utilized relative to elevation by both whole ant communities and individual species. We randomly exposed 10 replicates each of six experimental baits (treatments) along a 300m transect at eight sites along the gradient for one hour. The baits were: (1) C<sub>6</sub>H<sub>12</sub>O<sub>6</sub> (20% sugar), (2) NaCl (1% salt), (3) Amino Acid (20% glutamine), (4) C<sub>6</sub>H<sub>12</sub>O<sub>6</sub> + Amino Acid (honeydew mimic), and (5) lipids (olive oil), (6) Pure H<sub>2</sub>O was used as a control.

The species richness and number of their occurrences on baits decreased significantly with elevation across all treatments. However, the relative proportion of individual ants feeding on each bait showed significant variations across the sites. Lipid utilization declined steeply with elevation. In contrast, the proportion of individual ants utilizing honeydew and sugar increased while salt, amino acid and water remained relatively constant. We suggest that spatial variations in nutrient requirements by ants in natural ecosystems along the elevational gradient are driven by temperature, but also by nutrient availability and functional composition of ant communities.



## FUEL WOOD USE AND CLIMATE CHANGE IMPLICATION FOR SUSTAINABLE DEVELOPMENT

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About 2.5 billion people in developing countries rely on biomass fuels (such as firewood, charcoal and dung) to meet their cooking energy needs, and the demand is expected to increase to 2.6 billion by 2015, and 2.7 by 2030 due to population growth and urbanization. There is a positive relationship between growth in population and rate of charcoal use in many developing regions of the world. Global warming leads to climate change and in turn increase climate variability. Climate change is change in long term global average temperature and rainfall. The increase in global temperatures can be attributed partly to human activities and our greenhouse gas emissions mostly by fossil fuel, power plants, and other industrial factories. Mitigation and adaptation are the two primary instruments of the international climate convention to minimize negative impacts of climate change on humans and ecosystems. Forests, as “pool” and “sink”, are seen to play a major role in mitigating climate change. As such, since much of biomass, bioenergy, and woodfuels come from forests.

This poster presents an analysis about the role of fuel wood uses and climate change as well as their implications. Charcoal is the dominant energy used by urban households in Ghana. Charcoal use as household cooking fuel accounts for about 52.6% of total household energy consumption-mix. Statistics shows a clear imbalance between population density and woodfuel distribution and conservation. Demand for woodfuel is increasing with oil prices and local government agencies derive substantial revenue from woodfuel taxes. However, enabling policy, institutional, and investment conditions need to be developed at national, and local levels to achieve synergistic goals. Establishing woodlots is a comprehensive and straightforward approach to saving the forest in Ghana.

## DE NOVO TRANSCRIPTOME SEQUENCING AND COMPREHENSIVE ANALYSIS OF THE DROUGHT-RESPONSIVE GENES IN *ERYTHROPHLEUM* SPECIES

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The genus *Erythrophleum* (Leguminosae) includes about 12 species widely distributed in the tropical forests. In Africa, three species, *E. africana*, *E. suaveolens* and *E. ivorensis* are adapted to different soil and climate conditions. Despite interest in the evolutionary history of these species through phylogeographical and molecular dating reconstructions, the genetic basis and gene functions in response to environmental variation have not been yet elucidated.



In our ongoing study, seedlings of different species and different provenances for *E. suaveolens* were grown under controlled conditions and subjected either to control (well watered) or to water deficit conditions during two months. By using Next Generation Sequencing (NGS)-based RNA-seq technology, we aim to analyze the transcriptomic profiles of the leaves and roots at the seedling stage under drought stress compared with those under normal conditions. We will focus on the identification of gene-associated molecular markers as well as drought stress-induced differentially expressed genes (DEGs) and assess whether difference in drought-stress resistance between species and provenances can be explained by these genes.



## SEED BANK CHARACTERISTICS IN DEEP SOIL LAYERS OF CENTRAL AFRICAN FORESTS

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The soil seed bank is defined as the stock of viable seeds in the soil. Most studies focus sampling to the first 5 to 10 cm of soil. The aim of this study is to characterize the soil seed bank in two rain forests of the Congo Republic.

The study was conducted in two forest types: (i) an old secondary semi-deciduous forest on clay soils (relatively rich soils) at Loundoungou (LF) and (ii) a more mature evergreen forest on Carnot standstone (relatively poor soil) at Mokabi-Dzanga (MF). In each site, 30 soil samples were systematically collected in a plot of 400 ha at three depths: litter, 0-10 cm and 10-20 cm. Each sample was a mixture of three unitary subsamples of 10 x 10 cm.

Globally, we observed 297 seedlings of 53 species (LF) and 220 seedlings of 39 species (MF). The seed density was 330 seeds/m<sup>2</sup> (LF) and 244 seeds/m<sup>2</sup> (MF). The global diversity was estimated to 70-75 species (LF) and 60-70 species (MF) and communities varied between sites.

The soil seed bank composition and density vary but further studies are necessary to disentangle the effects of forest composition, soil and climate. Seeds of short and long-living pioneer tree species were observed exclusively in the deepest layer.

## WESTERN AND EASTERN AFRICAN RIFT LAKES AND WETLANDS HARBOUR DIFFERENT ESU'S OF PAPYRUS: A DISPERSAL MEDIATED BY ELEPHANTS?

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Aquatic plants occur in habitats surrounded by land masses acting as barriers to gene flow unless connecting rivers or dispersers facilitate contacts. This isolation and life-history processes influence gene diversity and structure. *Cyperus papyrus*, an asexually and sexually reproducing emergent macrophyte, occurs in African freshwater lakes, riverine edges and isolated wetlands. It is common in Lake Victoria and wetlands of the Western (Albertine) African rift and the Eastern (Gregory) African rift region. This represents an interesting case to test hypotheses of connectivity as Lake Victoria is situated in between both rifts.



Genetic diversity and structure of papyrus was assessed using nuclear microsatellites in 50 populations along Western rift (Rwanda lakes, Lake Tanganyika and Malagarasi swamps in Tanzania), in Lake Victoria (Southern part in Tanzania; Eastern part in Kenya), along Eastern rift (Lake Naivasha and isolated wetlands in Kenya; Lake Awassa and Ziway in Ethiopia) and beyond eastwards in Kenya (Lake Jipe, Amboseli NP). Most lakes displayed high allelic and gene diversity whereas several isolated wetlands contained few clones. Two evolutionary significant units (ESU's) were obtained. One ESU from the Western rift area (incl. Malagarasi entering L. Tanganyika) and another ESU from the upper Nile basin (L. Victoria) and Eastern rift. Many populations are strongly differentiated and we interpreted genetic structure in relation to geographic distance and drainage basins. Connectivity estimates confirmed hydrochory for within-lake sites but assume zoochory and historical inter-basin connection among nowadays isolated wetlands. Most probable historical gene flow pathways could be migratory waterfowl and large animals. Birds may consume seeds and help in inter-basin dispersal by endozoochory, whereas herbivores may disperse seeds through both endo- and epizoochory. We suggest elephant-mediated long distance dispersal of papyrus seeds, especially in Pleistocene refugia wetlands through both epizoochory (wallowing behaviour) and endozoochory means. This potential channel could explain the existence of isolated papyrus populations whose water recharge sources are underground, an indicative of water refugia sources during past documented droughts events in Eastern Africa.



## AFRIFORD PROJECT: GENETIC AND PALEOECOLOGICAL SIGNATURES OF AFRICAN RAINFOREST DYNAMICS: PRE-ADAPTED TO CHANGE?

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Tropical rainforests are the terrestrial biome with the greatest diversity of plant and animal species. Long-term stability has been considered for long as a prime cause of this remarkable biodiversity. However, paleoecological evidence of substantial change in the vegetation of tropical regions resulting from global climate fluctuation during the Quaternary, as well as evidence of significant ecological perturbation by humans in the last few thousand years, call for a reassessment of the temporal dynamics of biodiversity in tropical rainforests, and how this may influence their resilience and/or adaptation to rapidly accelerating human impact.

AFRIFORD is a multi-disciplinary research (2014-2017) project which aims to understand how past climate changes and the activities of ancient indigenous societies have shaped the current distribution and composition of African rainforests and the genetic diversity of their constituent tree species. This knowledge is essential for forecasting how the forest will respond to current and future environmental impacts, because the way tropical forests have responded to past climatic and human perturbation reveals their resilience, or innate adaptive capacity, to current and future perturbations resulting from massive ongoing deforestation, forest degradation and anthropogenic climate change.

AFRIFORD is therefore based on the integration of both paleoecological analyses (palynology, anthracology) on lake and soil sediments, dendrochronology, vegetation modelling and population genetics. Some key results of the project will be presented, to better:

- (1) understand the processes leading to the diversification/differentiation of African rainforest tree biodiversity at inter-specific and intra-specific levels.
- (2) document the main climatic and anthropogenic perturbations which affected the past vegetation dynamics in the Congo basin for a range of relevant time scales, with particular emphasis on the last glacial-interglacial cycle, the late Holocene where traces of forest fire become abundant, and the last two centuries when current tree communities were established.
- (3) develop and calibrate a vegetation model able to simulate reliably the changes in vegetation, productivity, and species distribution ranges in response to environmental forcing, in order to make predictions under scenarios of climate and anthropogenic environmental changes.



## THE IMPORTANCE OF ENVIRONMENTALLY MARGINAL HABITATS IN THE ATLANTIC FOREST DOMAIN OF SOUTH AMERICA

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Climate and vegetation structure are often used to map biomes, but both approaches have limitations. Using floristic composition represents an alternative approach at spatial scales where biogeographic history is not driving differentiation in species composition. Underlying a floristic approach is the logic that different plant species have different functional traits and that these traits influence ecosystem function. Our chief aims were to use a floristic approach to determine where the main biomes of LTSA are located in geographic and climatic space.

We compiled a database of 4103 geo-referenced woody plant floristic inventories distributed across LTSA (< 1000 m.a.s.l.). First, we used *a priori* classifications along with cluster analyses to assign inventories to biome. We then interfaced this classification with climatic variables often used in biome mapping to assess climatic overlaps amongst biomes.

Our analysis revealed five higher-level clusters: Amazon Forest, Atlantic Forest, Cerrado, Seasonally Dry Tropical Forests (SDTFs) and Chaco. We noted that: 1) the Amazon and Atlantic Forests seem to be distinct biomes in terms of climate and tree species composition; 2) semi-deciduous forests (e.g. gallery forests within Cerrado) cluster with the nearest moist forest biome; and 3) SDTFs from Bolivia to northeast Brazil form a single group, which is geographically interspersed with the Cerrado. Our results also convincingly show that climate alone cannot be used to distinguish the main biomes of LTSA. Also, the tree species composition of transitional zones between biomes, such as Chiquitania and Pantanal, resembles the tree species composition of the nearby environments. These results are important for the planning of conservation strategies in the face of climatic change. For example, since climate cannot be used as an accurate proxy for tree species distribution, it cannot be used as a means to map a given biome's distribution under climatic change scenarios.

## INFLUENCE OF BACTERIAL LEAF SYMBIOSIS ON THE EVOLUTION OF THE GENUS *PSYCHOTRIA* (RUBIACEAE)

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Mutualistic interactions between different organisms are known to influence the fitness of the partners involved and thus increase their reproductive success. One of the most widespread mutualisms is the interaction between symbiotic microorganisms and flowering plants. These symbioses can, among others, improve plant biomass production and increase offspring survival. Such close interaction between host plant and microorganism inevitably has an impact on the evolutionary dynamics of the host.



Within the coffee family (Rubiaceae), we study a specific endosymbiosis in which bacteria of the genus *Burkholderia* are present in specialized leaf nodules. This interaction is especially known from the species-rich genus *Psychotria* (+1600 species) that contains both species that have leaf nodules and species without leaf endophytes. Due to the specificity of the interaction, it is assumed that the interaction is very close and obligate. The function of the endophytic bacteria is to date unknown, but it is hypothesized that they are involved in the production of secondary metabolites that provide chemical defense against insect herbivory. If this is true, it is reasonable to assume that the bacteria may increase the fitness of their hosts and therefore influence their long-term evolution.

In this study, a phylogenetic tree of the genus *Psychotria* is reconstructed, making sure that both species with and without endophytes are represented. Using a large-scale phylogenetic dataset, the genus *Psychotria* is put in a temporal framework and the evolutionary patterns within the group are inferred using diversification rate analysis. These analyses will provide clues on the influence and importance of leaf nodulation on the evolution of *Psychotria* species and the possible benefits of bacterial leaf symbiosis.



## PHYLOGEOGRAPHIC STUDY OF THE TROPICAL AFRICAN TREE *STAUDTIA KAMERUNENSIS* USING NEWLY DEVELOPED MICROSATELLITE MARKERS

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Despite the high levels of tree biodiversity in African rainforests, current logging is mainly focused on a selected number of tree species, which causes these species to be under high pressure. To facilitate the conservation and regeneration of these valuable timber species, knowledge on the genetic population structure is extremely valuable.

In the current study, the genetic structure of *Staudtia kamerunensis* populations from Central Africa was analyzed with a set of newly developed microsatellite markers. The software QDD v2.1 was used to detect microsatellite loci of interest and to select suitable primers from a microsatellite enriched genomic library of *Staudtia kamerunensis*. Selected primers were then tested with different PCR conditions to ensure DNA amplification and readability after which polymorphic loci were retained and combined in multiplexed reactions using Multiplex Manager 1.2. Multiplexed reactions were carried out on populations from Cameroon, Gabon, Republic of the Congo and Democratic Republic of the Congo. Allele lengths of the different loci were analyzed with Peak Scanner Software 2 and Geneious 9.1.6.

Heterozygosity levels, allele frequencies and the number of alleles were then used to assess genetic diversity within and between populations and clustering analyses were carried out with Structure 2.3.4 and the *adegenet* package for the R software. Finally, these results were discussed in a historic climatological and biogeographical context.

## DIVERSITY ESTIMATES AND POPULATION STRUCTURE IN GLOBAL *CAMELUS DROMEDARIUS* POPULATIONS THROUGH GENOME-WIDE DDRAD SEQUENCING

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Mitochondrial panmixia and little population structure based on 18 microsatellites characterize the global dromedary populations. We adopted the recently released reference genome drafts as templates for a double - digest genome-wide Restriction site Associated DNA (ddRAD) sequencing approach, to screen for a potential more fine scale population structure in 120 dromedaries from 19 African, Arabian and Asian countries. This technology has the major advantages of not requiring substantial prior knowledge of both genome sequence and variability, while achieving per-site and per-individual costs below that of current SNP chip technology.



Over the 120 animals, we screened 200k genomic regions for each animal, at a theoretical coverage of 6X. From an initial set of 88K SNPs, we obtained 53K SNP genotypes after stringent filtering for a minor allele frequency (MAF) of 0.05 and locus missingness of 0.25 using PLINK. Similar to the previous study using microsatellite data on a global sample set, we could not find clear population structure, neither using STRUCTURE nor principal component analysis implemented in ADEGENET. However, we detected admixture and introgression of Bactrian camels in dromedaries from Kazakhstan and Iran. Further demographic analysis and selection tests are still on-going. This population genomic study will hopefully open the way to a larger collaborative effort for a more comprehensive characterization of the relationship between genetic and phenotypic diversity in the *Camelus dromedarius* species.



## SUGAR LOAF LAND IN SOUTH-EASTERN BRAZIL: A TROPICAL HOTSPOT OF INSELBERG PLANT DIVERSITY

Luiza F. A. de Paula<sup>1</sup>, Luísa O. Azevedo<sup>2</sup>, Luana P. Mauad<sup>3</sup>, Leandro Cardoso<sup>3</sup>, João Marcelo A. Braga<sup>3</sup>, João Renato Stehmann<sup>2</sup>, Ludovic Kollmann<sup>4</sup>, Cláudio N. Fraga<sup>3</sup>, Stefan Porembski<sup>1</sup>, Rafaela C. Forzza<sup>3</sup>

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Identification of the ecological and evolutionary processes that affect the biodiversity of ecosystems is a central problem in biology. Over the last few decades, the study of islands has advanced our understanding regarding questions related to the factors affecting biodiversity, especially aspects of evolution and speciation processes, providing insights about naturally fragmented habitats. Granitic and gneissic rock outcrops, known as inselbergs, form climatic, hydrological and pedological contrasts with surrounding landscapes, are considered as terrestrial islands, and are located in both temperate and tropical regions. Monocot mats occur on open rocky slopes, forming “cradle” habitats on these outcrops, and can be considered good models for studies of biodiversity issues. The Brazilian and Malagasy inselbergs have species-rich mats with high numbers of endemics, in contrast with the West African inselbergs which have a much lower percentage of endemics and richness. The Bromeliaceae species stand out as characteristic elements in the Brazilian communities, and seem to influence the high plant diversity on these rock outcrops. For the first time we have provided a checklist of mat-forming bromeliads on inselbergs in Brazil. We have also investigated whether the regional species-pool influences species diversity of mats, in order to shed light on the factors influencing diversity. Furthermore, through modelling analysis, we have looked for the potential distribution of bromeliads endemic to inselbergs, expecting that they would show a narrower niche width when compared to non-endemic species.

Our data indicate the existence of a particular phytogeographic region in the Atlantic Forest in south-eastern Brazil, comprising inselbergs harbouring a highly diversity of Bromeliaceae, which we have christened *Sugar Loaf Land*. In addition, our projections have revealed smaller predicted areas for bromeliads endemic to inselbergs compared to non-endemic species, the former seems to be mainly controlled by climatic factors. In addition to climatic and regional species pool factors, the island-like character of inselbergs seems to play an important role in the speciation of rupicolous Bromeliaceae.

## STRUCTURE AND DYNAMICS OF PLANT DIVERSITY IN DONG NA TARD PROVINCIAL PROTECTED AREA, LAO PDR

Somphong Chanthavong<sup>1</sup>, Inocencio Jr Buot (speaker)<sup>2</sup>

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The spatial distribution of plant diversity in Dong Na Tard Provincial Protected Area (PPA) has not been accurately documented yet. This study was conducted to assess and evaluate plant species and its correlation with environmental variables. Fifty-four plots measuring 10 x 10m each were established.

Results revealed seventy species belonging to thirty-three families of plants in the study site. Cluster analysis indicated six forest zones which were classified based on Relative Basal Area (RBA) of dominant species. The six zones were, Zone 1- Dipterocarpus-Afzelia-Diospyros zone, Zone II- Artocarpus-Ziziphus-Dipterocarpus zone, Zone III- Dipterocarpus-Irvingia-Dialium zone, Zone IV- Dipterocarpus-Anisoptera-Solanum zone, Zone V- Dipterocarpus-Dipterocarpus-Syzygium zone and Zone VI- Tectona-Eucalyptus plantation zone. The species structure in each forest zone was significantly influenced by slope, elevation, human disturbance, and distance from the main road. Dipterocarp species were the most dominant.



## ORIGIN OF THE GUIANESE DARK EARTHS: AN ANTHRACOLOGICAL APPROACH

Stéphanie Bodin<sup>1</sup>, Jean-François Molino<sup>2</sup>, Laurent Bremond (speaker)<sup>1</sup>

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Numerous studies in the Amazon basin have shown that human impact on the forest was much larger than we thought and questioning the concept of “virgin forest”. This impact is still perceptible in some places in terms of forest species composition and soils, resulting for example in a higher occurrence of palm trees and crops and the presence of rich black soils with numerous charcoals and high content of organic matter. These soils are known as Amazonian Dark Earths, or *terra preta*. If the studies are quite numerous in central and western Amazonia, there are rare in

French Guiana. However, traces of pre-Columbian activities are frequent with thousand of pre-Columbian raised fields surrounded by ditches located in the coastal zones of the Guianas or ring-ditches mountains in the forest. Also, useful species are found which are potential indicators of past human land use as *Bertholletia excelsa* (Brazil nut tree).

The object of the project is to define the impact of the pre-Columbian activities on the structure and composition of the forest using the identification of wood charcoals. This will be done along soil profiles around archeological sites where dark earths are observed. The charcoals are representative of the ligneous flora that burnt on the site. They will be dated with <sup>14</sup>C radiocarbon measurements and will permit to identify the vegetal communities present and used by humans at this time. The charcoals assemblages will be discussed with other pedological bio-proxies (structure, micromorphology and phytolith contents) and present floristic surveys.

## THE IMMEDIATE IMPACT OF HURRICANE DISTURBANCE ON MONITORING BUTTERFLY AND ANT COMMUNITIES IN BELIZE, CENTRAL AMERICA

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Tropical rainforests are well known as centres for biodiversity. However, they are under pressure from both climate and land-use change. As such, monitoring biodiversity and investigating how populations use these changing landscapes is essential in informing effective conservation efforts in the face of these threats. Key to this is to assess how rainforest communities respond to both anthropogenic disturbances, such as logging and/or clearance for agriculture, and increasing occurrence of natural disturbance events such hurricanes.



Here we provide an account of the immediate impact of hurricane disturbance on fruit-feeding butterflies and leaf-litter ant communities of a lowland forest in Belize, Central America. We sampled butterfly and ant communities alongside vegetation structure two weeks prior and two weeks post the forest disturbance caused by Hurricane Earl hitting Belize in August 2016. We describe how the disturbance event impacted butterfly and ant diversity and community structure.

Though only a category 1 hurricane, Hurricane Earl caused disproportionate localized disturbance, with some forest areas experiencing ~60% tree damage. We show the hurricane disturbance had an immediate effect on the species community composition of both taxa, along with greater trapping rate post event. These results reveal novel information about the intimate relationship between insect community and habitat disturbance essential.

### Merian Award Applicant



## THINK GLOBAL! WHAT BIODIVERSITY INFORMATION STANDARDS CAN DO FOR YOU!

Patricia Mergen<sup>1,2</sup>, Franck Theeten<sup>1</sup>, Larissa Smirnova<sup>1</sup>, Kim Jacobsen<sup>1</sup>, Garin Cael<sup>1</sup>, Henry Engledow<sup>2</sup>, Quentin Groom<sup>2</sup>

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Biodiversity Information offers methods for organizing, accessing, visualizing and analyzing biodiversity related data. It concerns disciplines such as taxonomy, biogeography, ecology and has close links with molecular biology and bioinformatics.

Adhering to biodiversity information standards enables the sharing and compilation of data among users at a global scale. It also facilitates the analysis of trends and the application of modeling algorithms to the data. Biodiversity Information Standards ([www.tdwg.org](http://www.tdwg.org)) goes back to 1985 and was originally established to standardize taxonomic databases and enable better data exchange. Today TDWG has evolved to a modern data standards ratification body for biological and biodiversity related data. It has done this by developing, adopting and promoting standards and guidelines for the recording and exchange of data about organisms. It promotes the use of standards through the most appropriate and effective means and acts as a forum through the organization of meetings and through various publications.

We illustrate how large networks have implemented portals, applications and other services by using TDWG standards in their developments. Chosen examples are from the Global Biodiversity Information Facility ([www.gbif.org](http://www.gbif.org)) and the Group on Earth Observation –Biodiversity Observation Networks ([www.geobon.org](http://www.geobon.org)). Currently GBIF is sharing information about more than 620 million occurrences from 1.6 million taxa issued from about 30 000 different databases worldwide. GEO-BON and its European contribution EUBON ([www.eubon.eu](http://www.eubon.eu)) made substantial progress in the definition of the Essential Biodiversity Variables (EBVs) towards the implementation of the Aichi Targets as recommended by the Convention on Biological Diversity (CBD) (<http://data.geobon.org/>). Widely used standards are for example DarwinCore and ABCD (for Access to Biological Collection Data).

Using data standards facilitates the publications of data and peer-reviewed data papers. Participants can find out more during the workshop on how to publish data papers in tropical ecology on Friday the 10<sup>th</sup> of February in the afternoon.

## MATANG MANGROVE FOREST AS A CLIMATE CHANGE MITIGATION SYSTEM: A BECOMING REALITY

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There is a growing interest in mangrove forests because of the variety of ecosystem functions, goods and services they provide (e.g. buffer against coastal erosion, habitat for fish and shellfish, timber and non-timber forest products). Mangroves are the most carbon-rich forests in the world and have a high economic potential yet they are facing increasing anthropogenic threats.



Matang Mangrove Forest Reserve (hereafter referred to as MMFR) is located on the northwest coast of Peninsular Malaysia (State of Perak at 04°45'N, 100°35'E) and covers approximately 40000 ha along 52 km of coastline. A large part of the area is covered by *Rhizophora apiculata*, which is the most important mangrove species in terms of commercial timber in the Asia - Pacific region. This reserve is under silviculture management by the Perak State Forestry Department since 1902. More than 30000 ha are exploited for charcoal (in 30 year cycles) and pole production (in 20 year cycles) for national and international trade. After harvesting, the area is replanted with *Rhizophora apiculata* and *R. mucronata* seedlings. This management process in Matang involves a series of exploitation activities that emit carbon, whereas other natural processes result in carbon sequestration.

The objective of this study is to calculate the emission of carbon produced by the exploitation activities as well as calculating the carbon sequestered by MMFR mangroves (through a meta-analysis of vegetation growth data). The final result will indicate whether or not the carbon release is outbalanced by carbon sequestration. Preliminary results will be presented, including the relative importance of various management activities with regard to carbon emissions, and the method & findings for calculating carbon sequestration by the mangrove forest.

With this project we aim to enhance the understanding of the potential of mangrove forests as key systems in effective climate change mitigation.



## THE TOTAL ECONOMIC VALUE OF THE VIRUNGA NATIONAL PARK

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This paper estimates the Total Economic Value of the Virunga National Park and how it contributes to the community well-being. Using ecosystem approach, cost efficiency analysis, direct and indirect methods of valuation, we estimated the value from the main park's ecosystem services including fish from Edward Lake, clean water, hydroelectric potential, Semliki River, fauna and forest, land and tourism.

The estimate shows an annual Total Economic Value of \$US 1,257,344,675. This may rise up to \$US 2,819,314,810 if ecosystems are restored at their level of 1990. This value benefits to the local community Well-being is improved through clean water consumption, employment, fishing, illegal bushmeat, agricultural harvest, fire wood and charcoal from illegal logging in the park. Illegal activities are under the control of militia. Shouldn't the park exist, the poverty level could be worse than it currently is for riverside people. However, the park constitutes an opportunity cost for agriculture and oil exploitation. But the benefits from conservation are likely higher than this opportunity cost.

Beyond these figures, the park has unique assets which values are inestimable. These include notably Ishango archeological site which has treasures of an ancient civilization dated from 22000 years and the Universal Exceptional Value as a UNESCO world heritage site. Indeed, all its natural resources are not yet known and valued. It is the case of biodiversity and resources likely useful for biotechnology industry. The park has strong existence, option and bequest value in local and national public opinion which supports its conservation.

## ECOLOGY, ECONOMICS AND MANAGEMENT OF FOREST AND WOOD SECTOR OF SPECIES *ENTANDROPHRAGMA* IN AFRICA. A REVIEW

Emmanuel Kasongo Yakusu (speaker)<sup>1,2,3</sup>, Joris Van Acker<sup>2</sup>, Franck Monthe<sup>4</sup>, Olivier J. Hardy<sup>4</sup>, Corneille E.N. Ewango<sup>5,3</sup>, Nils Bourland<sup>1,6,7</sup>, Hans Beeckman<sup>1</sup>

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The species of *Entandrophragma* are the subject of special attention of the part of foresters and scientist for decades. Establishing a comprehensive updated review of knowledge about the ecology, economy and management of the exploitation of species *Entandrophragma* is the aim of this literature review. Possible prospects to new research in African forests are proposed. This genus account of exploited species in Africa for the timber they provide to the market. However, few studies exist regarding the ecology, the wood technology, the tree-ring analysis, the dynamics and the forestry of *Entandrophragma*. Therefore, the current knowledge on its forest management is still insufficient while *Entandrophragma angolense*, *Entandrophragma candollei*, *Entandrophragma cylindricum* and *Entandrophragma utile* are considered "vulnerable" by the IUCN Red List.

To improve the understanding of *Entandrophragma* ecology and dynamics, studies should be conducted in the areas of: plant geography and spatial distribution, genetics and phylogenetics, phenology and the growth rate, anatomic characterization and variability, X-ray CT densitometry, dendrochronology and tree-rings analysis, forestry and natural regeneration, the carbon stock and stable isotopes and other themes not yet explored. Based on this enhanced knowledge, recommendations adapted to these species could ensure their sustainable exploitation.



## THE ROLE OF LIANAS FOR THE CARBON CYCLE IN THE TROPICAL RAINFORESTS OF THE CENTRAL CONGO BASIN

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Recent years have seen a heightened interest for liana studies in tropical forests. Current observations are pointing to the fact that liana abundance and biomass are increasing in South American tropical forests. Should this trend persist, there are worries that the composition and functioning of tropical forest ecosystems could be greatly impacted. It is believed that liana proliferation may entail a severe reduction in the carbon mitigation potential of tropical forests in case it results in excessive tree mortality and gap formation. The role of lianas in the climate response and carbon cycle of tropical forest ecosystems should therefore be taken into account when predicting climate change. This necessitates the integration of knowledge from community ecology into vegetation modeling work. Unlike in the Amazon basin, lianas are poorly characterized in the Congo basin. Not only little is known about liana biology and ecology in this region, field-based data on lianas in terms of carbon stock and underlying nutrient cycles are almost inexistent.

The present study intends to fill this gap. It aims to quantify the importance of lianas for the carbon cycle in the tropical forests of the Congo basin. More specifically, the study will focus in characterizing the structure, composition and dynamics of liana assemblage in lowland and montane forests of the Congo basin, elucidating the role of lianas in the carbon cycle of lowland and montane forests in the Congo basin, and validating a vegetation model that incorporates lianas as a key driver of tropical forest responses to climatic change. In this poster the setup of this study will be presented.

## THE SEASONAL AND DIURNAL RESPONSES OF SAP FLOW IN LIANAS AND TREES AND THEIR CONTRIBUTION TO STAND SCALE EVAPOTRANSPIRATION

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After the intriguing discovery of vast liana abundancy and biomass increase during the last decades in the neotropics, research efforts to describe the importance and the causal agent of this liana proliferation are advancing. Many researchers are convinced that this proliferation is linked to changing tropical ecosystem conditions due to climate change and various other anthropogenic disturbances. Considering this claim, lianas will potentially become even more dominant in the future, bringing along various unknown and potential unwanted consequences on the functioning of the tropical forest biome. Despite the fact that several explanatory hypotheses have been proposed, still the dominant underlying mechanism of this phenomenon is currently unknown. Perhaps the most popular explanation in this context are the distinct hydrological traits found in lianas, which might give them a competitive advantage under altered climatological condition, i.e. droughts.

This study describes the results of an extensive sapflow monitoring campaign on various lianas in the Paracou field station (French Guiana) spanning a time period of 1 year (10/2015-10/2016). Lianas of various diameter sizes, i.e. 9 - 13 - 25 - 30 and 50 mm, are equipped with EXO-skin sapflow sensors measuring at a time frequency of 30 minutes. Granier sapflow sensors are installed on the surrounding trees and on the biggest lianas, allowing a tree-liana comparison. The sensors are installed in the vicinity of the Paracou fluxtower that observes stand scale evapotranspiration. In addition meteorological variables such as rainfall, temperature, solar radiation and soil moisture content are monitored.

Our results show how lianas and trees respond to diurnal and seasonal fluctuations in meteorological conditions and how both growth forms contribute to the stand scale evapotranspiration.

Our dataset exposes similarities as well as dissimilarities in sapflow responses to drought between lianas and trees, but also among lianas with different diameters. Linking sapflow data with the meteorological data provides insights in the various drought strategies of the vegetation. Additionally, our setup of measuring various liana diameter classes allows to explore upscaling strategies from individual plant level (liana/tree) to stand level. This multiscale dataset will be used for vegetation modeling studies



## EFFECT OF DECREASING STREAM FLOW ON AQUATIC INSECT BIOMASS IN TROPICAL STREAMS

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Climate change is expected to impact Hawaii with drier and hotter days. Rainfall is anticipated to decrease resulting in decreased stream flow. Stream ecosystems are very important as they host many aquatic organisms. One component of stream ecosystems is aquatic invertebrates. Aquatic insects are important, as they are a food resource for native birds, bats and fish. They also contribute to biodiversity in the streams, as most of the insects in Hawai'i are native. Insects need the stream to move food resources downstream, create oxygen in the water, and overall provide a healthy habitat.

This study was conducted to show how the effects of decreasing stream flow effects aquatic insect biomass. Samples analyzed were previously collected in the year of 2012, using a surber sampler net. They were picked out of any substrate, identified, dried, and then weighed. The five most dominate species were analyzed, *Cheumatopsyche*, *Chironomidae*, *Hydrachnoidea*, *Cyclopidae*, and *Erinna*. A length-mass regression was used to determine biomass in two steams located on Hamākua, Hilo Hawaii. The first stream Kolekole with the most rainfall of 7,400 mm of rain/year and the second stream is Ka'awali'I with 400 mm of rain/year. After running a length-mass regression to determine total biomass, it was proven that there is a significant difference in biomass as stream flow decreases with a p-value of 0.05. Because there is decreasing biomass as stream flow decreases, stream organisms could potentially be influenced.

## GUT CONTENT AND ANATOMY IN TERMITES: AN INSIGHT INTO THE APICOTERMITINAE ASSEMBLAGE RULES

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The diet of soil-feeding termites is based on the acquisition of nutrients from surface mineral horizons. Species feed at different levels along the gradient of organic matter humification, playing an important role in the recycling of nitrogen and other nutrients. Here, we examine this issue from the termites' side, focusing on how Apicotermitinae species are distributed among dietary niches.

We studied the relationship between fore – mid – hind gut structures and gut content. We carried out morphometric measurements of crop and gizzard, mesenteron and first proctodeal section (P1) using a mathematical projection of those structures in image analysis software (FIJI).

Our preliminary results reveal a similar and important storage capacity of the crop/gizzard among all genera of Apicotermitinae with soldiers, differing from soldierless species. The latter tend to store a small and variable volume of soil in their crop/gizzard complex, while genera of Apicotermitinae with soldiers store large volumes of mineral-containing soil. Using a simple microscopic analysis of crop/gizzard content, we exposed the heterogeneity of stored material (organic or non-organic) which highlights soil microsite selection by different termite species.



## THE ASSOCIATION OF ANT-FOLLOWING BIRDS AND ARMY ANTS (DORYLUS SPP.) IN THE LOWLAND RAINFOREST OF KORUP NATIONAL PARK, CAMEROON (WESTERN AFRICA)

Janina Schäfer<sup>1</sup>, Matthias Waltert<sup>1</sup>, Marcell K. Peters<sup>2</sup>

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In the light of rainforest loss, habitat fragmentation and degradation, the strength of the association of possible obligate ant-following birds and their hosts on the African continent has to come into focus, since terrestrial bird species and especially ant followers are the guild most threatened to forest modification. In Africa, army ants associated with birds belong to the subfamily Dorylinae, subgenus *Anomma*, also referred to as driver ants. Basis of the association is the swarming behavior of army ants when going on a collective foraging raid. Some bird species have evolved

an exploiting-behavior to this foraging-type. They feed on both prey flushed and potential ant prey, making this association a parasitical interaction.

In 2016 in Korup National Park, Southwest Cameroon, distance sampling with combined line transects and point counts was conducted to give a general overview of understory bird abundance. In addition, bird flocks at army-ant swarms were observed to identify actual ant-following species. Finally, general abundance and abundance at army-ant swarms was then used to generate an index of specialization. 21 species were identified following ant raids of which at least five show a specialization. Bird flocks consisted of one to ten species, but were of rather small size compared to studies from Kenya (Africa) and South American countries. First explanatory approaches for this potential anomaly include the influence of the El Niño events in 2015/2016 and forest dynamics due to climate change.

### Merian Award Applicant

## TRAP NESTS FOR HYMENOPTERA: PAST, PRESENT, AND FUTURE OF A STANDARDIZED SAMPLING METHOD IN (TROPICAL) ECOLOGY

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Trap nests are man-made structures consisting of elongated cavities used to study cavity-nesting Hymenoptera such as Megachilidae bees or Eumeninae wasps and their interactions with their natural enemies. Since trap nests appeared first in science in the 1950s, the number of studies using trap nests as standardized sampling method has increased exponentially. Originally mostly used for conducting detailed natural history observations, trap nests are now also an established and valuable method to evaluate the quality of a habitat for insect diversity and functioning based on trophic interactions.



We synthesize the more than 400 trap-nest studies available in the ISI Web of Science™. Many of these studies are from tropical and subtropical ecosystems, but the geographical coverage is very irregular. Over 30% of all studies have been conducted in Brazil alone, while Africa and most of tropical Asia have not been investigated at all. We provide an overview how the study questions addressed with trap nests vary with study location and how they have evolved over time to identify further topics and questions for which this method can be useful. Based on our long experience, we also identify several common challenges researchers may encounter when using trap nest in tropical ecosystems and explain practical solutions to overcome those challenges under field conditions.

### Merian Award Applicant



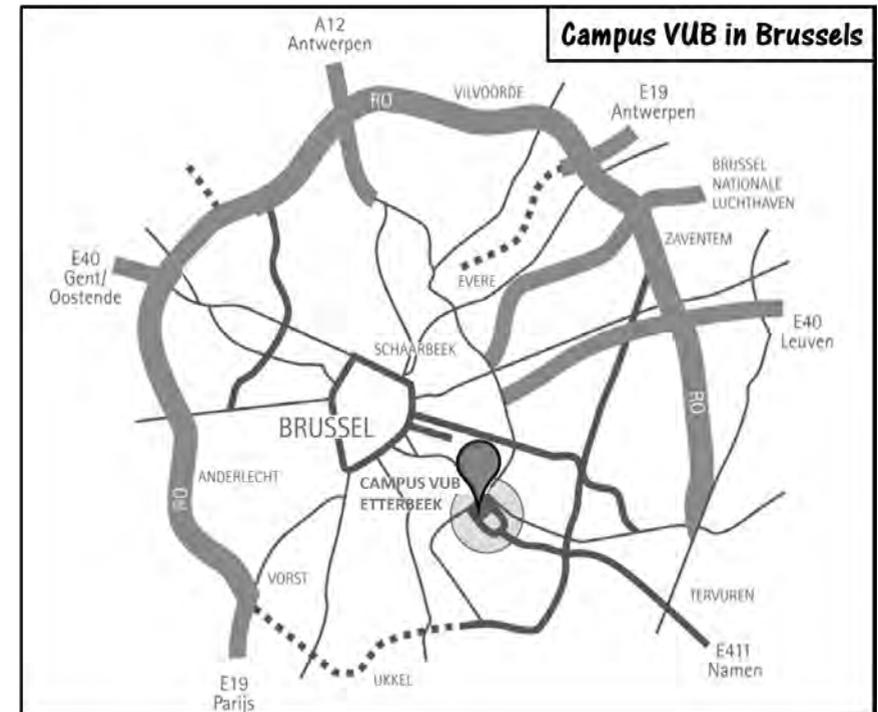
# INFORMATIONS FOR PARTICIPANTS



## ALL ABOUT THE CONFERENCE

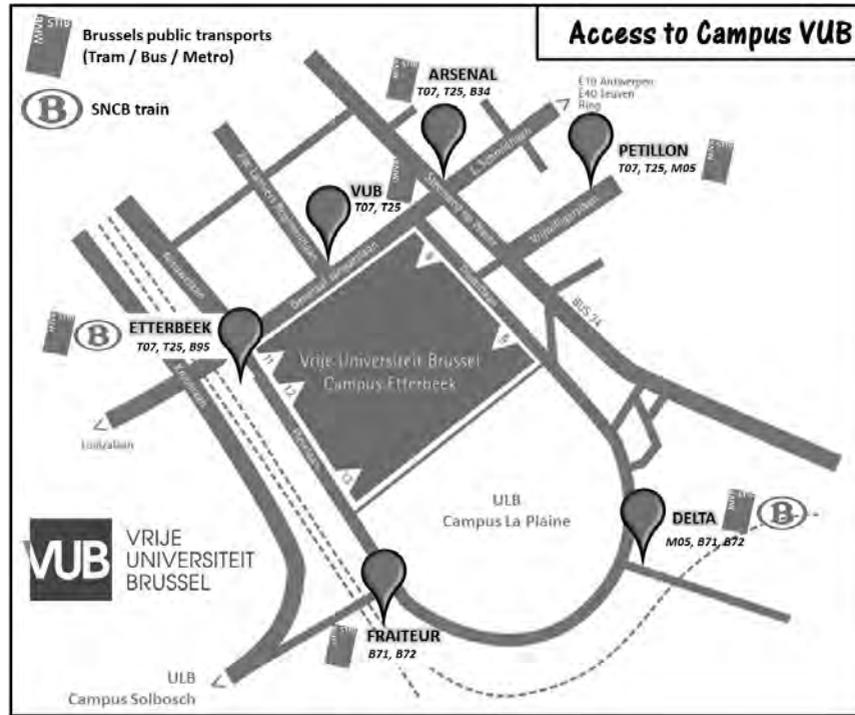
### VENUE - CONFERENCE CENTRE

→ The conference centre is located in the Vrije Universiteit Brussel (VUB) – Campus Etterbeek, Registration desk in Building D, level 02, 2 boulevard de la Plaine / Pleinlaan, 1050 Brussels. GPS coordinates (WGS84): Lat. 50.821579 / Long. 4.394752



- The companies that manage the public transport system in Brussels are:
- **STIB/MIVB** for metros, trams and buses within the Brussels city limits, plus some Airport bus to Brussels Zaventem airport (line 12 or 21).  
Website: <http://www.stib-mivb.be/index.htm?l=en>
  - **TEC** and **DE LIJN** for buses to Wallonia and Flanders, respectively,
  - **SNCB/NMBS** (Belgian Railways) for trains: the main stations within Brussels are called Midi, Central, Nord, Schuman, Luxembourg. Station Etterbeek is very close to the conference venue. There are direct connections between the national airport (Brussels airport Zaventem) and each of these stations.  
Website: <http://www.belgianrail.be>
- STIB/MIVB tickets will be available in the Conference registration desk (Building D Level 02).





→ By **public transport**, the campus is easily reached using tram lines 7 or 25, the bus lines 34, 71, 72 or 95, the metro line 5, or the railway station Etterbeek.

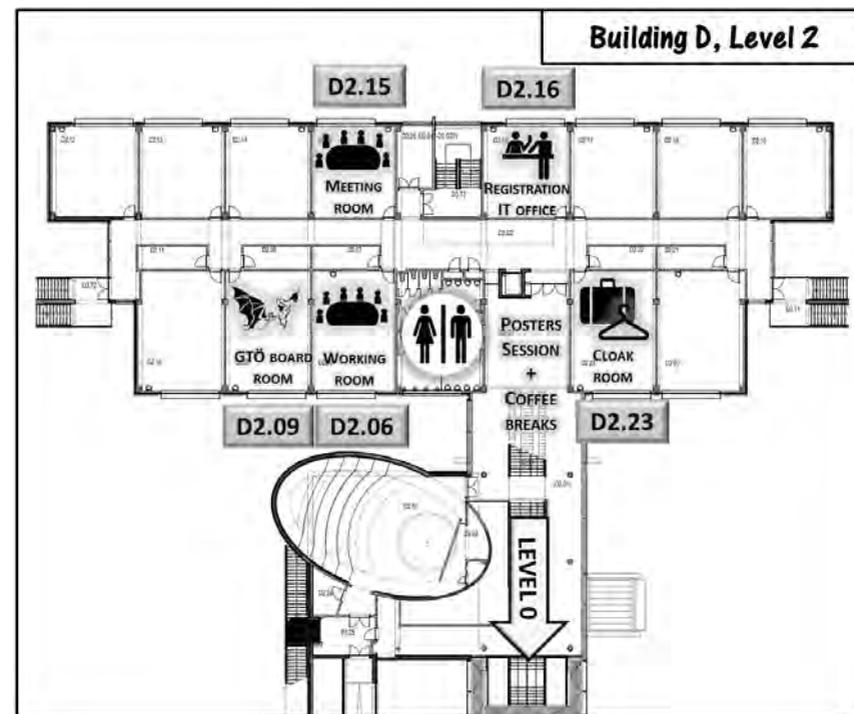
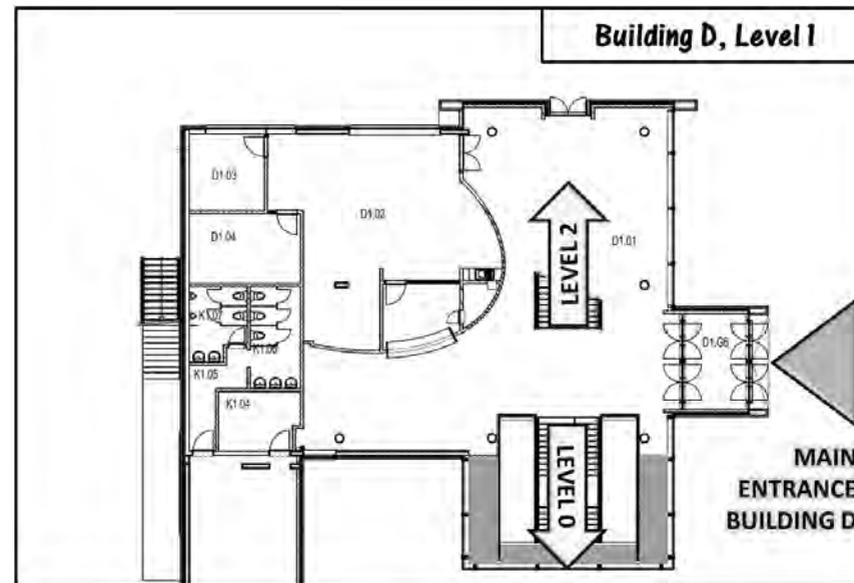
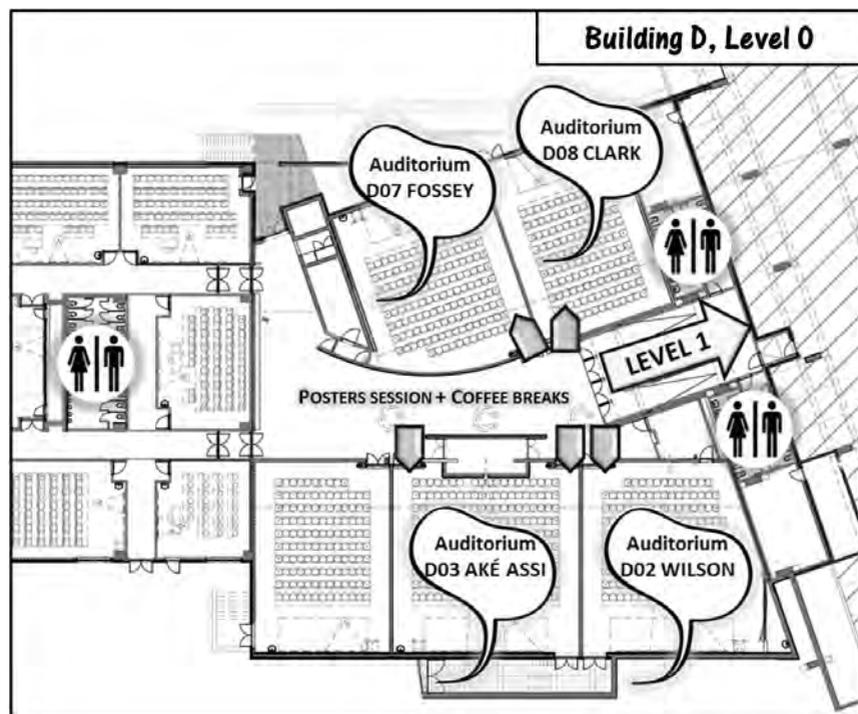
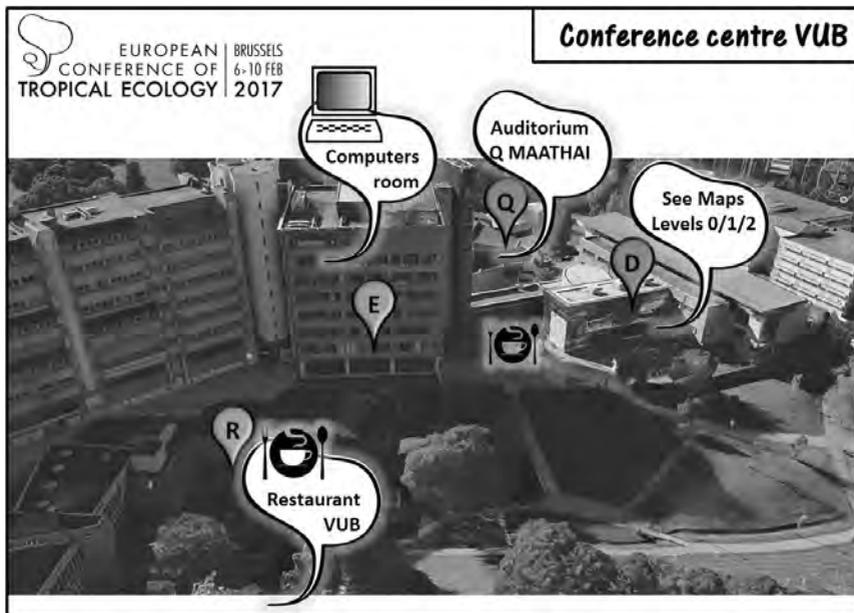
→ Access to the **VUB parking** (entrance 13) is possible, using the special barcode provided in your conference website space. But a sufficient number of places is not guaranteed, especially if you arrive late.

## ROOMS - CONFERENCE CENTRE

→ The conference centre is organized in four close buildings:

- Building D for registrations, the four parallel sessions, posters session, the welcome cocktail, coffee breaks, with also side rooms (cloak room, meeting/working rooms, gtö board room).
- Building Q for the opening and closing ceremonies, plenary talks, the public lecture, and gtö membership assembly.
- Building E for the computers room.
- Building R for the VUB restaurant, and especially the conference dinner party, lunch breaks (another snack is opened between buildings D and E).





## REGISTRATION DESK

- The registration will be open from Monday, 6<sup>th</sup> February 10:00 until Friday, 10<sup>th</sup> February 14:00 in Building D Level 2 (room D2.16, follow the arrows).
- Conference fees and additional bookings at the registration desk can be paid in cash and credit card (Master/Visa). Possibility also to buy lunch (VUB restaurant) and STIB/MIVB (bus, tram, metro) tickets.

## TALKS & POSTERS

- For **talks**, there will be 15 min for each speaker (12 min + 3 min discussion). Please make sure to respect this time period. It will not be possible to use your own computer. Please make sure that your PowerPoint presentation can run on a Windows computer, and prepare a PDF presentation to be sure...
- The **IT-Office** will be located in the registration desk in Building D Level 2 (room D2.16). Speakers, please provide memory stick to our staff in charge of uploading presentations in the IT Office at registration time Monday from 10:00. This allows us more time in case problems should occur. Speakers who might not plan to attend on Monday and are scheduled for a later date, please provide your presentation upon arrival to our staff at the IT Office. Please arrive latest 2 hours before the start of your session.
- **Posters** should be on display from 14:00 on Monday 06 February 2017 until the end of the Conference on Friday 10 February 2017, posters should be removed on Friday by 14:00 as remaining ones will be disposed. We will provide a map to indicate where to put your poster (building D, level 0 or 2), and material to fix it. Authors are expected to attend their poster at the scheduled time slot on Tuesday, 7<sup>th</sup> February from 16:00 to 18:30.

## CLOAK ROOM

- You may store your **luggage and clothes** in a room in front of the registration desk in the Building D Level 2 (room D2.23). Please be aware that the university cannot take responsibility for any loss.

## INTERNET ACCESS & COMPUTERS ROOM

- You can access the internet via the wireless networks of the VUB. Two options are available:
  - (01) Eduroam: Eduroam allows students, researchers and staff from participating institutions to obtain internet connectivity across campus. For further information visit [www.eduroam.org](http://www.eduroam.org)
  - (02) VUB access: Guest accounts can be provided for conference participants in the registration desk.
- A **computers room** is available during all the conference, with 18 computers (Windows), in building E, level 1.

## MEETING & WORKING ROOMS

- Two working/meeting rooms are available in building D, level 2 (rooms D2.006 and D2.15). These rooms are opened to all the participants during the week.

## LUNCH FACILITIES

- At the **VUB restaurant** (building R) you can have a healthy meal at a very reasonable price, with a wide range of hot and cold meals, while the **cafeteria** is the place to go for snacks, sandwiches and drinks. The menu of the day, the light menu or the vegetarian dish always includes: soup, main course with chips, potatoes, mashed potatoes or rice, and a sweet of your choice. There are also a grill menu, a large salad bar and cold dishes. The restaurant intends to serve healthy food produced in an ecologically-sound manner, to promote fair trade, to save energy and reduce waste in its daily operation.

**VUB restaurant** free-flow: from 11:30 to 13:45.

**Cafeteria:** from 7:30 to 16:00.

Another **snack/café** is also open between buildings D and E.

- They accept the following **payment methods:** Cash, Bancontact, Meal vouchers and tickets available in the registration desk. You can withdraw money or recharge your card at the ING bank (at the Esplanade, near the conference centre).



# SOCIAL & SIDE EVENTS

DURING THE CONGRESS THERE WILL BE MANY OPPORTUNITIES TO MEET UP WITH COLLEAGUES...



## ALL ABOUT THE SOCIAL & SIDE EVENTS

### WELCOME RECEPTION

- **Monday, 6<sup>th</sup> February from 18:30 to 20:30**, in the VUB Etterbeek campus – Building D.
- Open to all participants!
- A **welcome cocktail** to break the ice between participants and discover some Belgian specialties...

### PUBLIC LECTURE & DEBATE

- **Tuesday, 7<sup>th</sup> February from 18:30 to 20:00**, in the VUB Etterbeek campus – Auditorium Q Maathai.
- **Open to everyone!**
- Short presentations and debate at the interface between science, conservation and sustainable management of African forest resources (detailed program at the beginning of this book, after plenary talks). Invited speakers: Jean-Louis DOUCET, Katharine ABERNETHY, Paul-Emmanuel HUET, Kasso DAINOU, Richard EBAA ATYI Hans BEECKMAN, Maaïke DE RIDDER (moderator).

### FREE AFTERNOON - GUIDED TOURS

- **Wednesday, 8<sup>th</sup> February from 13:30 to 17:30**. Departure from the Building D entrance, in several groups under the supervision of Helpers.
- Open to all the participants already registered! But can be adjusted in the registration desk if new places become available (limited number of places, 5 €).
- Guided tours in one of the following institutions.

#### → (01) Botanic Garden in Meise

Something is growing in Meise! The total area of the Botanic Garden is 92 hectares and holds 18.000 kinds of plants. In the Plant Palace, you can experience plants all around the world no matter what the weather is; from carnivorous plants to succulents... The Castle regularly houses exhibitions that can be viewed at no extra cost. In late winter or very early spring, you may discover the idyllic domain still in its snow cover giving a romantic atmosphere to the first flowers such as the crocuses or Daffodils emerging in a wide range of enchanted colours.

Guided tours will include:

- Round trip by bus until Meise,
- The magnificent castle with the view from the top on the whole domain,
- The public greenhouses coupled with the breeding greenhouses and possibility of a walk on the roofs,



- The seedbank,
- The herbaria collections and digitalization facilities,
- The library and the archives,
- A good way also to freely discover the most beautiful Belgian botanical garden...

### → (02) Royal Museum for Central Africa in Tervuren

The Royal Museum for Central Africa (RMCA) is known for being one of the world's most beautiful and impressive museums devoted to Africa. Since its founding in 1910, its task has been to preserve and manage collections, carry out scientific research, and disseminate knowledge to a wide audience through its scientific, educational, and museological activities. The RMCA plays an active role in the sustainable development of Africa, and aspires to be a centre for collaboration and reflection on today's Africa and the challenges it faces. Its collections, noted for their diversity, are of enormous scientific value and are unique in many ways. Large portions have been digitised and made available to researchers worldwide.

Even if the Museum will be still closed begin 2017 for renovation, it will be possible to explore:

- The wonderful park and arboretum, and the Colony Palace,
- The wood collection (one of the most important in the world), as well as taxonomic and geological collections,
- The human sciences and ethnology collections,
- A good way also to use one of the most beautiful historical tram lines between Brussels and Tervuren (STIB tickets provided)...

### → (03) Royal Belgian Natural History Museum in Brussels

This museum is located inside a public park located within the Leopold Quarter (European Quarter) of Brussels. The Museum galleries only display a fraction of the 37 million specimens conserved. That makes it one of the ten most important natural history collections in the world, as well as the largest in Europe after Paris and London. Treasures such as the Bernissart Iguanodons, the Spy Neanderthals, the Dautzenberg shell collection, the four fragments of moon rock, the thylacine (Tasmanian wolf), and Baron De Selys Longchamps' insect collections are unique in the world.

Guided tours of the following Museum collections will be organized: entomology, recent invertebrates, recent vertebrates, anthropology, palaeontology and geology (STIB tickets provided).

## VISIT OF BRLU HERBARIUM

→ **Thursday, 9<sup>th</sup> February from 17:30 to 19:00.** Several departures from the Building D entrance, in several groups under the supervision of Helpers. The herbarium is located in the Campus ULB La Plaine, just a 10-minute walk from the Conference venue.

→ REGISTRATION MANDATORY IN THE REGISTRATION DESK.

→ The African herbarium of the Université Libre de Bruxelles (international acronym: BRLU) was founded by Paul DuVigneaud in 1948. BRLU is one of the very few University herbaria still active in Belgium. BRLU keeps ca. 250,000 plant specimens (of which > 450 type specimens). The collection is focused on Central Africa, especially D.R. Congo, Gabon, Cameroun, Sao Tomé, Equatorial Guinea. One of the most original parts of the collection is the flora of copper-cobalt contaminated soil in Katanga, assembled by Paul DuVigneaud between 1948 and 1960.

In addition to dry specimens, BRLU holds a spirit collection of Orchids and a collection of silica-dried materials for genetic studies. The herbarium provides logistic support to all researchers at the Université Libre de Bruxelles who collect plant materials in Africa. The herbarium is recognized as a research unit of the Faculté des Sciences, developing its own research program. In particular, BRLU actively collaborates with the Missouri Botanical Garden (Saint-Louis, USA) on taxonomy and conservation of Orchids of tropical Africa.

→ Website: <http://herbarium.ulb.ac.be/>

→ Contacts: Geoffrey FADEUR ([gfadeur@ulb.ac.be](mailto:gfadeur@ulb.ac.be)), Tariq STEVART ([tstevart@yahoo.com](mailto:tstevart@yahoo.com)), Pierre MEERTS ([pmeerts@ulb.ac.be](mailto:pmeerts@ulb.ac.be)).

## CONFERENCE DINNER PARTY

→ **Thursday, 9<sup>th</sup> February, from 19:30 to midnight,** in the VUB Etterbeek Campus Restaurant (Building R).

→ We try to have got everything you need to throw a party unlike any other! Belgian and more exotic specialties in a very good atmosphere punctuated by animations, music and several surprises... **Another opportunity to meet all your new colleagues!**



## WORKSHOPS

- **Friday, 10<sup>th</sup> February from 13:30 to 16:30**, in the VUB conference centre (see below).
- Free and open to all the participants already registered! But can be adjusted in the registration desk if new places become available (limited number of places).

### → W01 = Spatial ecology and Biogeography – Auditorium D02 FOSSEY

Chair: Alice C. HUGHES

*Xishuangbanna Tropical Botanical Garden - Chinese Academy of Sciences, Mengla (China)*

Contact: [ach\\_conservation2@hotmail.com](mailto:ach_conservation2@hotmail.com)

Ecology is spatial! However though new tools have become available, many researchers are still have a limited knowledge of how spatial approaches can be incorporated into ecological studies to gain new perspectives on species ecology, evolution and conservation. The workshop will be a combination of lecture and discussion, showcasing the array of questions which can be answered using GIS approaches, and how we can tailor our research design to most effectively to integrate spatial approaches into our studies. The session will centre around species and ecosystems, and explore how we can effectively use spatial approaches and understand how species ecology and physiology can be built into spatial analyses, and species distribution modeling approaches.

Participants should expect to broaden their understanding of the array of applications spatial analysis and modeling can be applied to, how to build studies and ask interesting questions; and how to develop those studies and select appropriate data.

No prior experience of GIS is necessary as we will focus on questions, experimental design and development, and though we will discuss spatial ecological approaches in a number of smaller thematic groups laptops are not essential to this session.

### → W02 = How to publish a Biodiversity Data Paper in tropical Ecology? – Computers room E1

Chairs: Patricia MERGEN

*Botanic Garden Meise, Meise (Belgium) Contact: [patricia.mergen@plantentuinmeise.be](mailto:patricia.mergen@plantentuinmeise.be) / PENSOFT*

*PUBLISHERS Contact: [penev\[at\]pensoft.net](mailto:penev[at]pensoft.net) / Urmas KÕLJALG, University of Tartu, Tartu (Estonia)*

*Contact: [urmas.koljalg@ut.ee](mailto:urmas.koljalg@ut.ee)*

In the framework of the EU project “Building the European Biodiversity Network” (EU BON), which is the European contribution to the Group on Earth Observations Biodiversity Observation Network (GEO BON), pre-existing tools and standards have been improved to cope with the challenges of data mobilization, sharing, description and publishing.

The workshop will give an overview about the main tools used in the framework of the EU BON project, with selected examples of datasets from tropical regions. The tools presented will be the GBIF IPT (Integrated Publishing Toolkit), which is an open source software widely used to publish and share biodiversity datasets on the Global Biodiversity Information facility and related networks. They are using for example the TDWG data standard Darwin Core extended for sample based data. Further tool is

(DEIMS): Drupal Ecological Information Management System, an extension of the Drupal content management system to facilitate the management and sharing of ecological data, particularly for the Long Term Ecological Research Network (LTER). The Biodiversity Data Journal (BDJ) and associated ARPHA publishing platform developed by the publisher Pensoft will be demonstrated. They enable to publish Data papers using directly the GBIF IPT system. Finally the Pluto F service will be presented. It is online service to create, record, manage, share, analyze and mobilize biodiversity data. Data types include ecology, taxonomy, metagenomics, nature conservation and natural history collections. It has been developed by the University of Tartu in Estonia. The main developers and training providers familiar with these tools will be present at the workshop and demonstrate them to the participants. There is a helpdesk and training material available to which the participants will have access, to test the systems with their own data as take home work, after having received extensive explanations and demos by the experts from the above mentioned networks. Particularly relevant to this conference are the 23 African GBIF Bid Grants for publishing Biodiversity data from 34 organizations from 20 African countries. They will make use of the tools and standards developed jointly by EU BON and GBIF.

The experts present at the workshop are involved in the mentoring program linked to these grants. Additionally, there are starting projects in the UNESCO Man and Biosphere reserves in Africa, where the applications of these tools will be tested to evaluate the economic value of the ecosystem services provided within such tropical protected areas. The Royal Museum for Central Africa, the Royal Belgian Institute for Natural Sciences and the Botanic Garden Meise, together with the Belgian Biodiversity Platform are particularly active in capacity building activities in African tropical regions.

### → W03 = What makes your CV stand out when you stay or leave academia? – Auditorium D03 AKÉ ASSI

Chair: Farid DAHDOUH-GUEBAS

*Université Libre de Bruxelles (ULB) / Vrije Universiteit Brussel (VUB) / KAOW-ARSOM, Brussels*

*(Belgium) Contact: [fdahdouh@ulb.ac.be](mailto:fdahdouh@ulb.ac.be)*

Present and offer a discussion forum to young researchers to discuss what are their current or future skills and qualities. We'll discuss more in particular: the academic career, grading systems, scientific publication strategies, conference presentations, awards, curriculum vitae design for academic and non-academic purposes (how to advertise your skills?), and time management.



# ALL ABOUT BRUSSELS



## ALL ABOUT BRUSSELS

### TRANSPORTS IN BRUSSELS

→ **Public transport:** Most public transport in the Brussels-Capital Region is organized by the STIB (Société des Transports intercommunaux bruxellois). The network includes metro lines, which connect the eastern and western districts of the city. Pre-metro lines (trams in the tunnels) complete the metro service. A great many metro lines also have above ground bus and tram connections. **Maps of the network** are available free of charge from the information service at the metro stations (available in the conference centre).

**Timetables:** 6:00 - midnight - Consult the timetables shown at the stops.

**STIB offices:** Koningsstraat / Rue Royale 76, 1000 Brussels, Info: 070 23 2000, Open from Monday to Friday: 8:00 - 19:00 & Saturday: 8:00 - 16:00.

**STIB's website:** [www.stib.be](http://www.stib.be)

**Traveltime by Metro from downtown (De Brouckère):** 7 min: Schuman (European district), 9 min: Merode (Cinquantenaire), 15 min: Roodebeek (Woluwe Shopping Center), 14 min: Louise (Shopping- uptown), 17 min: Roi Baudouin (Bruparck-Atomium), 19 min: Hermann-Debroux (Forêt de Soignes).

**Buying your ticket:** in the conference centre, in the various metro stations and at the STIB information offices, at many newsagents

**Fares:** single ticket JUMP: 2,10€ (purchased outside vehicle) / 2,50 € (purchased inside vehicle), 1 ticket STIB/SNCB: 4,20€, card for 5 journeys JUMP: 8,00€ (+ MOBIB basic = 5€), card for 10 journeys JUMP: 14,00 € (+ MOBIB basic = 5€), 1-day card JUMP: 7,50€, airport line - bus 12/21 - one way ticket: 4,50 € (1 journey purchased outside vehicle) / 6,00 € (1 journey purchased inside vehicle), airport line - train: one way ticket 8,60€ - return ticket 17,20€.

During the weekend, **nocturnal buses** link the key part of the city until 3:00 a.m.

→ **Bike renting:** Villo - Rent a bike everywhere in the city!

Website: [www.villo.be](http://www.villo.be)

→ **By foot:**

- Quartier Louise - Grand-Place: 15 minutes
- European district - Louise district: 25 minutes
- Louise district - Marolles: 5 minutes
- Marolles - Grand-Place: 10 minutes
- Sablon - Bois de la Cambre: 40 minutes
- Grand-Place - Sablon: 10 minutes



### → Taxis information:

Three elements make up the price of a taxi ride:

- the price per km (1,66 € or 2,70 € depending on whether the journey is inside or outside the 19 districts of Brussels);
- fixed charge: 2,40 € (4,40 € at night) ;
- the waiting time: 30,00 € per hour; certain companies charge reduced fares for journeys to the airport.

Tips and service are included in the price of the journey as shown on the meter, but a small extra tip is always well-received.

#### Brussels Taxi Companies:

- Autolux: Tel. (0)2 411 41 42
- Taxis Bleus: Tel. (0)2 268 00 00
- Taxis Orange: Tel. (0)2 349 43 43
- Taxis Verts: Tel. (0)2 349 49 49

## PRACTICAL INFORMATION

→ **Fire, medical emergency or ambulance in Belgium:** 100 and from a mobile phone: 112

In Belgium, local emergencies are organised under the free **100** number, which can be called for any accident or emergency to connect you to an operator who will arrange assistance and contact the emergency services. It works similar to **112** except that you need a SIM if you call via mobile (unlike 112).

**Police:** 101 | [www.police.be](http://www.police.be)

**Fire brigade:** 100 | [www.frcspb.be](http://www.frcspb.be)

**Red Cross ambulance:** 105 | [www.croix-rouge.be](http://www.croix-rouge.be) (French) | [www.rodekruis.be](http://www.rodekruis.be) (Dutch) | Help and intervention in case of disaster.

**Anti-poison centre:** 070 245 245 | [www.poisoncentre.be](http://www.poisoncentre.be) | 24/7 urgent medical aid and advice on drugs, medication, poisons and etc.

**Bank card lost or stolen:** Cardstop 070 344 344 and Mijn kaart | Belgium's national service can cancel bank and credit cards 24/7.

→ **Language:** There are three officially recognized languages: French and Flemish are the main languages; German is spoken by a small segment of the population and English is widely spoken.

→ **Clothing:** In February, bring warm clothes, and it is always a good idea to pack an umbrella and a rain coat.

→ **Electricity:** A.C. 220 volts - 50 cycles. Plugs are of the round 2-pin type.

→ Travel in Belgium presents very few **health problems**. The standard of care is extremely high; English is widely spoken by doctors and medical clinic staff and tap water is safe to drink. Citizens of the European Economic Area (EEA) are covered for emergency medical treatment on presentation of a European Health Insurance Card (EHIC), though they will be liable to pay a per-appointment fee as a local would. Citizens from other countries should find out if there is a reciprocal arrangement for free medical care between their country and Belgium. If not, health insurance is recommended for long stays.

→ **Pharmacies:** For minor self-limiting illnesses you might save a doctor's fee by asking advice at a pharmacy (apothek/pharmacie in Dutch/French). Most are open from about 8:30 to 19:00 Monday to Friday, plus Saturday mornings. At night or weekends ,duty' (wachtdienst/de garde) pharmacies charge higher prices. Use these websites to check which is open when: Belgium Pharmacies ([www.pharmacie.be](http://www.pharmacie.be) in French, [www.apotheek.be](http://www.apotheek.be) in Dutch) Search Pharmacie de Garde (French) or Apotheek van Wacht (Dutch).

→ **Phone country code:** 0032

→ **Banking hours, credit cards and ATM:** usually open Monday through Friday, 9:00 - 16:00. All major cards are usually accepted (Visa, MasterCard, American Express, Diners Club and Eurocard) as well as Traveler's Checks. ATM machines are available in all major cities.

→ **Post offices:** usually open Monday through Friday, 9:00 - 12:00 and 14:00 - 16:00. And open longer and on Saturday and for the Brussels Post Office (Avenue Fonsny Office at Brussels Midi Station). Stamps may be purchased at news stands, supermarkets and souvenir shops. Post boxes are red and marked „Poste“

→ **Shopping:** Store hours: Monday - Saturday, 10:00am - 6:00pm. Stores are closed on Sundays except in Brussels at the Gallerie St Hubert and gift shops near the Grand Place. Antique and flea markets are generally open on Saturdays and Sundays. Tax is always included in price.



## BRUSSELS WAY OF LIFE

Brussels, as the capital of 500 million Europeans, the „world city“ where 180 different nationalities mingle, making Brussels a cosmopolitan place with permanent links to the rest of the world...

→ **Belgium's culinary culture**, that you'll find served at many local restaurants, bistros and brasseries is especially represented by: Asparagus with Flemish Style, Croquettes, Eel (Paling / Anguilles), Fish Soup, Flemish Carbonades, Game, Gentse Waterzooi, Ham and Endive Gratin, Hutsepot, Meat Balls in Tomato Sauce (Boulettes), Moules Frites, Potjesvlees & Hennepot, Rabbit, Sole Meunière, Stoemp, Tomate Crevette, Trout, Vol-Au-Vent, without forgetting Belgian Fries, Sausages, etc. Belgium has one of the highest densities of Michelin-starred restaurants in Europe, although many Belgians' top favourite foods are also home-cooked comfort dishes and street-vendor snack foods. Just as the country is divided linguistically, it's also divided food-wise. Flemish cuisine has a strong Dutch influence, while Wallonian cooking is very similar to French foods with lots of rich sauces. When travelling around Belgium it sometimes seems that every village, town or city has its own typical specialty or dish. Most dishes are based around meat or fish, and top Belgian desserts are often rich pastries or decadent chocolates – and everything is usually washed down with wine or the national drink beer. All these typical dishes and products are notably described in this website:  
<http://belgium.beertourism.com/food/typical-dishes>

→ **Districts known for numerous and diversified restaurants:** around the Place du Châtelain (near Louise avenue), around the Place Sablon (near the historical centre, more touristic but very close to a beautiful park and church not far from the Grande Place), around the Ixelles Cemetery and the Flagey place (student districts near Etterbeek and Solbosch campus), around the Namur's door with the Matongé African district, around Place Jourdan (near the European district). See also:  
<http://www.resto.be/restaurant/bruxelles>.

→ **Belgian friteries**, and notably the best for us: Maison Antoine (Place Jourdan, 1040 Etterbeek = Near the Museum of Natural History; Website: <http://www.maisonantoine.be/>), Frit Flagey (Place Eugène Flagey, 1050 Ixelles). Fries are served as a side dish at bistros, brasseries and star restaurants or as a complete meal in one of the thousands of frite shops, locally called ‚frituur‘ or ‚friture‘. Sometimes they are nothing more than a shack or caravan on a market square others are worthy being called restaurants. Authentic Belgian fries are made from “Bintje” potatoes, fried twice in ox fat on different temperatures. Fries have become an essential part of Belgian heritage as well as a culinary sub-culture celebrated by thousands in Belgium each and every day.

→ **Drink a fresh beer:** It will come as no great surprise to anyone that Belgium is a great place to enjoy a good beer. We may not have the highest number of beers compared to the traditional beer countries but we offer an amazing diversity of beer styles, flavours and aromas. Enjoy!  
 Among others, you can visit in the historical center typical Belgian brasseries, even estaminet to discover the diversity of Belgian beers: Moeder Lambic Fontainas (8 Place Fontainas and 68 rue de Savoie); the Delirium Café (4 impasse de la Fidélité) and near the Floris Bar; the Poechenellekelder (5 rue du Chêne); A la Mort Subite (7 rue Montagne aux Herbes Potagères); the Brasserie Cantillon (56 rue Gheude)... Near the VUB and ULB Campus, around the Ixelles Cemetery district, you can also go to: L'Atelier, Le Tavernier, Café Belga (Flagey place)...

## TOURISM IN BRUSSELS

→ **Tourism information desks:**

- **visit.brussels - Brussels Info Place (BIP)**, rue Royale 2, 1000 Brussels, Tel. + 32 (0)2 513 89 40, e-mail: [tourist@visit.brussels](mailto:tourist@visit.brussels), [www.visit.brussels](http://www.visit.brussels), Open: Daily: 09:00 to 18:00. (Weekend and holidays included).
- **visit.brussels / European Parliament Tourist** - Town Hall of Brussels, Grand-Place, 1000 Brussels, Tel. + 32 (0)2 513 89 40, Open: Daily: 09:00 to 18:00. (Weekend and holidays included).
- **USE-IT info desk**, Galerie Ravenstein 25, 1000 Brussels, e-mail: [infodesk@use-it.be](mailto:infodesk@use-it.be), <http://brussels.use-it.travel>, Open: Monday to Saturday from 10:00 to 18:30. Special information and maps for young travellers!





# ACKNOWLEDGEMENTS



## ACKNOWLEDGEMENTS

- **Local organizing and scientific committee:** Olivier HARDY (ULB) - Chair, Jérémy MIGLIORE (ULB) - Coordinator/Secretary, Patricia MERGEN (RMCA & BGM), Farid DAHDOUH-GUEBAS (ULB & VUB & ARSOM/KAOW), Karolien VAN PUYVELDE (VUB), Marc KOCHZIUS (VUB), Jean-Louis DOUCET (ULg-GxABT), Maurice LEPONCE (RBINS), Steven JANSSENS (BGM), Erik VERHEYEN (RBINS), Yves ROISIN (ULB), Nico KOEDAM (VUB), Hans BEECKMAN (RMCA).
  
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Family name	First name	Organisation		E-Mail	Ref. Page
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