RESILIENCE OF TROPICAL ECOSYSTEMS – FUTURE CHALLENGES AND OPPORTUNITIES

Annual Conference of the Society for Tropical Ecology
(Gesellschaft für Tropenökologie e.V. – gtö)

ETH Zürich, April 7-10, 2015

IMPRESSUM

Editors
Chris J Kettle and Ainhoa Magrach
Ecosystem Management
Department of Environmental
System Science
Universitaetstrasse 16, CHN G75.1
ETH Zurich
8092 Zurich Switzerland

Cover Design
Wendy Martin
Front cover photo
Hirzi Luqman
Back cover photo
Zurich Tourism and ETH Zurich
Concept & Layout
roman.tschirf@gmail.com

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WELCOME AND FOREWORD

Dear Friends, Colleagues, Participants,

It is a great pleasure to welcome you all to the 28th Annual conference for the Society for Tropical Ecology, hosted by the Swiss Federal Institute of Technology, ETH Zurich and organised by the Ecosystem Management Group. In the last four years the conference has been hosted by Technical University of Munich (2014) University of Vienna (2013), University of Erlangen (2012) and University of Frankfurt (2011). Hosting the meeting in Zurich at the ETH represents the first time that the meeting has been held in Switzerland.

We hoped that our central location in European would help to attract a wide diversity and large number of participants. We are delighted that the 2015 meeting is one of the largest in recent years with over 300 participants. One of the key aims of this meeting was to raise the profile of the Society and especially the annual meeting to let you know that this really is the 'THE' meeting for Tropical ecologists in Europe. We hope to increase the number of international participants in annual meetings, and more importantly members to the Society to ensure an increasingly dynamic and successful Society and to enable the annual meetings to grow in strength and popularity.

We are all very aware of the rapid and dramatic impact that humans have on our planet. Many of us live in highly modified landscapes. Many tropical regions are still in a phase of transition where landscapes are changing at a rapid rate. These changes have local but also global impacts. As ecologists, conservation scientists, policy experts and students we all have a passion to see these changes made in a way that will create productive and resilient landscapes. The science presented at this meeting provides the state-of-the-art in this research and policy arena.

We urgue you to take advantage of this central location in the city of Zurich to explore and enjoy the many wonderful sights the city has to offer. We hope that you find this a highly inspirational scientific programme and this demonstrates to you both the high quality and friendly atmosphere of the annual meeting, making it an ideal event to showcase your work, network and develop new collaborative relationships.

We wish you the very best of times in Zurich.

Chris J Kettle

On Behalf of Local Organizing Committee
Chris J Kettle
Jaboury Ghazoul
Barbara Becker
Kentaro Shimizu
Claude Garcia
Michelle Grant

Dear participants,

welcome to the 28th annual conference of the **Society for Tropical Ecology - Gesellschaft für Tropenökologie (gtö)**. This conference is special in so far as it is the second hosted outside Germany. gtö was founded in Germany and established under German law as a non-profit organization. A few years ago the Board decided to make gtö more international. One step to achieve this is to have conferences outside Germany. The first one was held in Vienna in 2013 and now we meet in Zurich. Our conferences greatly benefit from international participation and we want to see the international importance of tropical ecology reflected by an increasing number of international gtö members.

The research on tropical organisms and ecosystems is facing great challenges and offering lots of opportunities and as far as the restoration of disturbed ecosystems is concerned there are both great risks and great hope. By putting this conference under the title: **"Resilience of Tropical Ecosystems: Future Challenges and Opportunities"**, we hope to provide an interdisciplinary platform for discussing these major challenges and future opportunities in tropical ecology, including the improved understanding of tropical biodiversity and the resilience of tropical ecosystems and learn novel approaches to understand and manage tropical biodiversity.

In addition to increasing our "internationality" we also hope more students and young scientists will become involved. Our aim is to make our annual conferences especially attractive and accessible for those early in their professional career in tropical ecology. For all participants, but especially for those younger ones, we try to keep conference fees as low as possible. gtö itself has only very limited financial means and so we are especially thankful to Chris Kettle of ETH Zurich as the coordinator of the local organizing committee for his creative and successful acquisition of external funds and of course we are grateful to our sponsors who greatly help us to achieve this important goal. We are proud to be hosted by ETH Zurich and thank ETH Zurich and the local organizers for all the work they have done to make this another important and successful event.

The Merian Award has been established especially for young scientists, and all our gtö members gain from a number of benefits. If you want to learn more about this, please refer to our homepage www.gtö.de.

If you are not yet a member of gtö, please join. And if you are a member, please become actively involved to help further develop our organization. At the members assembly, on Thursday the 9th of April, we will have the regular election of a new Board and we will vote on revised statutes. gtö members, please make use of your right to vote.

I am convinced, being hosted by ETH Zurich and with such a number of excellent speakers and sessions this will be a great international conference. Thank you for your participation and again, welcome to you all!

Prof. Dr. Manfred Niekisch
President of gtö

SOCIETY FOR TROPICAL ECOLOGY (FORMERLY 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 the study and understanding of all aspects of tropical ecology. A primary means toward this scope is through the organization of annual international congresses, usually four days in February in Central 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. In 2012, the Elisabeth-Kalko-Memorial-Lecture was established in memory of our former vice-president and highly esteemed colleague Prof. Dr. Elisabeth Kalko. The lecture is open to the public and is given in the language of the hosting city in order to establish a link between the society and the public.

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.
Merian Award: In 2001 the gtoe 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 highlights these contributions by publishing the abstracts. The gtoe has selected Maria Sibylla Merian as the patron of the Merian Prize 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 devil.

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 aren't a member yet just apply here.

The award ceremony takes place during the closing ceremony
Friday 10 April 15:30 - 16:00.

DETAILED CONFERENCE PROGRAMME

TUESDAY, APRIL 7TH

Registration
Registration starts from 10:00 am on Tuesday the 7th in the Main Building Hauptgebäude (HG) Foyer and Conference Office F 33.1.

Hauptgebäude (HG), Rämistrasse 101, 8092 Zürich, Switzerland.
See Map of Conference Venue on inside back cover.

13:30 Opening Ceremony

14:00 Plenary Session: Keynote 1 Prof Robin Chazdon Audimax 'Lemur 1'
14:45 Parallel Sessions

Sessions	S1 - PRESENT AND FUTURE ROLE OF MANAGED TROPICAL FORESTS, P. 40	S2 - SCENARIOS OF BIODIVERSITY FOR THE CONGO BASIN, P. 50	S3 - MODERN METHODS IN MONITORING TROPICAL ECOSYSTEMS, P. 56
Chairs	Ervan Rutishauser and Plinio Sist	Claude Garcia, Patrice Levang and Jean-Noël Marien	Jörg Bendix and Erwin Beck
14:45	**S1-O1: Plinio Sist** The Tropical managed Forests Observatory: a research network addressing the future of tropical logged forests	**S2-O1: Maxime Réjou-Méchain** Predicting forest composition across space and time in Central African forests	**S3-O1: Brenner Silva** RendezWUE in the forest - Using tower observations and remote sensing in the tropical mountain forest
15:00	**S1-O2: Ervan Rutishauser** Carbon sequestration in logged forests: some results from the Tropical managed Forests Observatory	**S2-O2: Pauline Gillet** State of the art on drivers of deforestation in the Congo Basin tropical forest	**S3-O2: Simone Strobl** Carbon and water relations of tropical trees in an Ecuadorian mountain rain forest - upscaling from the leaf to the tree level
15:15	**S1-O3: Angela Luciana de Avila** Forest recovery over 30 years following management interventions of different intensities in the Brazilian Amazon	**S2-O3: Stephan Pietsch** Resilience landscapes for the Congo basin	**S3-O3: Alexander Röll** Differences in transpiration among rainforest and transformation systems

15:30	**S1-O4: Philip Mundhenk** Long-term observation of post-intervention dynamics in a tropical moist forest in Surinam	**S2-O4: Eglantine Fauvelle** Models of change across the forest transition curve - Participatory modelling in the Congo Basin	**S3-O4: Gerhard Gerold** Water balance modeling in tropical catchments-results and problems in relation to scale and land management to assess water function resilience

15:45 Coffee Break

Sessions	**S1 CONTINUED**	**S4 - INTERACTION NETWORKS AND CONSERVATION, P. 78**	**S3 CONTINUED**
Chairs		Christopher Kaiser-Bunbury and Nina Farwig	
16:15	**S1-O5: Franziska Schier** Characteristics, structure and tree-species diversity of a tropical exploitation forest in regeneration - A case study from Gabon	**S4-O1: Christopher Kaiser-Bunbury** Mainstreaming network ecology in applied conservation	**S3-O5: Martyna Kotowska** Rainforest conversion in tropical lowlands increases seasonality of net primary productivity and lowers nutrient return to the soil
16:30	**S1-O6: Fritz Kleinschroth** Transience of logging roads in Congo Basin rainforests	**S4-O2: Gita Benadi** Mutualistic networks and community stability - a guide for empiricists	**S3-O6: Rico Fischer** Simulating tropical forest carbon stocks and fluxes in a changing world using an individual-based forest model.
16:45	**S1-O7: Nicolas Labrière** Ecosystem services in logged-over and natural forests: a case study from West Kalimantan, Indonesia	**S4-O3: Daniel Montoya** The restoration of species interaction networks	**S3-O7: Andre Velescu** Response of dissolved organic matter in ecosystem solutions to moderate N, P and N+P additions to a tropical montane forest in southern Ecuador

17:00	**S1-O8: Kai Timo Schönfeld** Resource efficiency in timber processing - a necessity for sustainable forest management in the tropics	**S4-O4: Bo Dalsgaard** Conservation biogeography: interaction networks matter	**S3-O8: Laura Sanchez Galindo** Litter mixture effects on microarthropod colonization and microbial biomass in the litter layer of a tropical montane rain forests in Southern Ecuador
17:15	**S1-O9: Alicia Ledo** Above-ground biomass assessment from long-term field data	**S4-O5: Ingo Grass** Identifying the relative importance of forest patch characteristics for bird guilds: a landscape-wide network approach	**S3-O9: Joshua Jones** Predicting Regeneration of the Brazilian Amazon Using a Process-based Model and EO data
17:30		**S4-O6: Matthias Dehling** The relationship between morphology and functional roles of species in interaction networks	**S3-O1O: Bernardo Flores** Blackwater floodplains and the resilience of Amazonian forests to fire
17:45		**S4-O7: Vojtech Novotny** Measuring herbivore host specificity in phylogenetic context: methods and examples from New Guinea rainforests	**Attention please: Session 3 is continued on Thursday at 14:15.** **See also: p. 23**

18:00 Poster Session 1 (Audimax and Poster Area 1)

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01-P01	Silvicultural interventions in a tropical mountain forest in Southern Ecuador - Dynamics of tree regeneration (p. 259)
01-P02	Thirty years after selective logging disturbance: are logging impacts still visible on anurans and their habitat? (p. 260)
01-P03	Impacts of grazing on biodiversity and stand dynamics of Ecuadorian Dry Forests (p. 261)
S2	**SCENARIOS OF BIODIVERSITY FOR THE CONGO BASIN**
02-P01	The ecological status of three species of priority non timber forest products around the Lobeke national park in Cameroon. (p. 262)
02-P02	How to achieve effective participation of forest communities in REDD+ mechanism in the Democratic Republic of Congo: Case of Measurement-Reporting-Verification (MRV) process (p. 263)

S7	**CONSERVATION GENETICS AND ECOSYSTEM RESILIENCE & GENOMICS**
07-P01	DNA Barcoding of Vascular Plants in Jambi, Indonesia (p. 288)
07-P02	Genetic diversity assessment on the regeneration of an endangered tropical tree, Shorea leprosula in Sabah Biodiversity Experiment (SBE) (p. 289)
S10	**SEED DISPERSAL**
10-P01	Interactions among frugivores and plants: comparing real-world networks to artificial fruit networks (p. 290)
10-P02	Long-term consistency in spatial patterns of primate seed dispersal (p. 291)
S11	**DROUGHT EFFECTS IN TROPICAL FORESTS**
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11-P02	Effect of drought on growth and biomass allocation of tree species from the Pacific dry forest of North Peru (p. 293)
11-P03	Lianas and trees show different responses to seasonal drought. (p. 294)
11-P04	Nonstructural carbohydrate use and allocation during drought in tropical tree seedlings (p. 295)
S12	**FREE SESSION**
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12-P02	Reconstruction of land use changes related to human impact during the late Holocene in SW Kalimantan NE Java based on pollen and dinoflagellate cysts (p. 297)
12-P03	Above- and below-ground carbon storage estimates for the largest peatland complex in Amazonia (p. 298)
12-P04	Why does the biota of the Madagascar region have such a strong Asiatic flavour? (p. 299)
12-P05	Indonesian Peat Swamp History: Environmental Dynamics and Human Impacts Inferred from the Sungai Buluh in Central Sumatra (p. 300)
12-P06	Exploring the complex network of the Amazon‘s water pump and flying rivers (p. 301)
12-P07	Detection of climate change in Lake Gahar region in Lorestan province of Iran as a subtropical region (p. 302)

19:00 Welcome Mixer

WEDNESDAY, APRIL 8TH

Registration from 08:00

08:15 Plenary Session: Keynote 2 Prof. Ahimsa Campos-Arceiz Audimax 'Lemur 1'
09:00 Parallel Sessions

Sessions	S5 - INTENSIFICATION OF TROPICAL AGRO-ECOSYSTEMS, P. 86	S6 - TROPICAL BIOCULTURAL RESILIENCE, P. 102	S7 - CONSERVATION GENETICS AND GENOMICS IN THE TROPICS, P. 114
Chairs	Christian Andres and Gurbir S. Bhullar	Maximilien Gueze, Manuel J. Macía and Victoria Reyes-García	Aline Finger, Sascha Ismail and Kentaro Shimizu, Soon Leong Lee and Michael Krützen
09:00	**S5-O1: Bea Maas** Birds and bats in tropical agroforestry landscapes - multitrophic interactions and crop yield	**S6-O1: Estela Quintero-Vallejo** Legacies of Amazonian Dark Earths on forest composition and dynamics in an Amazonian Bolivian forest	**S7-O1: Kevin Kit Siong Ng** Genome sequence and genome-wide polymorphism pattern of an important Southeast Asian dipterocarp, Shorea leprosula (Dipterocarpaceae)
09:15	**S5-O2: Miriam Teuscher** Diversity response of birds to enrichment plantings in oil palm plantations on Sumatra, Indonesia	**S6-O2: André Braga Junqueira** Anthropogenic soils influence plant cultivation and management by local Amazonian people	**S7-O2: Tomas Marques-Bonet** Great Ape diversity and Population history
09:30	**S5-O3: Patrick Cvecko** Leaf-tent architecture and first reported use of American Oil Palms (Elaeis oleifera) by Peters' Tent-making bat Uroderma bilobatum in Panama	**S6-O3: Carolina Levis** The distribution of domesticated species in Amazonian forests	**S7-O3: Michael Krützen** The Genomic Basis of Local Adaptations in Orang-utans

09:45	**S5-O4: Sarah H. Luke** Impacts of logging and oil palm plantations in Malaysian Borneo on stream environmental conditions and macroinvertebrate communities	**S6-O4: Eleanor Sterling** Biocultural resilience across land and seascape mosaics in Pacific Islands	**S7-O4: Jérémy Migliore** New genomic tools to explore the phylogeography of African rainforest trees

10:00 Coffee Break

Sessions	S5 CONTINUED	S6 CONTINUED	S7 CONTINUED
10:30	**S5-O5: Gurbir S.Bhullar** Can organic agriculture offer a suitable solution to sustain the tropical agriculture?	**S6-O5: Maximilien Gueze** Cultural change relates to forest tree diversity: the case of the Tsimane‘, Bolivian Amazon	**S7-O5: Mathias Scharmann** How can hybridising species remain distinct? Introgression among sympatric Nepenthes pitcher plants in Southeast Asia
10:45	**S5-O6: Wiebke Niether** Canopy openness and photosynthetic active radiation in different cocoa production systems in Alto Beni, Bolivia	**S6-O6: Catarina Jakovac** The ecology of „tired lands“: consequences of swidden-fallow intensification in the Amazon	**S7-O6: Boris Demenou** Phylogeographic insights on the origin of the Dahomey Gap, the long-term impact of forest fragmentation in a legume tree Distemonanthus benthamianus
11:00	**S5-O7: Eric Rahn** Classification of Arabica coffee agro-ecosystems in Mount Elgon, Uganda - A basis for trade-offs analysis	**S6-O7: Mar Cartró Sabaté** Oil spills ingestion by game species in the Peruvian Amazon	**S7-O7: Sonja Hassold** Are molecular identification techniques helpful to protect endangered rosewood species from Madagascar?
11:15	**S5-O8: Ainhoa Magrach** Pollination districts in Kodagu: coffee production, conservation and other benefits	**S6-O8: Nerea Turreira-Garcia** It‘s our forest too, - community monitoring for forest protection and peaceful dialogue in Cambodia	**S7-O8: Yanling Peng** Pleistocene climatic oscillations, not recent human disturbance, controlled the patterns of genetic diversity in Polylepis tarapacana

11:30	**S5-O9: Arne Cierjacks** Yield-diversity relationships in perennial crop fields of North-Eastern Brazil	**S6-O9: Rodrigo Cámara-Leret** Two-year participatory monitoring of extractivism in Brazilian Amazonia	**S7-O9: Natalie Breidenbach** Plant genetic diversity in tropical lowland rainforest transformation systems in Sumatra (Indonesia)
11:45	**S5-O10: Akanksha Singh** Maximize production, minimize space: Potential benefits of intercropping at high densities for okra farmers in Cameroon	**S6-O10: Francisco Benitez-Capistros** What does conservation mean? Galapagos experience and methodological perspectives	**S7-O10: Bekele Addisalem** Conservation genetics of Boswellia papyrifera (Del.) Hochst in Ethiopia, an economically important but threatened dry tropical forest tree
12:00	**S5-O11: Rafael E. Bernardi** Tree Cover Effects on Grasslands Productivity in Subtropical South America	**S6-O11: Logan Hennessy** Indigenous Peoples and Conservation in Guyana	**S7-O11: Claire Tito de Morais** Understanding local patterns of genetic diversity in dipterocarps: Implications for forest management and restoration.
12:15			**S7-O12: Aline Finger** The importance of gene flow for species resilience in fragmented landscapes

12:30	Lunch Break
12:30	Side event “Starting your research career – DFG funding programmes for early career researchers” Dr. Christoph Limbach, DFG Programme Officer’ F5 ‘Lemur 2’
13:30	Plenary Session: Keynote 3 Prof. Jane Hill Audimax ‘Lemur 1’
14:15	Parallel Sessions

Sessions	S5 CONTINUED	S8 - DIPTEROCARP ECOLOGY, P. 128	S9 - APPLIED CONSERVATIONS, P. 138
Chairs		Francis Brearley, Philippe Saner	Ainhoa Magrach and Emma Morgan
14:15	**S5-O12: Carola Paul** Agroforestry, coarse-level mixing of trees and crops or monocultures? Land-use decisions under uncertainty	**S8-O1: Philippe Saner** Soluble sugars and their response to a changing abiotic environment in dipterocarp seedlings	**S9-O1: Priya Davidar** The Asian elephant (Elephas maximus L) in southern India: a local success is not a license to kill
14:30	**S5-O13: Sarah Scriven** Oil palm plantations may act as barriers to the dispersal of tropical forest species	**S8-O2: Christopher Philipson** Spatial variation in density-dependent recruitment of Parashorea tomentella during low intensity flowering in Borneo	**S9-O2: Maholy Ravaloharimanitra** Lemurs, habitat requirements, and ecosystem resilience: Community-based monitoring for conservation in eastern Madagascar
14:45	**S5-O14: Lindsey Norgrove** Fallow recovery and tree species diversity: biomass relationships in timber agroforestry systems in the Congo Basin	**S8-O3: Jaboury Ghazoul** Micro-topography segregates dipterocarp seedlings in ephemerally flooded habitat	**S9-O3: Cesar Carvajal-Hernández** Distribution and conservation status of Phlegmariurus (Lycopodiaceae) in the state of Veracruz, Mexico
15:00	**S5-O15: Arne Wenzel** Diversity of vascular epiphytes in lowland rainforests and jungle rubber agroforestry systems in Sumatra (Indonesia)	**S8-O4: Francis Brearley** No evidence for the importance of incorporation into a common ectomycorrhizal network on dipterocarp seedling growth	**S9-O4: Victor Kakengi** Population performance and future prospects of Black rhinoceros in Tanzania

15:15 Coffee Break

Sessions	S10 - SEED DISPERSAL, P. 148	S8 CONTINUED	S9 CONTINUED
Chairs	Eckhard W, Heymann and Omer Nevo		
15:45	**S1O-O1: Tom Van der Stocken** Interaction between Wind and Water as a Driver of Passive Dispersal in Mangroves	**S8-O5: Lindsay Banin** Are Dipterocarps Different? Species traits and production rates in Bornean forests	**S9-O5: Wiebke Berg** Facing the heat: thermal compensation and thermal limits in tropical reptiles
16:00	**S1O-O2: Pierre-Michel Forget** Impact of hunting and road disturbance on fruit consumption and seed dispersal by frugivores in a tropical rain forest	**S8-O6: Sean Tuck** Seedling mortality of enrichment-planted dipterocarps in the Sabah Biodiversity Experiment	**S9-O6: Aravind Ananthram Neelavar** Endemic radiation in freshwater molluscs of mountain waterfalls in the Western Ghats, India
16:15	**S1O-O3: Franziska K Harich** How to benefit from being eaten? Elephant seed dispersal experiments with Dillenia indica in Southeast Asia	**S8-O7: Maria Kaye** Investigating the mechanisms of community assembly in a mixed Dipterocarp forest using functional traits	**S9-O7: Dennis Hansen** Island conservation megaherbivores: non-native, novel function welcome?
16:30	**S1O-O4: Pia Parolin** From the canopy to the floor - seed dispersal in Amazonian floodplains	**S8-O8: James Smith** Does seed dispersal govern spatial distribution in the Dipterocarpaceae? A Bornean case study	**S9-O8: Antje Ahrends** Do current trends of rubber plantation expansion threaten biodiversity and livelihoods?
16:45	**S1O-O5: Omer Nevo** Is fruit odor an adaptation to primate seed dispersal?	**S8-O9: Kentaro K. Shimizu** Ecological genomics of general flowering and drought responses of Dipterocarpaceae	**S9-O9: John Garcia - Ulloa** A CONTEXT-SPECIFIC AND DATA-EFFICIENT APPROACH FOR QUANTIFYING BIODIVERSITY BENEFITS AND IMPACTS OF LAND-USE POLICIES

17:00 Poster Session 2 (Audimax and Poster Area 2)

19:00 Public lecture:
Elisabeth Kalko memorial lecture Audimax 'Lemur 1'

Title:
Food systems resilience in theory and practice: Organic agriculture as a prototype?

Speakers:
Dr. Frank Eyhorn and Prof. Johan Six

S15	TROPICAL MOUNTAIN BIODIVERSITY
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12-P09	Abiotic factors affecting protist community composition in Costa Rican bromeliads (p. 304)
12-P10	Decadal changes in aboveground biomass accumulation and biodiversity across tropical secondary forests, Western Amazon (p. 305)
12-P11	Ecological and phylogenetic controls over foliar nitrogen and phosphorus in forests of Borneo: an island-wide analysis (p. 306)
12-P12	Gut passage duration and seed dispersal by East African Fruit bats (p. 307)
12-P13	Tolerance towards wild elephants is associated with socio-economic factors in the Nilgiri Biosphere Reserve, India (p. 308)
12-P14	Pheromone induced helping behaviour in the termite hunting ant Megaponera analis (p. 309)
12-P15	Comoé Research Station (p. 310)
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13-P01	Agricultural Land Use Constraints and Atlantic Forest Resilience: Challenges for Rural Activities and Opportunities for Ecosystem Recovery (p. 311)
13-P02	Relationships between Biosphere Reserve constraints and Natural Resources dependent households' Livelihoods? (p. 312)
S15	**TROPICAL MOUNTAIN BIODIVERSITY**
15-P01	Climatic fluctuations as motor for speciation processes in flightless grasshoppers (Insecta: Orthoptera): study on the African genus Parepistaurus (p. 313)
15-P02	Does drought make a difference? - Vegetation, climate and fire reconstructions at Mt. Kilimanjaro's drier northern slopes (p. 314)
15-P03	Biomass and growth dynamics of Entandrophragma excelsum (Meliaceae), the tallest forest tree species at Mt. Kilimanjaro (p. 315)
15-P04	Species richness and distribution of ferns and lycophytes along an elevational gradient at Cofre de Perote, central Veracruz, Mexico (p. 316)
15-P05	PRELIMINARY ANALYSIS OF AQUATIC MACROINVERTEBRATES OF ENVIRONMENTAL PROTECTION AREA - APA PEDRA BRANCA - POÇOS DE CALDAS' PLATEAU - BRAZIL (p. 317)

THURSDAY, APRIL 9TH

08:30 Plenary Session: Keynote 4 Prof. Jordi Bascompte Audimax 'Lemur 1'

09:15 Parallel Sessions

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Chairs	Jennifer Pett-Ridge, Tana Wood, Leonor Álvarez-Cansino, Patrick Meir, Lars Markesteijn		Alice Hughes and Heribert Hofer
09:15	**S11-O1: Patrick Meir** Responses to severe drought by tropical forest trees	**S10-O6: Ashwin Viswanathan** Seed dispersal by avian frugivores: non-random heterogeneity at fine scales	**S12-O1: Siria Biagioni** 8000 years of temporal pattern of vegetation dynamics of a unique inland peat ecosystem in Jambi, Sumatra
09:30	**S11-O2: Louis Santiago** Characterizing drought survival strategies in tropical trees	**S10-O7: Joanna Lambert** Linking primate frugivory and movement ecology to tree recruitment in landscapes with heterogeneous logging histories	**S12-O2: Julie Zähringer** Landscape mosaics to map shifting cultivation dynamics in a global biodiversity hotspot - insights from north-eastern Madagascar
09:45	**S11-O3: Mickey O'Brien** The role of nonstructural carbohydrates in tropical tree seedlings under drought regimes: insights from field and nursery experiments	**S10-O8: Olivier J. Hardy** Seed and pollen dispersal in Guineo-Congolian canopy tree species - insights from genetic markers in multiple species	**S12-O3: Kamaleddin Alizadeh** Why does an unexpected savanna occur in coastal area of Northern South America?
10:00	**S11-O4: Luitgard Schwendenmann** Water uptake dynamics and leaf chemical traits in a cacao agroforestry system during a throughfall reduction experiment	**S10-O9: Eckhard W. Heymann** Primate seed dispersal can influence plant spatial-genetic population structure	**S12-O4: Teyebeh Akbari Azirani** The effect of global warming in Zagros Mountains of Iran as a subtropical region

10:15 Coffee Break

Sessions	S11 CONTINUED	S13 - RESILIENCE OF TROPICAL FORESTS: THE HUMAN FACTOR, P. 180	S12 CONTINUED
Chairs		Dr. Carmenza Robledo, Dr. Claude Garcia	
10:45	**S11-O5: Daniel Kübler** Seasonal stem diameter dynamics in a tropical dry forest	**S13-O1: Aoife Bennett-Curry** Smallholder Property Rights and Forest Regrowth in the Amazon: A missed opportunity for forest conservation?	**S12-O5: Alice Hughes** Environmental stability and biodiversity
11:00	**S11-O6: Milena Holmgren** Understanding the effects of rainfall variability on tropical tree cover	**S13-O2: Johanna Jacobi** Combining indigenous and scientific agricultural knowledge for resilience building: learning from Bolivian agroforestry initiatives	**S12-O6: Siouxsie Correa** Effect of CO_2 and temperature on relative growth rate of tropical epiphyte plants
11:15	**S11-O7: Melanie Forker** Floristic comparison of different successional stages of Caatinga-Forests in Sergipe, Brazil	**S13-O4: Rabin Raj Niraula** Tenure security as the main driver of forest cover change	**S12-O7: Edison Diaz Alvarez** Responses to simulated nitrogen deposition and a stable isotopic assessment for the neotropical epiphytic orchid Laelia speciosa
11:30	**S11-O8: Bettina Engelbrecht** Drought as well as herbivores and nutrients shape tree distribution in tropical forests: implications under global climate change	**S13-O5: Patrick Waeber** Understanding the socio-ecological landscape of the Alaotra-Mangoro, Madagascar	**S12-O8: Eike Neuschulz** A global assessment of the effects of forest disturbance on the regeneration cycle of plants
11:45	**S11-O9: Julian Gaviria** Distribution of tree species along a tropical rainfall gradient: Combined effects of herbivory and drought on seedling establishment	**S13-O6: Claude Garcia** Learning begins when gaming stops. Role Playing Games and Community Wildlife Management in the Colombian Amazon	**S12-O9: Norbert Kunert** Partitioning the contribution to stand transpiration by different tree size classes

12:00	**S11-O10: Bonnie Waring** Soil microbial compositional and functional responses to water availability in tropical wet and dry forests	**S13-O7: Hélène Dessard** Resilience thinking confronted with the giants of the Anthropocene era: are we serious?	
12:15	**S11-11: Delphine Zemp** Cascading effects of increased dryness and reduced forest resilience in the Amazon region		

12:30 Lunch Break

13:30 Plenary Session: Keynote 5 Dr Toby Gardner Audimax 'Lemur 1'

14:15 Parallel Sessions

Sessions	**S14 - CORAL REEF RESILIENCE AND MANAGEMENT, P. 188**	**S15 - TROPICAL MOUNTAIN BIODIVERSITY, P. 198**	**S3 CONTINUED FROM TUESDAY**
Chairs	Claudia Pogoreutz, Ulisse Cardini and Christian R. Voolstra	Michael Kessler and Dirk Karger	
14:15	**S14-O1: Laura Stoltenberg** Elevated CO_2 reduces photosynthetic output and lowers bleaching threshold of the finger coral Porites porites	**S15-O1: Jan Beck** Species richness of a hyperdiverse insect group, the geometrid moths, along elevation gradients: a global meta-study	**S3-O11: Arie Staal** Coexistence of tropical forest and savanna as alternative stable states
14:30	**S14-O2: Pia Kegler** Coral reefs in the face of multiple stressors: Experiments on combined effects of pollution and global warming on Pocillopora sp.	**S15-O2: Marcell Peters** Patterns and predictors of biodiversity at Mt. Kilimanjaro across taxa	**S3-O12: Francesco Fava** Satellite monitoring of spatial and temporal patterns of bamboo flowering and wildfires in the forests of the Arakan mountain range (South East Asia)

14:45	**S14-O3: Claudia Pogoreutz** Hard coral holobiont responses to elevated dissolved organic carbon and nitrogen (DOC and DON) concentrations in the Central Red Sea	**S15-O3:Alice Classen** Temperature versus resource constraints: which factors determine bee diversity on Mt. Kilimanjaro, Tanzania	**S3-O13: Tana Wood** Assessing the resilience of tropical forests to increased temperature with in situ warming: Lessons learned from a new experiment in Puerto Rico
15:00	**S14-O4: Leonard Chauka** Tanzanian reef building corals may succumb to bleaching events: Evidences from coral-Symbiodinium symbioses	**S15-O4: Gang Feng** Assembly of forest communities across East Asia - insights from phylogenetic community structure and species pool scaling	**S3-O14: Christine Wallis** Developing Andean Functional Biodiversity Indicators with Remote Sensing: The Potential of Image Textures

15:15 Coffee Break

Sessions	S14 CONTINUED	S15 CONTINUED	S3 CONTINUED
15:45	**S14-O5: Ulisse Cardini** Revising the role of biological dinitrogen fixation in biogeochemical cycling of coral reef ecosystems	**S15-O5: Claudia Hemp** Speciation mechanisms on geologically old and young mountains in East Africa: a case study on Afroanthracites and Afroagraecia, (Insecta: Orthoptera)	**S3-O15: József Geml** Effects of climate change on keystone Andean cloud forest species: a case study of Alnus acuminata and associated fungi
16:00	**S14-O6: Amanda Ford** Disentangling the effects of global and local stressors on coral reefs in the South Pacific	**S15-O6: Julien Vieu** Biogeography and diversification of the plant genus Macrocarpaea (Gentianaceae) in the middle elevation montane forests of the tropical Andes	**S3-O16: Yvonne Bachmann** Impact of future climate and land use changes on diversity patterns of plant species used for nutrition (Burkina Faso)
16:15	**S14-O7: Carlo Bianchi** Coral reef resilience in the Maldives	**S15-O7: Guy Atchison** Ecological release, perenniality and evolutionary plant radiations on island systems	**S3-O17: Nikolai Knapp** How forest modeling can improve remote sensing of tropical forest biomass

16:30	**S14-O8: Ines Stuhldreier** Highly dynamic benthic communities in upwelling exposed Costa Rican coral reefs	**S15-O8: Michael Kessler** Ecology and Evolution of Tropical Mountain Biodiversity - Conclusions	**S3-O18: Ingeborg Haug** Monitoring of fungal communities on reforestation plots and pristine forest: Cloning and Sanger sequencing versus deep sequencing.
16:45			**S3-O19: Dušan Jelić** Sensitivity Index as new tool for assessment of local biodiversity
17:00			**S3-O20: Carlos Manchego** Resilience indicators and distribution-shift of native tree species in continental Ecuador according to predicted environmental change
17:15			**S3-O21: Bert Wuyts** Resilience of tropical forests to human impact: a data-driven complex systems approach

17:30	GTÖ General Assembly Audimax 'Lemur 1'
18:30	Guided Tours/ night safari of the Masoala
19:30	Conference Dinner Zurich Zoo Masoala Resturant

FRIDAY, APRIL 10TH

09:00 Plenary Session: Keynote 6 Prof. Uma Shaanker Audimax 'Lemur 1'

09:45 Parallel Sessions

Sessions	S16 - TROPICAL MONTANE ELEVATION TRANSECTS, P. 208	S17 - HUMAN-MODIFIED TROPICAL FORESTS, P. 224	S18 - FOOD WEBS IN TROPICAL LANDSCAPES, P. 240
Chairs	Gregory Goldsmith, Jürgen Homeier and Yadvinder Malhi	Yit Arn Teh	Michael Staab and Alexandra-Maria Klein
09:45	**S16-O1: Jörg Bendix** Cloud and rainfall patterns along two altitudinal transects at the tropical eastern Andean slopes	**S17-O1: Katherine Roucoux** Pollen evidence for century-scale compositional change in a terra firme forest in Western Amazonia	**S18-O1: Michael Staab** Drivers of parasitism and host-parasitoid networks in a subtropical forest
10:00	**S16-O2: Yadvinder Malhi** Insights into ecosystem function from a 3300 m elevation gradient in the Peruvian Andes	**S17-O2: Caroline Lehmann** Understanding global trends in savanna tree cover.	**S18-O2: Lydia Hönig** High local tree diversity promotes fungal species richness and shield young subtropical forests from fungal infestation
10:15	**S16-O3: Christoph Leuschner** Carbon storage and turnover along a 2000 m-elevation Transect in Ecuador	**S17-O3: Erika Buscardo** Biogeochemistry as an integrating factor of human impact on tropical forest ecosystems	**S18-O3: Catrin Westphal** Land use intensification and landscape simplification reduce complexity of plant-pollinator interaction networks in rice production landscapes
10:30	**S16-O4: Imma Oliveras** Effects of fire across the Andean forest-puna timberline	**S17-O4: Madelon Lohbeck** The importance of biodiversity for multiple ecosystem functions in a human-modified landscape in the tropics	**S18-O4: Pierre Gras** Trophic shifts of omnivorous ants along environmental gradients in tropical agroforestry

10:45 Coffee Break

Sessions	S16 CONTINUED	S17 CONTINUED	S18 CONTINUED
11:15	**S16-O5: Marife D. Corre** Fluxes and fates of nitrogen in soils of old-growth montane forests in Ecuadorian Andes with four years of elevated nitrogen input	**S17-O5: Masha van der Sande** Understanding the dynamics of managed forests - the role of environment, traits and diversity	**S18-O5: Daniela Marenco Hurtado** Unmasking the Trojan Horse: Leaf-cutting ants learn the growth-inhibitory effects of herbivore induced plant volatiles on their symbiotic fungus
11:30	**S16-O6: Patrick Meir** Microbial and environmental controls on soil-atmosphere trace gas exchange in the tropical Peruvian Andes	**S17-O6: Minerva Singh** ENSURING BIODIVERSITY CONSERVATION WITHIN A REDD+ FRAMEWORK: CASE OF VICTORIA-ANEPAHAN RANGES IN PALAWAN ISLANDS, PHILIPPINES	**S18-O6: Erik T Frank** Optimal foraging behaviour in the termite hunting ant species Megaponera analis
11:45	**S16-O7: Tessa Camenzind** Shifts in arbuscular mycorrhizal responses to nutrient additions along an altitudinal gradient in Southern Ecuador.	**S17-O7:Yuanyuan Huang** Resources and enemies, which have bigger influence on the biodiversity-ecosystem functioning relationship in the subtropical forest?	**S18-O7: Patricia Landaverde-Gonzalez** Sweat bees on hot chilies: pollination services provided by native bees in slash-and-burn tropical agriculture in Yucatan, Mexico
12:00	**S16-O8: Karla Dietrich** Phosphomonoesterase activities in the organic layer are modified by nutrient addition in a tropical montane forest in Ecuador	**S17-O8: Andy Hector** Degradation and Restoration of Tropical Forest Diversity and Functioning	**S18-O8: Eri Yamasaki** Ant-repelling pollinators of the ant-plant Macaranga winkleri (Euphorbiaceae)
12:15	**S16-O9: Sam Jones** Methane uptake by Andean forest soils in southeastern Peru	**S17-O9: Katharina Schulz** Land-use impacts on biodiversity and carbon sequestration in grazed Caatinga dry forests, NE Brazil	

12:30 Lunch Break

FRIDAY

Sessions	S16 CONTINUED	S17 CONTINUED	S19 - MANGROVE CONSERVATION, P. 250
Chairs			Martin Zimmer
13:30	**S16-O10: Juergen Homeier** Tree species richness and functional diversity along an elevational transect in the Andes of southern Ecuador	**S17-O10: Viktoria Oliver** Sensitivity of soil respiration to land-use and the combined influence of soil temperature and moisture in agricultural soils from the tropics	**S19-O1: Marco Fusi** Mangrove crabs vulnerability to climate change
13:45	**S16-O11: Lisa Bentley** The relationship between chemical and physiological leaf traits along a tropical montane elevation gradient in Peru	**S17-O11: Frances Manning** Exploring the spatial variation of soil respiration in oil palm on peat soil.	**S19-O2: Elisha Mrabu** Occurrence of wide ranging insect infestation on the pioneer mangrove Sonneratia alba J. Smith along the Kenyan coast.
14:00	**S16-O12: Inocencio Jr Buot** Plant biodiversity along altitudinal gradients of a forest ecosystem in Palawan Island, Philippines	**S17-O12: Norliyana Zin Zawawi** THE EFFECT OF NITROGEN FERTILISER ON NITROUS OXIDE EMISSION IN OIL PALM PLANTATION	**S19-O3: Nico Koedam** How to guarantee sufficient water transport in mangrove trees in the challenging conditions of the intertidal zone?
14:15	**S16-O13: Yvonne Tiede** Taxonomic, phylogenetic and functional diversity of trees respond differently to changes in elevation and topography	**S17-O13: Graham Prescott** Effects of land-use change and landscape configuration on avian functional diversity	**S19-O4: Dennis De Ryck** Dispersal limitation of Avicennia marina among deep inlets of South African coastline in contrast to high connectivity among East African mangroves
14:30	**S16-O14: Greg Goldsmith** Variation in leaf water repellency along a 4000 m elevation transect in the Peruvian Andes	**S17-O14: David Costantini** Impact of logging on birds and mammals in Borneo: a meta-analysis	**S19-O5: Arimatéa Ximenes** MAPPING OF THE BRAZILIAN MANGROVE FOREST WITH ENVIRONMENTAL DRIVERS

14:45	**S16-O15: Simon Segar** Against the Flow? Population Genetic Structure of Montane Ficus	**S17-O15: André Jankowski** Amphibian diversity change in degraded habitats in Sumatra, Indonesia	**S19-O6: Lucy Gillis** Mind the gap: managing cross-ecosystem fluxes as key for preserving and restoring tropical coastal seascape.
15:00			**S19-O7: Gesa Dickhof** Mangrove conservation for local communities: a case study to estimate the value of mangrove-associated fishery resources

15:20 Closing ceremony and Meriam Awards Audimax 'Lemur 1'

16:00 End

PLENARY SESSIONS – ABSTRACTS

Tuesday 7th April
Plenary 1 13.30 Audimax 'Lemur 1'

Robin Chazdon
Dept. of Ecology and Evolutionary Biology at the University of Connecticut, USA

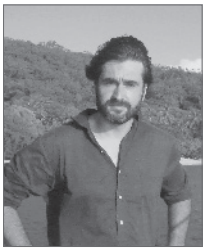
RESILIENCE AND STEWARDSHIP: A NEW PARADIGM FOR THE CONSERVATION AND MANAGEMENT OF TROPICAL FORESTS

Since the 18th century, the paradigm of sustainable timber production based on single-good, command and control forestry spread from northern Europe to guide the management of forests across the world. This entrenched paradigm resulted in limited success in sustaining diverse forest resources, particularly in the species-rich tropics. Environmental movements of the 1960s generated new paradigms for the management of tropical forests as ecosystems that support diverse plant and animal life. The ecosystem management paradigm supported policies regarding establishment of protected reserves and application of logging techniques that mimic natural disturbance regimes. Yet tropical forests continued to be cleared with little hope of sustaining high levels of biodiversity, maintaining levels of timber production, or maintaining stable and genetically diverse natural populations of high-value timber species. In the 1990s, global threats of climate change and uncontrolled rates of deforestation led to the emergence of the paradigm of ecosystem services. This paradigm promoted policies to recognize the value of tropical forests for their high capacity to sequester carbon, in addition to production of multiple goods and environmental services based on the diverse functions of resident plant and animal species. The ecosystem services paradigm provided the foundation for the development of UN REDD+ policies. Protection of remaining intact tropical forests is no longer sufficient action to conserve tropical species or to maintain ecosystem functions on a planetary scale. It is time for a new era of conservation and management of tropical forests based on the emerging paradigm of resilience and ecosystem stewardship. The central goal of ecosystem stewardship is to sustain adaptive capacity to provide ecosystem services that support human well-being under conditions of uncertainty and change. The stewardship concept rests on recognizing and enhancing the adaptive capacity of socio-ecological systems and adopts a forward-looking approach to shaping trajectories of change. Ecosystem stewardship views tropical forests and landscapes as complex adaptive systems with interacting social and ecological components whose behavior leads to emergent system dynamics.

Wednesday 8th April
Plenary 2 08.15 Audimax 'Lemur 1'

Ahimsa Campos-Arceiz
School of Geography, University of Nottingham Malaysia Campus, Malaysia

THE ELEPHANT IN THE ROOM, THE DIFFICULT TASK OF CONSERVING ELEPHANTS IN A CROWDED WORLD



Elephants and other megafauna play key and irreplaceable roles in ecosystem processes but – due to their high demand for resources and lack of natural predators – are maladapted to the Anthropocene's human-dominated world. If we want elephants to survive beyond the bottleneck of the 21st we need to find effective ways to coexist with them. Peninsular Malaysia is home to approximately 1,500 wild elephants that in less than two generations have seen over half of their natural habitat replaced by rubber, oil palm, and other land uses. This has led to a sharp decline in elephant range and increase of human-elephant conflict (HEC) in the form of crop raiding. Over the past 40 years, elephant management in Malaysia has largely been based on the translocation of elephants from conflict zones to protected areas. In this presentation I will introduce the work of the 'Management & Ecology of Malaysian Elephants' (MEME), an interdisciplinary project run as a collaboration between the local wildlife authorities and university researchers that aims to bring an evidence-based approach to the conservation of Malaysian elephants. We use a combination of GPS-satellite tracking, camera-traps, non-invasive molecular tools and other ecological and social science techniques to (1) study the ecology and behavior of elephants in tropical rainforests; (2) assess the impact of current management, particularly translocation, on the wild elephant population; and (3) identify alternative strategies for long-term human-elephant coexistence. Peninsular Malaysia can afford to conserve its elephants in the long-term but important changes in people's behavior are needed for this to happen.

Wednesday 8th April
Plenary 3 13.30 Audimax 'Lemur 3'

Jane K. Hill
Department of Biology, University of York

CONSERVING SPECIES IN TROPICAL AGRICULTURAL LANDSCAPES

Extensive areas of tropical lowlands are increasingly dominated by agriculture. These areas support very high levels of rainforest biodiversity, and species within these landscapes are having to respond and adapt to the twin environmental stressors of land-use change and climate warming. I will discuss our research on the island of Borneo (Sabah, Malaysia) where lowland areas are increasingly dominated by oil palm plantations. These plantations are vital to the regional economy, making it important to develop more sustainable practises that reduce biodiversity losses. We have been focussing specifically on the role of forest fragments for conserving biodiversity within agricultural landscapes. I will examine how habitat fragmentation affects plants (dipterocarps) and animals (dung beetles, ants, butterflies), and the ecosystem functions they provide. I will also discuss the role of habitat connectivity for promoting responses of range-shifting species to climate warming and highlight new research challenges.

Thursday 9th April
Plenary 4 08.30 Audimax 'Lemur 3'

Jordi Bascompte
Intergrative Ecology Group Estación Biológica de Doñana, CSIC, Spain

PLANT-ANIMAL MUTUALISTIC NETWORKS: THE ARCHITECTURE OF BIODIVERSITY

The mutualistic interactions between plants and the animals that pollinate them or disperse their seeds can form complex networks involving hundreds of species. These coevolutionary networks are highly heterogeneous, nested, and built upon weak and asymmetric links among species. Such general architectural patterns maximize the number of coexisting species and increase the range of variability that these mutualistic networks can withstand before one or more species goes extinct. Therefore, mutualistic networks can be viewed as the architecture of biodiversity. However, because pylogenetically similar species tend to play similar roles in the network, extinction events trigger non-random coextinction cascades. This implies that taxonomic diversity is lost faster than expected if there was no relationship between phylogeny and network structure.

Thursday 9th April
Plenary 5 13.30 Audimax 'Lemur 3'

Toby Gardner
Stockholm Environment Institute, Sweden

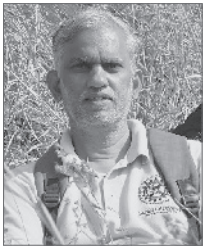
TROPICAL FORESTS IN THE ANTHROPOENCE: CHALLENGES AND OPPORTUNITIES FOR THE SCIENTIFIC COMMUNITY

The Anthropocene is characterized as an epoch when human influence has begun to fundamentally alter many aspects of the Earth system and many of the planet's biomes, including tropical forests. With this as a starting point my talk will consist of two parts. First, I will review and synthesize key aspects of our emerging understanding of Anthropocene change in tropical forests, offering a panorama of the myriad and often interacting drivers of ecological change, and resultant shifting patterns of biodiversity that have left few, if any corners of the tropics free of human impact. I will draw both on a recent review of the literature as well as new findings from a multi-taxa survey of biodiversity and ecosystem change across nearly 400 study sites in the eastern Brazilian Amazon. I will posit that the fate of tropical forests will be determined by the bottleneck of the early Anthropocene period, and that these forests may adopt radically different trajectories depending on their stewardship in the coming decades. In the second part of this talk I will draw on this synthesis to appraise what is unquestionably a new phase of challenge and opportunity for ecologists and other researchers worldwide. I will highlight many of the urgent knowledge gaps within the ecological sciences, but also the opportunities presented by new ways of working that are vital to addressing the scale of the problems facing tropical forests – including the increasingly prominent role of research and learning networks. I will end with some personal reflections on my experience of stepping outside ecology and contributing towards the development of conservation policy in Brazil at both state and national levels, together with emerging ideas as to how the science of ecology can be more effectively situated within a broader sustainability agenda.

Friday 10th April
Plenary 6 13.30 Audimax 'Lemur 3'

R.Uma Shaanker
Department of Crop Physiology and School of Ecology and Conservation, University of Agricultural Sciences, Bangalore, India

ECOLOGICAL NICHE MODELS AND ADAPTIVE LANDSCAPES OF SPECIES: HYPOTHESIS, VALIDATION AND EXTRAPOLATIONS



In recent years ecological niche models (ENMs) have become an extremely popular tool in predicting habitat suitability of species based on their current occurrence. The ENMs have been used widely, from planning conservation and management of species, predicting impact of global climate change, predicting spread of invasive species and to understanding evolution and diversification of taxa. An implicit assumption in the prediction of habitat suitability by the ENMs is that the current distribution of species reflects a time-averaged adaptation of species to its niche. Thus, in a Darwinian context, fitness of species in habitats predicted to be highly suitable would be highest compared to that in habitats predicted to be poorly suitable or unsuitable. In this talk, I shall review some ongoing work in our lab that has attempted to validate this assumption and discuss some extrapolations emerging from this consideration with particular relevance to niche diversification of invasive species and evolution of plant defensive compounds.

PUBLIC LECTURE

Wednesday 8th April
Audimax 'Lemur 3'

19.00 Public Lecture Elisabeth Kalko Memorial Lecture 2015

FOOD SYSTEMS RESILIENCE IN THEORY AND PRACTICE: ORGANIC AGRICULTURE AS A PROTOTYPE?

Welcome - Dr. Chris Kettle
Ecosystem Management Group, ETH Zurich

19.10 Prof. Johan Six
Chair, Sustainable Agroecosystems ETH Zurich, Institute of Agricultural Sciences

19.30 Dr. Frank Eyhorn
Team Leader, Rural Economy HELVETAS Swiss International Cooperation

19.50 Questions and Discussion
Moderator: Michelle Grant Executive Director, ETH Zurich World Food System Center

20.15 Apéro

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The World Food System Center is a competence center at ETH Zurich that supports multi- and cross-disciplinary approaches to addressing the challenges confronting the world food system. We do this through research, education, and outreach activities that contribute to sustainable food security.

This event is part of the WFSC's public lecture series and is made possible thanks to the Mercator Foundation Switzerland, whose support aims to explore the role and potential of organic farming systems (certified and non-certified) to contribute to global food security.

SESSION 1

S1 - PRESENT AND FUTURE ROLE OF MANAGED TROPICAL FORESTS

Chairs: Ervan Rutishauser and Plinio Sist
Contact: er.rutishauser@gmail.com

THE TROPICAL MANAGED FORESTS OBSERVATORY: A RESEARCH NETWORK ADDRESSING THE FUTURE OF TROPICAL LOGGED FORESTS

Plinio Sist[1], Ervan Rutishauser[2]

[1]Cirad, Montpellier, FR, sist@cirad.fr
[2]CarboFor-Expert, Geneva, CH

While attention to logging in the tropics has been increasing, studies on the long-term effects of silviculture on forest dynamics and ecology remain scare and spatially limited. Indeed, most of our knowledge on tropical forests arise from studies carried out in undisturbed tropical forests. This bias is problematic given that logged and disturbed tropical forests are covering now a larger area than the so-called primary forests. A new network of permanent sample plots in logged forests, the Tropical managed Forests Observatory (TmFO), aims to fill thisgap by providing unprecedented opportunities to examine long-term data on the resilience of logged tropical forests at regional and global scales. This presentation aims to introduce the TmFO which currently includes 24 experimental sites distributed across three tropical regions, with a total of 490 permanent plots and 921 ha of forest inventories. We will present here the main objectives and research questions of TmFO as well as its methodological approach and preliminary results.

CARBON SEQUESTRATION IN LOGGED FORESTS: SOME RESULTS FROM THE TROPICAL MANAGED FORESTS OBSERVATORY

Ervan Rutishauser[1,2], Plinio Sist[2], TmFO partners[3]

[1]CarboForExpert, Genève, CH, er.rutishauser@gmail.com
[2]CIRAD-UMR B&SEF, Montpellier, FR, er.rutishauser@gmail.com
[3](various institutions), TmFO, GF

Nowadays, human disturbed forests form most of tropical landscapes. Commercial logging is often recognized as the main driver of forest disturbances, having profound and long-lasting environmental impacts. If post-logging stand dynamics is documented at a few sites in the Amazon basin, no regional assessment has been carried out yet. Moreover, effects of logging are generally investigated at forest stand level, while impacts at tree level remains poorly addressed. The present contribution will explore the impact of logging (i) at forest stand level on biomass/carbon recovery, and (ii) at tree level, on their morphology. From these results, some perspectives on future tropical forest management are proposed.

FOREST RECOVERY OVER 30 YEARS FOLLOWING MANAGEMENT INTERVENTIONS OF DIFFERENT INTENSITIES IN THE BRAZILIAN AMAZON

Angela Luciana de Avila[1], Ademir Roberto Ruschel[2], João Olegário P. de Carvalho[3], José Natalino Silva[5], Lucas Mazzei[2], Carsten F. Dormann[4], Jürgen Bauhus[1]

[1]Chair of Silviculture, University of Freiburg, Freiburg im Breisgau, DE, angeladeavila@gmail.com
[2]Agricultural Research Corporation (Embrapa) of the Eastern Amazon, Belém, BR
[3]CAPES/CNPq/Federal Rural University of Amazonia, Belém, BR
[4]Department of Biometry, University of Freiburg, Freiburg im Breisgau, DE
[5]Federal Rural University of Amazonia, Belém

When managing tropical forests sustainably, a detailed understanding of these ecosystems and their responses to management effects is required. The recovery of tropical forests following silvicultural interventions is not yet well understood, in particular the medium and long-term responses to these anthropogenic disturbances have not been amply analysed. In this study, we will present results on one long-term experiment on forest dynamics following logging and thinning conducted at the Tapajos National Forest in the Brazilian Amazon. We analysed the influence of different silvicultural disturbance intensities on forest recovery compared to the pre-logging condition and to a control treatment. The interventions comprised logging in 1982 and thinning in 1993-1994 and ranged from 19 to 53% reduction of the original basal area. Trees with diameter at breast height (DBH) ≥ 5 cm were measured on eight occasions in 41 permanent sample plots of 0.25 ha each. Stand basal area returned to similar levels within 30 years except for the highest disturbance intensity. Number of stems per hectare increased with disturbance intensity. Mortality was high soon after logging but following this period recruitment exceeded mortality for about five years. Annual mortality and recruitment rates declined over time but they were still higher than in the unlogged forest. These results improve our understanding of the medium-term responses of tropical rain forests in the Brazilian Amazon to different silvicultural disturbance intensities. Additional studies are needed to evaluate the recovery of other ecological and productive features so as to provide sound information that can support future decisions on sustainable forest management in this region.

Merian Award Applicant

LONG-TERM OBSERVATION OF POST-INTERVENTION DYNAMICS IN A TROPICAL MOIST FOREST IN SURINAM

Philip Mundhenk[1], Inez Demon[2], Maureen Playfair[2], Michael Koehl[1]

[1]*University Hamburg, Hamburg, DE, philip.mundhenk@uni-hamburg.de*
[2]*CELOS, Paramaribo, SR*

Treatments in tropical silviculture have been introduced to strengthen sustainable forestry by controlling the composition, structure, and dynamics of forests. Beside securing regeneration and improving stocking, silvicultural treatments aim at an increase of the growth of remaining future crop trees (FTC). By thinning treatments FCT are released from competition by removing immediate neighboring trees, which generally results in increased growth due to increased exposition to light and access to soil resources.

In 1978, a silviculture experiment has been established in Surinam to investigate long term impacts of the CELOS Management System (CMS) on timber production in a tropical moist forest. CMS is a polycyclic system consisting of two components: the CELOS Harvesting System (CHS) to provide sustained yields by controlled, polycyclic harvests and the CELOS Silvicultural System (CSS) to increase the growth of commercial tree species by refinements. In the experiment, combinations of three different logging intensities (removing 15 m^3 , 23 m^3 , and 46 m^3 of timber) and three levels of liberation thinning (poison girdling of all non–commercially interesting trees species > 20 cm DBH, > 30 cm DBH, and no girdling) have been applied to 27 one hectare plots. Data were collected for all trees ≥15 cm DBH in 1983, 2000 and 2012. We investigated potential effects of the different treatment combinations on the mortality, survival, recruitment and growth of commercial tree species 4, 22 and 34 years after intervention. The stimulating effect of both logging and liberation thinning on diameter and volume growth of the remaining stand has frequently been described. The results of our experiment do not support these findings. The outcomes of our analysis suggest that 22 and 34 years after intervention no statistically significant differences in commercial timber volume can be detected among the different treatments.

CHARACTERISTICS, STRUCTURE AND TREE-SPECIES DIVERSITY OF A TROPICAL EXPLOITATION FOREST IN REGENERATION - A CASE STUDY FROM GABON

Franziska Schier[1], Stephan A. Pietsch[2]

[1]BOKU, Vienna, AT, schier.franziska@gmail.com
[2]IIASA, Laxenburg, AT

Biodiversity potentially influences ecosystem functioning and the provision of goods and services. Maintaining forests' diversity increases the forests' resilience against global changes, contributes to climate change mitigation and maintains livelihoods benefits. Forest degradation due to unsustainable forest exploitation affects the structure and diversity of the Congo Basin rainforests. However, the carbon and biodiversity implications of forest degradation are less well known than those of deforestation. In reference to proper management options for tropical forests, including habitat restoration and conservation, robust information on the impact of degradation and the forest recovery potential after disturbances seems to be fundamental.

This case study increases the knowledge on long-term dynamics of logged-over forests. It examines the impact of century-long timber exploitation on key forest characteristics, stand structure, and tree-species diversity. The regeneration potential of a degraded forest under protection as well as the interdependencies between biodiversity and biomass carbon recovery are analyzed.

Ground-based measurements used for the study were taken in the coastal rainforest of Mondah (Gabon) in 1993 and 2011. Additional information on mature rainforests was used to benchmark the state of the forest. Data analysis proved proceeding forest recovery. After more than 40 years of natural regeneration, stem count, stand basal area, forest biomass and carbon stocks approximate those of regional mature forests stands. Signs of previous exploitations are evident in the stand structure. Human disturbances led to decreasing forest diversity. Here, changing levels of the woody plant species diversity has no long-term effects on forest biomass production and carbon stocks. Since most of the carbon in tropical forests is stored in stems, increasing timber volume due to proceeding forest maturation directly results in carbon benefits.

The results suggest that the restoration of essential forest functions and services (e.g. biomass production and carbon storage) comparable to primary levels is possible under effective forest protection.

TRANSIENCE OF LOGGING ROADS IN CONGO BASIN RAINFORESTS

Fritz Kleinschroth[1,2], Sylvie Gourlet–Fleury[2], Plinio Sist[2], John R. Healey[1]

[1]*Bangor University, School of Environment, Natural Resources and Geography, Bangor, UK, fritz.kleinschroth@cirad.fr*
[2]*CIRAD, Biens et services des écosystèmes forestiers tropicaux, Montpellier, FR, fritz.kleinschroth@cirad.fr*

Logging roads are considered to be drivers of tropical forest degradation by fragmenting the forest and opening it for human and biological invasions. However, most secondary logging roads are abandoned after a short period of timber harvesting. Little is known about long-term forest recovery on and around these roads and about the persistence of their impacts on biodiversity. We used a time series of satellite images dating back 27 years to determine the time when roads had been abandoned after logging. We then sampled roads of different ages in seven logging concessions in South-East Cameroon. At each site we carried out plot-based vegetation inventories on a gradient from the former roadway up to 50 m into the adjacent logged forest. On the roadway we identified a clear succession trajectory, with pioneers being gradually replaced by non-pioneer-light-demanders and shade-bearers. Abundance of regenerating commercial timber species was 10-times higher on the roadway than in the closed forest, although the abundance of all other groups of species showed an opposite trend. Tree species richness was lower on the roadway than in the forest but it increased with time after abandonment. The invasive herb *Chromolaena odorata* occurred on recently abandoned roads but disappeared almost entirely within 10 years. Roads abandoned more than 10 years ago no longer seemed to be penetrable for any type of motorized traffic. Our results highlight the role of logging roads as transient elements in the landscape with road-related impacts on forest ecosystems being less persistent than expected. Moderate openings of canopy and exposure of soil can even facilitate the establishment of light-demanding timber species. Invasive weeds do not obstruct this process. Poachers seem to lack resources to systematically clear roads and therefore cannot use them with motorcycles for a long time. Given these patterns of fast vegetation recovery, we advocate use of greater effort to fully obliterate roads after use instead of reserving them to be re-opened in subsequent harvest cycles.

Merian Award Applicant

ECOSYSTEM SERVICES IN LOGGED-OVER AND NATURAL FORESTS: A CASE STUDY FROM WEST KALIMANTAN, INDONESIA

Nicolas Labrière[1,2], Bruno Locatelli[1,3], Yves Laumonier[1,4]

[1]CIRAD - UR BSEF, Montpellier, FR, nicolas.labriere@gmail.com
[2]ABIES doctoral school, Paris, FR, nicolas.labriere@gmail.com
[3]CIFOR - CRP FTA, Lima, PE
[4]CIFOR - CRP FTA, Bogor, ID

As the extent of Southeast Asian tropical rainforests affected by logging keeps increasing, the impact of logging on ecosystem services' delivery needs to be clarified. We focused on 3 ecosystem services relevant to mankind at different scales: climate regulation through carbon storage, tree diversity and soil conservation against erosion. We surveyed 1 ha of logged-over (selectively logged ca. 7–15 yr prior to survey) and natural forest close to a village where livelihoods depend on swidden agriculture and smallholder rubber tapping. Data to assess carbon stocks in above-ground biomass and topsoil (0–20 cm) and tree diversity were collected. A network of silt fences was also set up and eroded material collected, dried and weighted on a monthly basis. Mean carbon stocks in above-ground biomass were significantly higher in natural compared to logged-over forests. Though mean carbon stocks in topsoil were almost twice as important in natural forest than logged-over one, the difference was not significant due to high spatial heterogeneity in topsoil carbon content. Erosion rate was low for both forest types (up to 2-order of magnitude lower than tolerable soil erosion rate). That said, we did not include landslides along the logging road that are numerous and expected to lead to an increase of the total sediment yield of logging activities. Species richness was similar for the two forest types, but community composition analysis revealed strong difference, with the noticeable reduction in importance value for the Dipterocarp family. Overall, ecosystem services' provision was lower in logged-over forests than in natural ones (for the services we focused on, that were mostly regulating services), and we stress than sufficient time between consecutive rotations is compulsory so as to enable maximum recovery of carbon stocks (both in above-ground biomass and topsoil) and re-establishment of late-successional tree species.

RESOURCE EFFICIENCY IN TIMBER PROCESSING - A NECESSITY FOR SUSTAINABLE FOREST MANAGEMENT IN THE TROPICS

Kai Timo Schönfeld[1]

[1]*Institute for World Forestry, Hamburg, DE, kai.timo.schoenfeld@uni-hamburg.de*

Many measures have been taken to minimize and monitor the negative effects of logging in tropical forests. Still, a high percentage of the tropical timber that – even if harvested sustainably – is afterwards lost in the saw mill. Studies focusing on the timber processing industry in tropical countries have shown that merely between a third and a half of round wood are actually made into products. A sustainability that is strived for in the forest is neglected as soon as the timber leaves the forest boundaries and enters processing in the saw mill. In comparison to efforts supporting measures that are implemented in the forest, activities focusing on resource efficiency in the sawmilling sector are lacking throughout and are mainly put under the responsibility of the particular businesses.

A case study carried out in Suriname provided evidence that along with losses of timber a high share of residuals is not used whether as material nor for energy. A cross-section analysis examined the timber processing industry and identified potentials in the course of expert interviews and production measurements. On the basis of the collected data cutting simulations were performed to show resource savings potentials of the processed timber. Possible optimization measures are determined and show ways of how efficient timber processing may be implemented in a cost-beneficial manner and at short notice leading to long-term major impacts in the protection of tropical forests. Timber input reduction may result in a reduction of timber exploitation from forests. Thus, special emphasis needs to be placed on the improvement of raw material efficiency and the use of wood processing residuals. As tropical log production "has become increasingly supply constrained" (ITTO, 2012) efforts promoting an efficient resource utilization of extracted timber are of uttermost importance.

ABOVE-GROUND BIOMASS ASSESSMENT FROM LONG-TERM FIELD DATA

Alicia Ledo[1], Helene Muller-Landau[2], S. Joseph Wright[2], Janine B. Illian[3], David F.R.P. Burslem[1]

[1]University of Aberdeen, Aberdeen, UK, alicialedo@gmail.com
[2]Smithsonian Tropical Research Institute, Panama, US
[3]University of St Andrews, St Andrews, UK

International policies for climate change mitigation rely on the future capacity of tropical forests to increase carbon capture in biomass and soil. AGB estimation underlies key recommendations of the reports of the Inter-governmental Panel on Climate Change and is a key metric for characterising the success of initiatives under the UN-REDD+ program. However, AGB estimation by these agencies relies on equations relating tree diameter to AGB that were first fitted more than 20 years ago, and do not account for independent effects of tree height, wood density, trunk irregularities or particular environmental conditions, such us local temperature. In addition, for precise prediction of the spatio-temporal dynamics of AGB change it is necessary to account for the cumulative effects of interactions among stand age, density and local tree neighbourhoods that influence the growth and mortality of individual trees. Understanding these neighbourhood interactions is challenging because it requires spatially-explicit long-term datasets of tree demography over several decades, high-resolution data on environmental covariates, and complex statistical modelling techniques, involving spatio-temporal stochastic processes. In this paper we present a powerful new approach to fitting models with complex dependency structures to evaluate the spatio-temporal dynamics of AGB dynamics over decadal time scales using data from the 50 ha CTFS-ForestGEO plot on Barro Colorado Island (BCI) in Panama. When scaled across multiple plots in the CTFS-ForestGEO network, this approach has potential to improve forecasts of future changes in tropical forest AGB in response to anthropogenic global change.

SESSION 2

S2 - SCENARIOS OF BIODIVERSITY FOR THE CONGO BASIN

Chairs: Claude Garcia, Patrice Levang and Jean-Noël Marien
Contact: claude.garcia@usys.ethz.ch

PREDICTING FOREST COMPOSITION ACROSS SPACE AND TIME IN CENTRAL AFRICAN FORESTS

Maxime Réjou-Méchain[1,2,3], Frédéric Mortier[2], Fabrice Bénédet[2], Xavier Bry[5], Jérôme Chave[6], Guillaume Cornu[2], Jean-Louis Doucet[4], Adeline Fayolle[4], Sylvie Gourlet-Fleury[2], Raphaël Pélissier[3], Catherine Trottier[5]

[1]French Institute of Pondicherry, Pondicherry, IN, maxime.rejou@gmail.com
[2]UPR BSEF, CIRAD, Montpellier, FR, maxime.rejou@gmail.com
[3]IRD, UMR AMAP, Montpellier, FR, maxime.rejou@gmail.com
[4]Unité de gestion des ressources forestières et des milieux naturels (GRFMN), Gembloux, BE
[5]Université Montpellier 2, Montpellier, FR
[6]Laboratoire EDB, Toulouse, FR

Predicting the current and future natural distributions of species is challenging, especially in the tropics where large remote areas remain poorly known. Such challenge can only be met with an in-depth understanding of the drivers of species distribution, a well-designed and extensive survey and appropriate statistical models. In this study, we use a large dataset of forest inventories from logging companies, which provides information on the abundance of 215 tree genera, in more than 115,000 plots spread over four Central African countries. In order to predict the current and future distribution of these tree genera, we use a set of bioclimatic, geological and anthropogenic variables. We rely on a recently published methodology, called Supervised Component Generalized Linear Regression (SCGLR), which identifies the most predictive dimensions among a large set of predictors. Using a calibration and validation scheme, we show that the distribution of most tree genera can be well predicted over the whole study area. At the community level, the floristic and functional composition of tree genera is inferred with a high accuracy. Finally, using climatic and anthropogenic scenarios we predict the expected change in functional and phylogenetic structure of tree communities over the western part of the Congo Basin. Overall, our study provides useful ecological insights and shows that tropical tree distributions can be predicted with good accuracy, offering new perspectives to manage tropical forests at large spatial scales.

STATE OF THE ART ON DRIVERS OF DEFORESTATION IN THE CONGO BASIN TROPICAL FOREST

Pauline Gillet[1], Cédric Vermeulen[1], Laurène Feintrenie[2], Hélène Dessard[3], Claude Garcia[4]

[1]ULg- GxABT, Gembloux, BE, pgillet@ulg.ac.be
[2]CIRAD- UR B&SEF, Yaoundé, CM
[3]CIRAD- UR B&SEF, Montpellier, FR
[4]ETH- FORDEV, Zurich, CH

In comparison to other rainforests around the world, the pressure on biodiversity is comparatively low in the Congo Basin. But land use intensification and climate change are poised to increase the rate of forest loss. The changes to the landscapes and the development pathways that the Congo basin will follow will result from the complex interplay of ecological, economic and social drivers. To account for this complexity and to represent it in models of land use and forest cover change, we analyzed the existing literature in search of the current direct and indirect drivers of deforestation in the Congo Basin forest and in Cameroon and Gabon specifically.We identified and documented the following direct drivers of deforestation: (i) the expansion of agriculture - either family farming or agribusiness; (ii) the extraction of timber for commercial timber (iii) the development of infrastructure leading to the opening up of forested land and populations, and (iv) the mining industries, a driver so important in the future of the forests of the Congo Basin that it warranted a category on its own. The underlying causes mentioned in the literature relate to (i) the economic factors such as the demand for environmental resources in local and global markets and the need for national income; (ii) the technological factors allowing more cost-efficient timber removal; (iii) cultural factors like the perception of the forest as a frontier for development and an important source of economic income for populations and decision makers alike ; (iv) institutional factors like the informal taxation system on logging for the domestic markets; and (v) the demographic drivers such as the increased local densities resulting from migration and the demographic transition. In doing so, we refine and expand the framework proposed by Geist & Lambin in 2002 and adapt it to the Central African context.

RESILIENCE LANDSCAPES FOR THE CONGO BASIN

Stephan Pietsch[1], Sishir Gautam[1], Johannes Bednar[1], Aline Mosnier[1], Michael Obersteiner[1]

[1] *IIASA, Laxenburg, AT*

We will provide resilience landscapes for the Congo basin vs. Impacts of climate change and human activities. Current concepts of resilience assessment are based on statistical analysis of observed distribution patterns, which fail to deliver information on the temporal development of the resilience space. We will present natural forest resilience, managed forest resilience and shifting cultivation forest resilience in the context of existing statistical perceptions of resilience. Additionally we try to extend the current statistic resilience concept to a dynamic concept of measurable numerical values.

MODELS OF CHANGE ACROSS THE FOREST TRANSITION CURVE - PARTICIPATORY MODELLING IN THE CONGO BASIN

Eglantine Fauvelle[1], Christophe Rouxel[1], Gilles Somgwag[1], Louis Bernard Cheteu[2], Laurène Feintrenie[1], Claude Garcia[1,3]

[1]CIRAD, Montpellier, FR
[2]IRAD, Yaoundé, KH
[3]ETH, Zurich, CH, claude.garcia@usys.ethz.ch

The futures of tropical forest landscapes are shaped by the land use and climate change. Increased demand for agricultural products, wood and fibers, the aspirations of rural and forest dwelling communities and a growing recognition of planetary boundaries outline the complex trade-offs resource users face every day. How can we imagine landscape trajectories that will accommodate these apparently conflicting demands?

The project CoForTips explores this question through the development of participatory models of change. These models describe the interactions and process that link ecosystems, actors and norms. The models are then used to run simulations – describing changes to the social and natural components under different scenarios. One of the particularities of this approach is that we use role playing games, allowing real stakeholders to bring in their own strategies, beliefs and intentions.

We launched parallel participatory modelling processes in three sites distributed across the forest transition curve: 2 in Cameroun (Guéfigué, Central Region and Mindourou, Eastern region) and 1 in Gabon (Makokou, Province of Ogooué-Ivindo).

In Makokou, the participatory modelling process highlighted the critical role that elephants and their forays into the village fields play in the strategies of land use by the farmers.

In Mindourou, the models focused on the decrease in forest cover of the community forests as a result of the expansion of cultivated areas by migrants around small urban centers, leading to tensions between locals, migrants and the forest logging companies that brought the migrants to the area.

In Guéfigué, at the far end of the forest transition curve, the local community highlighted the critical role played by the cocoa and other cash crop supply chains. They helped to initiate a dialogue on the local options for agricultural development.

All these processes have started a dialogue between local stakeholders and academics that will continue through 2015 to create common mental models of the forest landscapes of the Congo Basin.

SESSION 3

S3 - MODERN METHODS IN MONITORING TROPICAL ECOSYSTEMS

Chairs: Jörg Bendix and Erwin Beck
Contact: bendix@staff.uni-marburg.de

RENDEZWUE IN THE FOREST - USING TOWER OBSERVATIONS AND REMOTE SENSING IN THE TROPICAL MOUNTAIN FOREST

Brenner Silva[1], Simone Strobl[2], Paulina Alava-Nunes[1], Erwin Beck[2], Jörg Bendix[1]

[1]*University of Marburg, Marburg, DE, silvab@geo.uni-marburg.de*
[2]*University of Bayreuth, Bayreuth, DE*

Evapotranspiration, primary production, and water use efficiency (WUE) are indicators of the ecosystem's water and carbon cycles, which can be directly observed in or above the forest canopy and can be linked with remote sensing data for area-wide monitoring. In the San Francisco Reserve, located at the eastern slopes of the Andes of South Ecuador, we investigate the relation of the indicators between tree individuals and the forest stand at the landscape level. Our approach is called RendezWUE, in reference to the combined use of laser scintillometer, portable photosynthesis systems, weather station, and infrared gas analyzer, which are installed on towers in the natural forest. In addition, remote sensing data have been processed to allow for area-wide estimates of the indicators. Remote sensing techniques used are airborne discrete laser scanning, hyperspectral scanning, and multispectral satellite observations. In this work, we first focused on the direct relation between measurements of leaf transpiration and canopy evapotranspiration, where r_2 values higher than 0.6 have been observed. Then, a footprint analysis has been used to investigate if the variability in the observed data is related with the forest stand structure and tree species composition within the scintillometry fetch area. Last, indicators have been linked with the structural and spectral properties, which are retrieved from remote sensing data (e.g. canopy height, leaf area, vegetation indices) and can be analyzed at individual level using tree-crown detection and ancillary data (e.g. leaf photosynthesis). In this presentation, we show the current state of analyzes and upscaling with remote sensing products, which lead to insights into local and area-wide functional indicators ragarding water and carbon cycles of the tropical mountain forest.

Merian Award Applicant

CARBON AND WATER RELATIONS OF TROPICAL TREES IN AN ECUADORIAN MOUNTAIN RAIN FOREST - UPSCALING FROM THE LEAF TO THE TREE LEVEL

Simone Strobl[1], Brenner Silva[2], Michael Schorsch[3], Johannes Knüsting[3], Renate Scheibe[3], Jörg Bendix[2], Erwin Beck[1]

[1]*University of Bayreuth, Bayreuth, DE, simone.strobl@uni-bayreuth.de*
[2]*University of Marburg, Marburg, DE*
[3]*University of Osnabrück, Osnabrück, DE*

Experimental approach: With leaves from the sun and the shade crown, we measured leaf transpiration and carbon uptake by porometry with a portable gas analyzer (Li-Cor) on 7 tree species and water use efficiency (WUE) was calculated of the daily sums. Percentage of the shade and the sun crown of the entire foliage are provided from LIDAR-measurements. From these data, an average water use efficiency of the crown was determined.

For water consumption and carbon uptake on the whole tree level, total daily water consumption of the trees was measured with the sap flux technique (thermal dissipation probes). Using the average water use efficiency and the total water consumption during day time, total carbon uptake of the tree could be calculated.

First result: we show first results from a tree of the Ecuadorian mountain rain forest, *Vismia tomentosa*, which grows at an altitude of 1990 m asl.

On a day without precipitation, an individual of a *V. tomentosa* with a dbh of 22 cm consumed 10 l water and fixed 115 g CO_2. On the same day, similar individuals of four other tree species showed a higher whole-tree water consumption, ranging between 29 and 43 l.

Of a selection of 7 tree species, 4 trees showed a similar WUE as Vismia, while those of two others were two times as high.

Upscaling: for upscaling from the tree to the landscape level, the transpiration measurements of the trees of a whole forest stretch will be correlated with the data of a laser scintillometer which measures the dynamics of the water content in the atmosphere above the canopy. These measurements will be used to link single tree data to a forest area.

DIFFERENCES IN TRANSPIRATION AMONG RAINFOREST AND TRANSFORMATION SYSTEMS

Alexander Röll[1], Furong Niu[1], Afik Hardanto[1,2], Hendra yanto[3], Dirk Hölscher[1]

[1]Tropical Silviculture and Forest Ecology, Georg-August-Universität Göttingen, Göttingen, DE, aroell@gwdg.de
[2]Universitas Jenderal Soedirman, Purwokerto, ID
[3]Institut Pertanian Bogor, Bogor, ID

Rainforest transformation most likely alters ecosystem water cycles with respect to the magnitude of fluxes, their spatial heterogeneity, and their temporal variability. In this study, we assessed tree and palm transpiration rates in forests, jungle rubber, and rubber and oil palm monoculture plantations. Each land use type was studied with eight replicate plots in the lowlands of Jambi, Sumatra, Indonesia. Stand-scale transpiration rates were derived from sap-flux measurements with thermal dissipation probes and stand inventories. Average transpiration rates and the plot-to-plot variability of transpiration were similar for forest and oil palm stands. Rubber plantations had 30% lower average transpiration rates than forests and oil palm plantations; jungle rubber showed intermediate rates. Rubber plantations effectively reduced transpiration rates during dry periods by partially shedding leaves. The day-to-day variability of transpiration was almost two-fold higher in the forest than in oil palm, which points to a buffered response of oil palm transpiration to environmental drivers and is indicative of an anisohydric behavior. The dicot trees in the forest but also rubber showed a much closer response to environmental drivers, in particular to radiation. In conclusion, our results suggest relatively strong consequences of rainforest transformation on stand-scale transpiration rates as well as differences among land use systems that replace forests; we assume that these consequences and differences will also influence the response to climatic changes.

WATER BALANCE MODELING IN TROPICAL CATCHMENTS-RESULTS AND PROBLEMS IN RELATION TO SCALE AND LAND MANAGEMENT TO ASSESS WATER FUNCTION RESILIENCE

Gerhard Gerold[1,2], Gabriele Lamparter[1,2]

[1]*Gerhard Gerold, Göttingen, DE, ggerold@gwdg.de*
[2]*Gabriele Lamparter, Göttingen, DE, ggerold@gwdg.de*

In the tropics, deforestation and further land use change in combination with changes of precipitation pattern due to climate change are well known threats for the regional water balance and water ecosystem services. Local and experimental micro-catchment research in the humid tropics proved that deforestation results in distinct consequences for the water balance, with increased runoff (danger of floods) and discharge variability.

Disregarding changes in precipitation, the relationship of deforestation and intensification of land use with the runoff rate on catchment scale is as yet poorly understood. Further, this relationship also depends on the characteristic of the soil and the definition and measurements of hydrological relevant vegetation parameters. Land use change threshold values to maintain water ecosystem services are still in discussion with sometimes contradictory viewpoints in catchment studies and water balance modeling approaches.

The work presented here incorporates a wide range of approaches: experimental and modelling work on micro- and macro catchment scale for two fast developing agricultural frontiers (Indonesia and Southern Amazonia (Mato Grosso - www.carbiocial.de). Knowledge of the experimental work was used for scale dependent parametrization of soil and vegetation parameters for two different models (SWAT, WASIM-ETH). With the help of these water balance simulation an estimation of land use change thresholds for critical runoff changes are determined and dicussed,

Similar to the regional change of yearly precipitation in the Amazon with a threshold around 40-60% deforested area (decrease of precipitation) our preliminary results shows a steep increase of runoff after 40-50% areal deforestation for small catchments. However, the model results for the macro catchments do not result in a clear signal for the relationship between deforested area and increase in river discharge (some scenarios result in runoff decrease).

The ambiguous results of the modelled scenarios suggest that the inclusion of more detailed knowledge in the model is relevant. For example across and within river basins feedbacks between deforestation and annual precipitation and land management practice (e.g. minimum tillage in the case of Mato Grosso) must be considered for modeling consequences of land use change on water balance and water provision. In conclusion, regional water balance modeling should include the complex interaction between climate (precipitation change) and bio-pedosphere (land use change).

RAINFOREST CONVERSION IN TROPICAL LOWLANDS INCREASES SEASONALITY OF NET PRIMARY PRODUCTIVITY AND LOWERS NUTRIENT RETURN TO THE SOIL

Martyna Kotowska[1], Triadiati Antono[2], Dietrich Hertel[1]

[1] *University of Göttingen, Göttingen, DE, mkotows@gwdg.de*
[2] *Bogor Agricultural University, Bogor, ID*

Ongoing conversion of rainforest in the tropics dramatically alters not only carbon storage and vegetation dynamics, but also nutrient cycling in these ecosystems. In the wet tropics temperature and photoperiod are relatively constant, however together with land-use change seasonal variation in rainfall and weather extremes are reported to increase. The goal of this study was to assess whether net primary productivity (NPP) is related to seasonal patterns in rainforest transformation systems and if nutrient return from these system vary among each other. We examined leaf litterfall, root litter production as well as stem wood growth of anatural old-growth forests, rubber agroforests under natural shade tree cover ('jungle rubber'), rubber monocultures, and oil palm plantations in Jambi province, Sumatra. We found an increased coefficient of variance (CV) for nearly all components of NPP from natural forest to all plantation systems. Leaf litterfall in rubber monocultures peaked during dry season, whereas it remained nearly constant in natural forest. Furthermore, the strongly artificially managed oil palm plantations show a nearly quadrupled root litter production in the dry season. Even though, total NPP was highest in oil palm plantations, nutrient return to the soil via leaf litter was significantly reduced for C, N, K, Ca, Mg, Mn and Na in all plantations, particularly in rubber monocultures causing high demand for fertilizer use.Under current land-use and climate change in tropical lowlands we expect further increases in seasonality of NPP in the landscape as well as potentially increasing drought stress and decreasing nutrient cycling in these originally subhumid and fertile regions.

SIMULATING TROPICAL FOREST CARBON STOCKS AND FLUXES IN A CHANGING WORLD USING AN INDIVIDUAL-BASED FOREST MODEL.

Rico Fischer[1], Andreas Huth[1]

[1]*Helmholtz Centre for Environmental Research – UFZ, Leipzig, DE, rico.fischer@ufz.de*

Large areas of tropical forests are disturbed due to climate change and human influence. Experts estimate that the last remaining rainforests could be destroyed in less than 100 years with strong consequences for both developing and industrial countries.

Using a modelling approach we analyze how disturbances modify carbon stocks and carbon fluxes of African rainforests. In this study we use the process-based, individual-oriented forest model FORMIND. The study regions are tropical rainforests in the Kilimanjaro region and Madagascar. Modelling above and below ground carbon stocks, we analyze the impact of disturbances and climate change on forest dynamics and forest carbon stocks. Droughts and fire events change the structure of tropical rainforests. Human influences like logging intensify this effect. With the presented results we could establish new allometric relationships between forest variables and above ground carbon stocks in tropical regions. Using remote sensing techniques, these relationships would offer the possibility for a global monitoring of the above ground carbon stored in the vegetation.

RESPONSE OF DISSOLVED ORGANIC MATTER IN ECOSYSTEM SOLUTIONS TO MODERATE N, P AND N+P ADDITIONS TO A TROPICAL MONTANE FOREST IN SOUTHERN ECUADOR

Andre Velescu[1], Jürgen Homeier[2], Wolfgang Wilcke[1]

[1]*Karlsruhe Institute of Technology, Institute of Geography and Geoecology, Karlsruhe, DE*
[2]*University of Göttingen, Institute of Plant Sciences, Göttingen, DE*

Environmental changes threaten biodiversity and functioning of natural ecosystems in the Tropics. The tropical montane forest on the Amazonian exposed slopes of the southern Ecuadorian Andes has experienced a strong increase in N deposition during the past fifteen years, which is also accompanied by reduced soil moisture due to increasing temperatures and unevenly distributed rainfall, allowing for longer dry spells. The observed N deposition can mainly be attributed to biomass burning resulting from the conversion of natural forests to agricultural land in the Amazonian Basin. Higher nutrient availability will impact the functioning and services of the studied ecosystem, which belongs to the biodiversity hotspots of the Earth.

In 2007, we established an interdisciplinary nutrient manipulation experiment (NUMEX) to understand the response of the forest ecosystem to increased nutrient input. Since 2008, we have applied 50 kg ha−1 a−1 of N, 10 kg ha−1 a−1 of P, 50 kg + 10 kg ha−1 a−1 of N and P in a randomized block design in the Reserva Biologica San Francisco at 2000 m a.s.l.

We observed an increased leaching of TOC and DON from the canopy in response to the N and N+P additions. In the litter leachate of the unfertilized plots, TOC and DON concentrations showed high seasonal variability and decreased significantly in the plots with P and N+P additions. TOC and DON fluxes were significantly lower in the combined N+P treatment compared to the control. These observations strongly indicate that the availability of P plays a key role in the mineralization of DOM in the organic layer. TOC/DON ratios, however, did not show any temporal trends. Our observations indicate an enhanced microbial activity which is co-limited by N and P. Thus, added N can be more efficiently used by the microbial community only if P availability is improved.

Merian Award Applicant

LITTER MIXTURE EFFECTS ON MICROARTHROPOD COLONIZATION AND MICROBIAL BIOMASS IN THE LITTER LAYER OF A TROPICAL MONTANE RAIN FORESTS IN SOUTHERN ECUADOR

Laura Margarita Sanchez Galindo[1], Olaf Butenschön[1], Franca Marian[1], Dorothee Sandmann[1], Valentyna Krashevska[1], Mark Maraun[1], Stefan Scheu[1]

[1] *J.F. Blumenbach Insitute of Zoology and Anthropology, Georg-August-University Göttingen, Göttingen, DE, laurysaga@hotmail.com*

The effect of litter mixture and litter traits (quality) on microarthropod colonisation and microbial biomass and activity in a tropical montane rain forest in southern Ecuador was assessed in a litterbag study. Leaf litter from four abundant tree species with different litter traits were collected at the study site at 2000 m a.s.l.. The litter material was cleaned and dried and litterbags with leaf monocultures and all possible two and four species combinations were placed in the field for 6 months.

Microbial biomass and activity in the litter material was measured and mobile soil animals were extracted by heat and determined, focusing on oribatid mites, which were determined to species level. Previous studies had shown that litter mixture is a major driver for decomposition processes at this study site, with accelerated litter mass loss in mixtures compared to monocultures after 6 month exposure in the field. By investigating colonization of the litter by microorganisms and soil arthropods further insight was gained into the mechanisms of these mixture effects. Both results on litter decomposition processes and colonization by soil biota including microorganisms and arthropods will be presented.

Merian Award Applicant

PREDICTING REGENERATION OF THE BRAZILIAN AMAZON USING A PROCESS-BASED MODEL AND EO DATA

Joshua Jones[1], Peter Bunting[1], George Petropoulos[1], Richard Lucas[2], Joao Carreiras[3]

[1]Aberystwyth University, Aberystwyth, UK, jsj8@aber.ac.uk
[2]University of New South Wales, Sydney, AU
[3]University of Sheffield, Sheffield, UK

Across the world, particularly in the tropics, the extent of forest clearance has been widespread. At present, few studies have been undertaken and little is known on the long-term effect of land use history following clearance, on forest recovery, a significant sink for atmospheric CO_2.

This study aimed at quantifying the capacity of regenerating forests in the Brazilian Legal Amazon (BLA) to recover carbon using a combination of Earth Observation (EO) data and the 3-PG forest growth model. As a case study, three sites were selected within the BLA, representative of different clearance histories on which extensive deforestation has occurred. Land use history for these areas was obtained from Landsat images time-series (1970's - present) analysis. The tree species diversity was calculated from forest inventory data collected during three field campaigns conducted in 1993, 1995 and 2014. This dataset was used to interpret the reflectance trajectories of these areas, which were used to identify alternative pathways of succession. An advanced sensitivity analysis (SA) based on the Gaussian process emulator was also carried out on the 3-PG model to identify its most sensitive model inputs when applying it to a mixed tropical rainforest. A parameter set for mixed tropical forests was identified using a Monte-Carlo simulation and by comparing simulated outputs to field data. These parameters were then used within 3-PG to provide yearly estimates of carbon sequestrated.

Results of our study showed that sites with a higher land use intensity accumulated biomass at a significantly slower rate than those used less intensively. Accumulation rates predicted from the model closely matched those calculated from the forest inventory data gathered at each site. SA results demonstrated scientifically credible behavior of the model and allowed identification of the most responsive model inputs and interactions. Findings also illustrated the suitability and potential of 3-PG process based model when combined with EO data as a way to forecast the productivity of mixed secondary successional forest in Brazil. Development of these methodologies has applications to other tropical ecosystems that have experienced a similar history of disturbance and can provide invaluable information for future land-use planning and REDD+ monitoring.

BLACKWATER FLOODPLAINS AND THE RESILIENCE OF AMAZONIAN FORESTS TO FIRE

Bernardo Flores[1,2,3], Milena Holmgren[2], Marten Scheffer[1]

[1]*Aquatic Ecology and Water Quality Management Group, Wageningen University, Wageningen, NL, mflores.bernardo@gmail.com*
[2]*Resource Ecology Group, Wageningen University, Wageningen, NL, mflores.bernardo@gmail.com*
[3]*Centre for Biosciences, Federal University of Rio Grande do Norte, Natal, BR, mflores.bernardo@gmail.com*

Extreme droughts have recently revealed the vulnerability of Amazonian forests to fires. Drought-driven fires kill trees and favor the expansion of herbaceous vegetation increasing forest flammability. This flammability feedback may become more important as climate variability increases with global warming. Most studies on fire ecology in the tropics have been conducted in upland ecosystems at forest-savanna borders and, more recently, at the deforestation frontier. Yet, few have assessed the effects of forest fires on Amazonian wetlands. We studied the effects of fire on forest resilience in blackwater floodplains and uplands of the Amazon using a combination of remote sensing data, field surveys and field experiments.

We found that in uplands across the Amazon forests are dense and savanna tree-cover levels are rare. In contrast, sparse tree-cover typical of savannas was present in floodplains towards the drier end of the Amazon basin. Our field surveys indicate that two fire events within 20 years can arrest the regeneration of burnt blackwater floodplain forests, maintaining a state characterized by sparse tree-cover and persistent herbaceous vegetation. Burnt floodplains progressively lose soil nutrients, indicating that a strong leaching process leads to soil degradation. Colonization of trees in these more degraded areas was dominated by species typical of floodplain savannas, suggesting a shift in tree community composition and structure. Upland forests, however, can burn several times and recover canopy closure within five years, likely because soil degradation occurs at a lower rate. Our results suggest contrasts in the resilience of upland and floodplain forests to fire, and highlight new mechanisms underlying the fragility of Amazonian forests.

COEXISTENCE OF TROPICAL FOREST AND SAVANNA AS ALTERNATIVE STABLE STATES

Arie Staal[1], Stefan Dekker[2], Chi Xu[3], Egbert van Nes[1]

[1]*Wageningen University, Wageningen, NL, arie.staal@wur.nl*
[2]*Utrecht University, Utrecht, NL*
[3]*Nanjing University, Nanjing, CN*

Analyses of satellite data have supported the hypothesis that tropical forest (±80% tree cover) and savanna (±10% tree cover) are alternative stable states (ASS) under a range of mean annual precipitation (MAP). Simple models predict that there is a critical MAP value for each state at which it loses its stability; in between these two tipping points, both states are stable. Such bistability suggests that the states can occur together until climatic change crosses a tipping point for one of them. However, when spatial interactions are included in the simple models, it is possible that over a large range of parameters there can be no stable boundary between both states: the least stable state is not resilient to intrusion of the most stable one. Thus, at given conditions the most stable state tends to dominate, but only if there is enough connectivity between modeled patches. Consequently, local coexistence of ASS becomes rare, except around a point of equal stability ("Maxwell point"). If this applies to forest and savanna, then their boundaries would shift in accordance with a spatial movement of the MAP at which forest and savanna have equal stability. We estimate this MAP for South America and Africa using tree-cover data. We show that it coincides with an increased probability of local coexistence of forest and savanna (local bimodality within 0.5° cells), although there is a wider MAP range of apparent bistability. These findings are consistent with a bistable system in which connectivity favors the most resilient state, which partly reduces the system's catastrophic behavior. Hence, we endorse the hypothesis that tropical forest and savanna may undergo catastrophic shifts, but also expect that climatic changes will cause more gradual shifts of forest-savanna boundaries than simple tipping-point models suggest.

SATELLITE MONITORING OF SPATIAL AND TEMPORAL PATTERNS OF BAMBOO FLOWERING AND WILDFIRES IN THE FORESTS OF THE ARAKAN MOUNTAIN RANGE (SOUTH EAST ASIA)

Francesco Pietro Fava[1], Roberto Colombo[1]

[1]*Department of Earth and Environmental Sciences, University of Milano-Bicocca, Milan, IT, francesco.fava@unimib.it*

A large scale mast flowering event of the semelparous bamboo *Melocanna baccifera* has occurred between 2006 and 2011 in the Arakan mountain range, which runs for about 950 km parallel to the North-East coast of the Bay of Bengal. Bamboo flowering, fruiting and mortality was observed in Mizoram and Manipur (India), East Chittagong (Bangladesh), Chin and Rakhine (Myanmar). Following bamboo fruiting, rodent outbreaks were reported across the region, causing serious damages to crops and a food security crisis. The event was not unexpected, as similar ones were described in the past with an approximate repeating cycle of 50 years. Although this event has been widely discussed in the scientific literature as well as in popular mass media, the documentation is mostly focused on the dramatic rodent outbreak and associated food security crisis. Scientific documents on the distribution of the bamboo flowering, fruiting and mortality, as well as on large scale ecological impacts other than rodent outbreaks are lacking. Wildfires are a remarkable example: according to a debated theory, known as fire-cycle hypothesis, the mass mortality of bamboo generate a widespread fuel load, which might increase the potential of wildfires ignition and propagation.

This study integrates different information sources, mainly from earth observation satellites, to investigate the spatial and temporal distribution of bamboo mast flowering in the region and its ecological impacts, with specific focus on wildfires. MODIS satellite NDVI time series were analyzed to identify greenness anomalies associated to bamboo flowering. The results obtained evidence the widespread distribution of the masting event. Large patches of bamboo flowered synchronously starting in 2006 in the Northern part of the region. Flowering continued with a spotty pattern southerly until 2010. Overall, bamboo flowering involved more than 30000 km^2 of open evergreen forests and shrublands. MODIS "Active fire" and "Burned area" products were analyzed to assess fire activity. An overall increase in wildfire occurrence was observed, generally within one or two years after flowering, with the total burned area in open evergreen forests and shrublands almost doubled during the event compared to previous years. Meanwhile, the burned area increase was mainly located in Chin and Rakhine, while no significant differences were observed in Mizoram and Chittagong. This pattern might be related to the land management policies, including fire prevention, implemented in the latter regions during the masting event.

ASSESSING THE RESILIENCE OF TROPICAL FORESTS TO INCREASED TEMPERATURE WITH IN SITU WARMING: LESSONS LEARNED FROM A NEW EXPERIMENT IN PUERTO RICO

Tana E. Wood[1,2], Sasha C. Reed[3], Molly A. Cavaleri[4]

[1]US Forest Service, Rio Piedras, PR, wood.tana@gmail.com
[2]Puerto Rico Conservation Foundation, San Juan, PR, wood.tana@gmail.com
[3]US Geological Survey, Moab, US
[4]Michigan Technological University, Houghton, US

Current literature suggests the tropics are likely to experience rapid and unprecedented increases in temperature in the coming decades. Understanding how such temperature change will affect tropical forests is of global concern due to the large percentage of the World's biodiversity supported by these systems, as well as the significant role that they play in regulating Earth's climate. Natural temperature gradients in the tropics offer great opportunities for understanding temperature effects on plant and ecosystem functioning; however, predicted temperature regimes are not present in the lowland tropics today and the warm ends of such gradients are likely to see further warming over the coming decades. Thus, the only way to achieve predicted temperature regimes for these systems is to manipulatively warm the warmest forests. Field-based warming experiments offer a powerful approach, yet such warming manipulations have remained missing in tropical ecosystems despite their widespread implementation in higher latitudes.

Here, we present the experimental design for the first field warming experiment in a wet tropical forest in Puerto Rico (Tropical Responses to Altered Climate Experiment; TRACE). This experiment utilizes a suite of *in situ* warming technology to investigate temperature responses of the most biogeochemically-active components of the system: canopy leaves, roots, and soil microbes. Using a mechanism-based approach to hypothesis testing, we aim to improve Earth System Model parameterization of pools and fluxes of water, carbon, and nutrients. We additionally expect this experimental framework will provide innumerable research opportunities for wide-ranging collaborative projects, including the effects of warming on: tree seedling demography, biogenic volatile organic carbon emissions, insects, roots and mycorrhizae, soil macro- and micro-fauna, and even reptiles and amphibians. With insight gained from this experiment we have the opportunity to further enhance our understanding of carbon cycling mechanisms in a changing climate.

DEVELOPING ANDEAN FUNCTIONAL BIODIVERSITY INDICATORS WITH REMOTE SENSING: THE POTENTIAL OF IMAGE TEXTURES

Christine Wallis[1], Yvonne Tiede[1], Isabel Pérez Postigo[1], Annika Niepoth[2], Birgit Ziegenhagen[1], Roland Brandl[1], Nina Farwig[1], Jörg Bendix[1]

[1]*University of Marburg, Marburg, DE, christine.wallis@biologie.uni-marburg.de*
[2]*Humboldt University, Berlin, DE*

Monitoring impacts of global environmental changes on biodiversity and ecosystem functioning of megadiverse tropical mountain forests is a challenging task: Species composition, its functional roles and feedbacks with the highly varying abiotic factors are complex. Especially, biodiversity-related indicators (e.g. indicator species) for ecosystem functions are not well studied in the high altitude tropics at larger scales, yet. To date, various studies analyse the capabilities of remote sensing data like discrete-return Lidar variables or satellite image textures, mostly to determine the spatial dimension of species diversity, without relations to ecosystem functions. Here, the derived metrics areparticularly used to determine inter- and intra-habitat heterogeneity of species composition by their dependence on horizontal and vertical vegetation structure. However, respective transfer functions can not only help to develop spatial-explicit indicator systems for determining species richness, but also its functional role. Besides direct species diversity indicators, we also hypothesize that phylodiversity can act as a surrogate for ecosystem processes which can be monitored by the help of remotely sensed data. In our presentation, we use image textures to develop spatial-explicit models for both, species and functional indicators. Regarding species composition we focused on the variables species diversity and community compositionfor birds and trees.To develop functional indicators, we considered phylodiversity herbivory and predation. For the latter, we chose the leave area loss of understory plants and canopy leaves as a proxy for herbivory, and the predation rate of birds and ants on artificial caterpillars as a proxy for predation. First results in modelling avian diversity and community composition revealed benefits of using image textures instead of Lidar-derived metrics. Our findings will thus provide deeper insights on the potential of image texture indicators as surrogate for biodiversity and ecosystem functions.

EFFECTS OF CLIMATE CHANGE ON KEYSTONE ANDEAN CLOUD FOREST SPECIES: A CASE STUDY OF ALNUS ACUMINATA AND ASSOCIATED FUNGI

Chritsian Wicaksono[1,2], Jesus Aguirre Guiterrez[1], Eduardo Nouhra[3], Nicolás Pastor[3], Niels Raes[1], Silvia Pacheco[4], József Geml[1,2]

[1]*Naturalis Biodiversity Center, Leiden, NL*
[2]*Leiden University, Leiden, NL*
[3]*Universidad Nacional de Córdoba, Córdoba, AR*
[4]*Fundación ProYungas, Yerba Buena, AR*

The Andean cloud forests (Yungas) are extremely diverse and rich in endemics. The Andean alder (*Alnus acuminata* Kunth) is a keystone early colonizer species restricted to the upper altitudinal zone of the Yungas (1500-3000 masl). Its key ecological role is due to the fact that *A. acuminatais* among the very few tree species capable of associating with both ectomycorrhizal and arbuscular mycorrhizal fungi as well as with nitrogen-fixing bacteria. While the generally negative effects of climate change on the potential distributions of several cloud forest animal and plant species have been studied, there is very little known on how the distribution of fungal species may shift in response to the predicted scenarios. In this study, we 1) estimated the current distribution of *A. acuminata* in the Tucuman-Bolivian Yungas using Species Distribution Modelling methods; 2) compared soil fungal diversity in the different altitudinal zones of the Yungas based on a DNA metabarcoding dataset; and 3) selected indicator fungal taxa that were significantly associated with alder-dominated montane cloud forests sites. In addition, we predicted the potential distribution of *A. acuminata* and the associated fungal indicator species for 2050 based on the available climate change scenarios. Current and future (2050) habitat models were developed based on *A. acuminata* occurrence data from GBIF using the package biomod[2] in R with an ensemble of five different algorithms and were used to develop habitat model for current situation and 2050 scenario. In addition, the models predicted susbtantialloss of the currently suitable area by ca. 2050. Although *A. acuminata* will likely colonize some new areas, the area with a suitable climate will likely be smaller in 2050 than at present.

IMPACT OF FUTURE CLIMATE AND LAND USE CHANGES ON DIVERSITY PATTERNS OF PLANT SPECIES USED FOR NUTRITION (BURKINA FASO)

Yvonne Bachmann[1], Sarah Cunze[1], Marco Schmidt[1,3,6], Salifou Traoré[2], Benjamin Stuch[4], Rüdiger Schaldach[4], Alexander Zizka[5], Adjima Thiombiano[2], Karen Hahn[1,6], Brice Sinsin[7], Oliver Tackenberg[1], Cyrille Chatelain[8], Georg Zizka[1,3,6]

[1]*Institute of Ecology, Evolution and Diversity, Goethe University, Frankfurt, DE, bachmann@bio.uni-frankfurt.de*
[2]*Department of Plant Biology and Physiology, University of Ougadougou, Ouagadougou, BF*
[3]*Department of Botany, Senckenberg Research Institute, Frankfurt, DE*
[4]*Center for Environmental Systems Research, Kassel, DE*
[5]*Department of Biological and Environmental Sciences, University of Gothenburg, Gothenburg, SE*
[6]*Biodiversity and Climate Research Centre (BiK-F), Frankfurt, Frankfurt, DE*
[7]*Laboratory of Applied Ecology, Faculty of Agronomical Sciences, University of Abomey-Calavi, Cotonou, BJ*
[8]*Conservatoire et Jardin Botanique de la Ville de Génève*

In West Africa rural people strongly depend on a variety of plant species to maintain their livelihoods. Climate and land use changes represent high risks for the diversity patterns of these plant species and endanger the wellbeing of the people. We studied the current and future (2050) diversity patterns of 263 plant species used for nutrition purposes in Burkina Faso in relation to climate and land use changes. Land use simulations were obtained from the LandSHIFT model under the assumptions of technological stagnation and technological change. We ran seven species distribution models implemented in Biomod and built a consensus model for each species based on weighted averages to decrease uncertainty. Our results reveal that future climate and land use changes severely impact the diversity patterns of nutrition plant species in Burkina Faso. The most important diversity patterns are presently situated in the North-Sudanian agro-ecological zone. By 2050 this zone will have faced a severe diversity loss and the main nutrition plant species diversity patterns will then be distributed in the South-Sahelian agro-ecological zone. This shift northwards and the resulting species gain there are induced by the future increase in annual precipitation. Regarding the drivers climate and land use change, climate change will affect the future diversity patterns of nutrition species more seriously than land use change. However, technological improvements in the agricultural sector lead to higher future diversity patterns in the North-Sahelian and South-Sudanian agro-ecological zones compared to the modeled diversity patterns under the assumption of technological stagnation. We conclude that future nutrition plant species diversity patterns in Burkina Faso react differently to climate and land use changes depending also on the current conditions.

HOW FOREST MODELING CAN IMPROVE REMOTE SENSING OF TROPICAL FOREST BIOMASS

Nikolai Knapp[1], Rico Fischer[1], Andreas Huth[1]

[1]*UFZ, Leipzig, DE, nikoknapp@posteo.de*

Remote sensing has improved our abilities of forest monitoring remarkably over the past years. In particular, light detection and ranging (LiDAR) allows us to derive scans of forest structures. Various LiDAR metrics have been shown to correlate well with structural forest properties, e.g. above ground biomass. However, calibration of LiDAR-to-biomass-relationships relies on ground truth data from field inventory plots. Manual field data collection is laborious and thus plots for ground truthing are limited in number, extent, successional stage and number of measured tree attributes. To overcome these limitations, we went a new way by combining forest modeling with LiDAR simulations. Instead of using collected inventory data we ran computer simulations of tropical rainforest dynamics with the model FORMIND. With FORMIND we can simulate the development of arbitrarily large plots of rainforest under different disturbance regimes. Its simulations provide information on a wide variety of tree and ecosystem attributes. A newly developed LiDAR model can subsequently sample the virtual forest to create a 3D point cloud. Hence, we can obtain large quantities of virtual forest inventory data and corresponding LiDAR data. This unique type of dataset allows us to systematically screen for the best methodology of processing remote sensing data with the aim to predict any kind of forest variable. In a first application of our approach we tested different LiDAR metrics for their potential to predict biomass of the rainforest on Barro Colorado Island (BCI), Panama. We included fires in the forest simulation. The forest succession after fire events created a heterogeneous dataset, covering a much wider range of biomass classes than available from the BCI 50 ha forest observation plot. Several LiDAR metrics turned out as good biomass predictors, including some that had not been applied on tropical forests before. For the future, we see great potential of our in silico ground truthing approach in the search for remote sensing metrics that go beyond static biomass prediction by directly detecting annual carbon dynamics from forest structure.

Merian Award Applicant

MONITORING OF FUNGAL COMMUNITIES ON REFORESTATION PLOTS AND PRISTINE FOREST: CLONING AND SANGER SEQUENCING VERSUS DEEP SEQUENCING.

Ingeborg Haug[1], József Geml[2], Juan Pablo Súarez[3]

[1]*Evolutionary Ecology of Plants, Tübingen, DE, ingeborg.haug@uni-tuebingen.de*
[2]*Naturalis Biodiversity Center, Leiden, NL*
[3]*Universidad Technica Particular Loja, Loja, EC*

Fungi are fundamental to the functioning of almost every ecosystem. In the tropical mountain forests they serve as one of the principal decomposers and they are involved in mutually beneficial mycorrhizal associations with most of the plants. Because of limiting morphological structures molecular analyses are necessary to get insight in the fungal communities. Most AM diversity data are based on cloning and Sanger sequencing of clones. Since several years this method was used for the monitoring of arbuscular mycorrhizal fungi in pristine forest and reforestation plots in the tropical mountain rain forest of South Ecuador. Recent studies have adopted next generation sequencing technologies for fungal community analysis which overcome the cloning step and provide orders of magnitude more data while saving time, labour and financial costs. However the sequence lengths are still narrow and necessitate another choice of primers. To compare the influence of primers and methods on the composition of the fungal communities we investigated in parallel 24 mycorrhizal samples (*Cedrela montana, Tabebuia chrysantha*) of reforestation plots and pristine forest, respectively. The PCR for cloning and Sanger sequencing was done with a nested PCR using the primer pairs NS1/NS4 and AML1/AML2. For Ion Torrent sequencing the primer pairs AMV4.5NF/AMDGR and fITS7/ITS4 were used. The latter primer pair is universal for all fungi and allows insights in the community of Asco- and Basdiomycota beside of Glomeromycota. Preliminary results of Ion Torrent sequencing indicate a very strong effect of the habitat, the effect of the host is rather weak. We review the different approaches for further use in monitoring of fungal communities.

SENSITIVITY INDEX AS NEW TOOL FOR ASSESSMENT OF LOCAL BIODIVERSITY

Dušan Jelić[1], Mikael Hietala[1]

[1]*Croatian Institute for Biodiversity, Croatian Herpetological Society HYLA, Zagreb, HR, jelic.dusan@gmail.com*

There are several global methodologies for assessment of plants and animals, IUCN Red listing being the most famous one. Here at least one of four criteria is used to assess species risk of extinction. ZSL EDGE of existence is another global level assessment where IUCN status is combined with evolutionary distinctiveness to define Worlds most threatened and evolutionary distinct animals. But both of these two only assess the sensitivity after the species is already in visible decline and if there is enough local research to confirm these criteria. These are both systems developed for developed north-western countries where biodiversity is generally lower, already there is severe damage to the ecosystems and level of expert and scientific research is very high. On the other hand this criteria work very poorly in developing countries that maintain the highest proportion of World biodiversity, their nature is now in the process of being destroyed and there is shortage of expert and scientific capacities. All of this contributes that we only register the decline after it has become very severe and cases occur where animals go extinct before the decline is noticed. Baseline is that in these areas we need to assess the sensitivity of the species and ecosystem before they go into any kind of decline. We tested the new methodology for Sensitivity Index assessment based on 15 ecological, behavioural and anthropogenic criteria on 53 Amphibian species registered in Nepal. All criteria were broken in four categories (0, 1, 2, 3 points), always characteristics were ordered from lowest to highest contribution to sensitivity. Overall mean index of all criteria was calculated for all species and plotted against their known geographical distribution in ESRI ArcGIS 10.2. to define the Amphibian Important Areas in Nepal. Sensitivity Index was proven as very good toll as the assessment has shown statistically significant correlation ($p<0,001$) with IUCN global status of tested species.

Merian Award Applicant

RESILIENCE INDICATORS AND DISTRIBUTION-SHIFT OF NATIVE TREE SPECIES IN CONTINENTAL ECUADOR ACCORDING TO PREDICTED ENVIRONMENTAL CHANGE

Carlos Manchego[1,2], Augusta Cueva[2], Sven Günter[3]

[1]*Technische Universität München, Munich, DE, cemanchego@utpl.edu.ec*
[2]*Universidad Tecnica Privada de Loja, Loja, EC, cemanchego@utpl.edu.ec*
[3]*Johann Heinrich von Thünen Institute, Braunschweig, DE*

Many people living in tropical regions depend directly on the forest as resource for income, food, construction, energy and medicine. In the tropical mountains of Ecuador these human activities promote land-use change, which together with the effects of climate change can pose a major threat to conservation. One counter-measurement to prevent the negative impacts is to improve current forest management strategies, paying special attention to the resilience of forest species against environmental change. This study uses species distribution models to assess the potential impact of climate change on the geographical distribution of important tree species native to continental Ecuador. Tree species were selected based on the relative importance for local livelihoods, e.g. providers of timber or non-timber forest products; as well as their importance for biodiversity, whether they are considered as umbrella species or classified as threatened by the IUCN red list. We obtained geographical distribution of species from national and international herbaria and other databases. In order to construct current and future species distributions, we used Maxent based on Worldclim scenarios and IPCC last assessment report. Our findings predict that suitable habitat of most tree species will shift in their location. In the case of long-lived species i.e. timber species, this could occur as soon as only 50 years from now. Future steps of this study, will attempt to answer how resilient these tree species are individually to new environmental factors e.g. CO_2 concentration, temperature increases and deficit or surplus of rainfall values. To evaluate the resilience on a species by species basis, we propose three approaches, 1) molecular analysis to see the genetic diversity among different tree provenances, 2) comparative studies of dendrochronology belonging to dissimilar habitats and 3) seed germination tests under the new predicted climate conditions.

RESILIENCE OF TROPICAL FORESTS TO HUMAN IMPACT: A DATA-DRIVEN COMPLEX SYSTEMS APPROACH

Bert Wuyts[1], Alan Champneys[2], Jo House[3]

[1]*Bristol Centre for Complexity Sciences, Bristol, UK, bert.wuyts@bristol.ac.uk*
[2]*Engineering Mathematics, Bristol, UK*
[3]*School of Geographical Sciences, Bristol, UK*

In complex environmental systems such as tropical rainforests, it is often not feasible run ecosystem-scale experiments. Additionally, there will be always variables that cannot be fully controlled. Therefore, environmental scientists usually rely on simulation models, data analysis or a combination. Earth system simulation models can be seen as our best attempt to synthesize environmental processes in a computer model under computational constraints but their complexity can make their output often difficult to interpret. Likewise, the idea that complex behaviour can emerge from a limited set of simple rules suggests that at least for some cases we do not need such advanced models to understand system behaviour.

In this study, we make an attempt to analyse and model the core complexity of the world's tropical forest's dynamics from a complex systems perspective. We start from recent insights in savanna ecosystem theory, that sees the local environment as in three possible stable tree cover states (forest, savanna or treeless). We estimate the bifurcation diagram from high-resolution remote-sensed tree cover data and merged remote sensed - gauge rainfall and find that human impact considerably affects the derived hysteresis and resilience.

We finally set up an ecosystem-scale model, derived from tree cover data by a reconstruction of the system's potential using the steady state solution of its Fokker-Planck equation. We estimate model structure and parameters for human-impacted and natural dynamics separately.

SESSION 4

S4 - INTERACTION NETWORKS AND CONSERVATION

Chairs: Christopher Kaiser-Bunbury and Nina Farwig
Contact: ckaiser-bunbury@bio.tu-darmstadt.de

MAINSTREAMING NETWORK ECOLOGY IN APPLIED CONSERVATION

Christopher Kaiser-Bunbury[1]

[1]*Ecological Networks, TU Darmstadt, Darmstadt, DE, ckaiser-bunbury@bio.tu-darmstadt.de*

Mutualistic interactions such as pollination are critical ecosystem processes. Community ecologists use network analysis tools to shed light on the complexity of mutual dependencies in an ecosystem context. In recent decades network ecologists have made substantial theoretical advances in describing the structure, and understanding the dynamics of mutualistic networks. These co-evolved and inherently robust networks have become increasingly fragile and rarefied by anthropogenic disturbance. To address the threats to ecosystem processes, conservation practitioners implement management measures, which aim to preserve native biodiversity and restore plant and animal communities. Many conservation activities, however, apply trial and error due to various constraints. Guiding principles based on ecological theory are needed, and effectiveness monitoring is critical for adaptive management. Here, I introduce a pathway for mainstreaming network ecology in applied conservation. Specifically, I will present a framework on how ecological indicators derived from plant-pollinator network analysis can be harnessed to advance conservation action on the ground. These indicators can be used to evaluate how best to achieve continued progress towards long-term conservation goals.

MUTUALISTIC NETWORKS AND COMMUNITY STABILITY - A GUIDE FOR EMPIRICISTS

Gita Benadi[1]

[1]*University of Freiburg, Freiburg im Breisgau, DE, gita.benadi@biom.uni-freiburg.de*

Mutualistic networks are a useful tool to describe the complex structure of mutualistic interactions between species-rich communities such as plants and their pollinators or seed dispersers. Understanding how the properties of these networks (e.g. connectance, nestedness) influence community stability is not only relevant for the development of ecological theory, it has also important implications for the conservation of communities engaged in mutualistic interactions. Since the relationship between network structure and stability is difficult to study empirically, research on this issue has focused on analyses of mathematical models, most of them extensions of the classical Lotka-Volterra competition equations. However, the results of these analyses are often equivocal, with some authors claiming that (for example) nestedness increases community stability, while others find the opposite pattern.

Here, I describe how these contradictory findings result from differences in model assumptions and stability measures. I discuss which features a minimally adequate model of mutualism should incorporate and show examples of how the predictions of such a model differ from previous results on network structure and stability. Finally, I consider the implications of these results for the management of mutualistic communities subject to multiple anthropogenic disturbances.

THE RESTORATION OF SPECIES INTERACTION NETWORKS

Daniel Montoya[1], Jane Memmott[1], Miguel Lurgi[2], Fernanda Ribeiro da Silva[3,4], Rafael Furtado[3], Marco Aurelio Pizo[3], Ricardo Ribeiro Rodrigues[4]

[1]University of Bristol, Bristol, UK, daniel.montoya@bristol.ac.uk
[2]University of Adelaide, Adelaide, AU
[3]Universidade Estadual de Campinas, Sao Paulo, BR
[4]Universidade de Sao Paulo, Sao Paulo, BR

Network perspectives of biological communities are increasingly recognized as an important tool for guiding conservation policies. The reason for this is that network properties underpin many aspects of the structure and stability of biological communities, as well as the provision of fundamental ecosystem functions and services such as pollination, decomposition, pest control, and water regulation. Because the aim of ecological restoration is to restore not only biodiversity but also the functioning of ecosystems, the information provided by network approaches is highly relevant for restoration projects that seek to recover stable and functional communities. In this talk I will present examples of how species interaction networks approaches can be applied in restoration ecology. Recent findings related to community recovery trajectories and some important restoration outcomes will be presented, including (i) a theoretical model that simulates complex interaction networks and their recovery dynamics under restoration, (ii) an observational study on the restoration of seed-dispersal networks in the Brazilian Atlantic forest, and (iii) a field experiment investigating the recovery of complex food webs in salt marsh ecosystems. These studies suggest that, in order to successfully fulfil the restoration objectives stated by the Convention of Biological Diversity, a network approach of ecological interactions is key.

CONSERVATION BIOGEOGRAPHY: INTERACTION NETWORKS MATTER

Bo Dalsgaard[1]

[1]*Center for Macroecology, Evolution and Climate, Natural History Museum of Denmark, University of Copenhagen, Copenhagen, DK, bo.dalsgaards@gmail.com*

Disturbance – both natural and anthropogenic – may disrupt interactions between species, changing community structure and possibly causing especially specialized species to go locally extinct. In order to conserve communities of species, it is therefore important to understand how disturbance affect the web of interactions between species. Here I take a biogeographical approach to examine the influence of historical climate-change and current anthropogenic impact on mutualistic plant-animal interaction networks. I show that plant-pollinator networks are more modular and plant-hummingbird networks more specialized in areas having experienced stable temperatures since the Last Glacial Maximum. Furthermore, our results supported a positive relationship between the proportion of smaller-ranged hummingbird species and community-level specialization, even when accounting for contemporary and Quaternary climate stability. For plant-frugivore bird networks current human impact limit modular organization, i.e. geographically the most modular plant-frugivore networks are were human impact is the least. These results have implications for conservation of species engaging in mutualistic associations, highlight the importance of conservation strategies aimed at specialized/modular communities with high proportions of smaller-ranged species as they may not only be vulnerable to disturbance because of the species' small ranges, but also because they are ecologically more specialized. I discuss how these results may be used in conservation planning.

IDENTIFYING THE RELATIVE IMPORTANCE OF FOREST PATCH CHARACTERISTICS FOR BIRD GUILDS: A LANDSCAPE-WIDE NETWORK APPROACH

Ingo Grass[1,2], Pedro Astudillo[2,3], Edwin Zárate[3], Nina Farwig[2]

[1]Georg-August-Universität Göttingen, Göttingen, DE, ingo.grass@agr.uni-goettingen.de
[2]Philipps-Universität Marburg, Marburg, DE, ingo.grass@agr.uni-goettingen.de
[3]Universidad del Azuay, Cuenca, EC

In an ever more human-shaped world, a better understanding of associations between fragmented habitats and species in mosaic landscapes becomes increasingly important. So far, these associations have mostly been investigated based on correlations, and in an isolated, patch-by-patch manner. Yet, mobile taxa such as birds often use and connect multiple habitat patches, resulting in habitat-species networks. Here, we studied networks composed of Polylepis forest patches and three habitat guilds of birds (i.e. Polylepis specialists, generalist birds that use both Polylepis and surrounding á habitats, and á specialists) in the high-altitude Andes of Ecuador. We used centrality indices of Polylepis patches within these networks as a measure of their relative importance for birds within a given guild. Patch centrality differed considerably depending on guilds and patch characteristics. For Polylepis specialists, patch centrality decreased with larger and more irregularly shaped patches, but increased with higher altitude. In contrast, patch centrality for generalist birds was positively related to patch area and shape irregularity, but not to patch altitude. Increasing influence of the surrounding á vegetation reduced the patch centrality for both Polylepis specialists and generalist birds. Patch centrality for á specialists was not related to the recorded patch characteristics. In conclusion, the relative importance of forest patches for Polylepis specialists in our study area is driven by characteristics related to the quality but not the quantity of available habitat, whereas forest generalists depend on larger Polylepis patches and positively respond to edge effects. A network approach facilitates identifying those patches that are crucial contributors to the overall structure of the habitat-species network at the landscape scale. Thus, our approach is a promising tool to guide conservation decisions and landscape planning in mosaic landscapes.

Merian Award Applicant

THE RELATIONSHIP BETWEEN MORPHOLOGY AND FUNCTIONAL ROLES OF SPECIES IN INTERACTION NETWORKS

Matthias Dehling[1]

[1]*Biodiversity and Climate Research Centre (BiK-F), Frankfurt, DE, matthias.dehling@senckenberg.de*

The concept of functional diversity assumes that species' traits reflect their functional roles. However, this relationship has never been tested for species interactions. Here, I introduce and test a framework for assessing whether species' morphologies reflect their functional roles in mutualistic networks. Using data from plant-bird interactions and multivariate statistics, I tested whether the morphologies of species correspond to the morphologies of their interaction partners and whether morphological differences between species correspond to differences in their interaction partners. I also tested whether morphologically specialised species fulfil specialised functional roles. With the new framework, I identified strong links between the morphologies of species and their functional roles. The framework can be used to identify functionally important species by their traits and by the traits of their interaction partners in all types of bipartite interaction networks. The framework can also be extended to infer unknown interactions between co-occurring species from functional traits.

Merian Award Applicant

MEASURING HERBIVORE HOST SPECIFICITY IN PHYLOGENETIC CONTEXT: METHODS AND EXAMPLES FROM NEW GUINEA RAINFORESTS

Vojtech Novotny[1,2], Leonardo Re Jorge[3], Thomas Lewinsohn[3]

[1]Czech Academy of Sciences, Ceske Budejovice, CZ, novotny@entu.cas.cz
[2]University of South Bohemia, Ceske Budejovice, CZ, novotny@entu.cas.cz
[3]UNICAMP, Campinas, BR

Host specificity is a key functional parameter in food webs, but also a phylogenetically constrained result of the host-parasite/predator evolution. These two perspectives lead to different measures of host specificity, taking into account the phylogeny of hosts, or both hosts and consumers, or neither of these groups. Here we demonstrate new host specificity measures incorporating host phylogeny and apply them to extensive data on plant-insect herbivore food webs from New Guinea lowland rainforests. We are using these results to discuss the ecological importance of host specificity, particularly for the possible role of herbivores as density-dependence agents maintaining the diversity of tropical vegetation.

SESSION 5

S5 - INTENSIFICATION OF TROPICAL AGRO-ECOSYSTEMS

Chairs: Christian Andres and Gurbir S. Bhullar
Contact: christian.andres@fibl.org

BIRDS AND BATS IN TROPICAL AGROFORESTRY LANDSCAPES - MULTITROPHIC INTERACTIONS AND CROP YIELD

Bea Maas[1], Yann Clough[1,2], Teja Tscharntke[1]

[1]Georg August University, Goettingen, DE, beamaas@gmx.at
[2]Centre for Environmental and Climate Research, Lund, SE

Birds and bats are effective predators of arthropods, an ecosystem service significantly linked to human welfare and of particular importance in tropical agroforestry systems. Negative impacts of land-use change on predators can affect insect communities and plant productivity, but biocontrol services are still largely unquantified. We analyzed the impact of birds and bats on arthropods and crop yield in Indonesian cacao agroforestry. In an exclosure experiment on 15 cacao plantations, we manipulated the access of birds and bats on cacao trees (day, night and full exclosures, open control). We investigated, for the first time, the effect of predator exclosures on the abundance of arthropods on the cacao trees (phytophagous insects, aphids, predatory ants and spiders), fruit development and crop yield for 15 months. Unlike previous studies, we investigated the contingency of the effects on local and landscape scales (gradients of shade tree cover and distance to primary forest of the Lore Lindu National Park).

As expected, arthropod densities, depending on their main feeding preferences and activity period, significantly increased in the exclosures. We found that fruit development was negatively affected in all exclosure treatments, with the full exclosure of birds and bats decreasing crop yield by more than 30%. These dramatic yield effects, which correspond to a loss of 730 USD per ha and year, were consistent across local and landscape changes. Our results highlight the tremendous economic impact of birds and bats for cacao agroforestry and the importance of multitrophic interactions for cacao fruit development. The consistency over the plantations investigated suggest, that common bird and bat species of the agricultural landscape provide substantial ecosystem services and should be an essential part of a sustainable use of natural resources and agricultural land in tropical landscapes.

Merian Award Applicant

DIVERSITY RESPONSE OF BIRDS TO ENRICHMENT PLANTINGS IN OIL PALM PLANTATIONS ON SUMATRA, INDONESIA

Miriam Teuscher[1], Anne Gérard[1], Miriam Vorlaufer[1], Bambang Irawan[2], Yeni Mulyani[3], Dirk Hölscher[1], Holger Kreft[1], Meike Wollni[1], Yann Clough[1], Ulrich Brose[1]

[1]Georg-August Universität Göttingen, Göttingen, DE, miriam.teuscher@biologie.uni-goettingen.de
[2]University of Jambi, Jambi, ID
[3]Bogor Agricultural University, Bogor, ID

Global land-use change has drastic consequences for biodiversity leading to losses of ecological functioning, ecosystem services and human well-being. While species dependent on undisturbed natural habitat are most affected by conversion to agriculture, even populations of disturbance-tolerant species can be endangered in landscapes dominated by high-input mono-cultural cropping systems such as oil palm plantations. Thus, the re-establishment of diverse habitats by restoring ecological multi-functionality in oil palm landscapes is urgently needed. It is, however, largely unknown, how, if, and at what cost a diversity of species can be conserved in such habitats.

In a pilot study for an enrichment planting experiment, we investigatedthe relationship between bird diversity and economic outcomes of remnant or planted trees in smallholder oil palm plantationsin the province of Jambi, Sumatra.Our results show that there is a win-lose relationship between ecological and economic functions but also that there is room for tree-based enrichment of intensively managed oil palm plantations, where a relatively high increase in bird species richness could be achieved at relatively low cost.

In a next step, we established an enrichment planting experiment on a mono-cultural oil-palm plantation in the Jambi Province to investigate experimentally, under which planting strategy and at what cost biodiversity and ecological functions can be restored. We created 48 tree islands and systematically varied plot size, tree species identity and tree species richness following a random partitions design with four partitions series.

Preliminary results indicate that, at this stage of the experiment, there is no effect of plot size, tree species richness and tree species identity on bird diversity. Based on further results, we aim to evaluate the effectiveness of this enrichment planting to contribute to the development of ecologically improved management concepts in oil palm landscapes.

LEAF-TENT ARCHITECTURE AND FIRST REPORTED USE OF AMERICAN OIL PALMS (ELAEIS OLEIFERA) BY PETERS' TENT-MAKING BAT URODERMA BILOBATUM IN PANAMA

Patrick Cvecko[1], Stefan Brändel[1,2], Thomas Hiller[1,2], Marco Tschapka[1,2]

[1]Institute for Evolutionary Ecology and Conservation Genomics, Ulm, DE, Patrick.Cvecko@hotmail.de
[2]2Smithsonian Tropical Research Institute, Balboa Ancón, Panama City, PA

More than half of the known bat species worldwide rely on plants as roosting sites. This strong relationship is most diverse in tropical forests, where a group of so called "Tent-making bats" have specialized to roost under modified leafs of various trees and understory plants. The first bat species reported to roost under modified leaves was *Uroderma bilobatum* with the distinctive vernacular name "Peters` Tent-making Bat". So far, *U. bilobatum* is known to use 19 different plant species. Here, we report the American Oil Palm *Elaeis oleifera* as an additional plant species used by *U. bilobatum* and analyze the tent structure.

Tent characteristicswere measured on twelve leaf tents in fronds of *E. oleifera* palms. We found a uniform modification pattern mainly consistent of a cut line of modified leaflets tapering apically towards the midrib of the frond. The resulting V-shaped pattern is a common characteristic of *U. bilobatum* reported from tents in large and broad pinnate leaves. We compared these architectural patterns to tent roosts of *U. bilobatum* in *Cocos nucifera* of another study and found similarities probably caused by the close similarity between the leaf shapes of these two palm species.

This flexibility in the use of different plant species as roosting sites could explain the wide distributional range of *U. bilobatum* from southern Mexico to the South-east of Brazil.

Merian Award Applicant

IMPACTS OF LOGGING AND OIL PALM PLANTATIONS IN MALAYSIAN BORNEO ON STREAM ENVIRONMENTAL CONDITIONS AND MACROINVERTEBRATE COMMUNITIES

Sarah H. Luke[1], Anand Nainar[3], Rory P. D. Walsh[2], Holly Barclay[4], David C. Aldridge[1], William A. Foster[1]

[1]*Department of Zoology, University of Cambridge, Cambridge, UK, sarah.h.luke@gmail.com*
[2]*Department of Geography, Swansea University, Swansea, UK*
[3]*Water Research Unit, School of Science and Technology, Universiti Malaysia Sabah, Kota Kinabalu, MY*
[4]*School of Science, Monash University Malaysia, Kuala Lumpur, MY*

Freshwaters provide essential ecosystem services and functions, and habitat for lots of species. However, freshwater ecosystems are increasingly threatened, in particular by catchment land use change. Conversion of natural habitats to agricultural, urban or industrial uses causes dramatic changes in flow and inputs of sediment and organic matter into the waterways that run through them. In Southeast Asia, tropical rainforest streams are increasingly being affected by rapid expansion of rainforest logging and oil palm cultivation, but research into the impacts of these activities on freshwater systems has been very limited.

We consider how catchment land use affects average in-stream environmental conditions and the occurrence of extreme flooding events, along with associated macroinvertebrate communities. Macroinvertebrates form a major part of the freshwater biota and changes in their assemblages are likely to have significant impacts on ecosystem function. We studied streams in pristine forest, logged forest of varying quality, oil palm plantations with riparian buffer strips and oil palm with no buffers, at the Stability of Altered Forest Ecosystems (SAFE) Project, in Sabah, Malaysia. In-stream conditions were measured through a combination of continuous monitoring at hydrology stations and single measurements from stream transects, whilst forest quality was assessed by analysis of remote sensing images and on-the-ground measurement. We surveyed benthic insect larvae at matched points in the stream using a Surber sampler.

Streams in more disturbed catchments showed changes in in-stream environmental conditions, occurrence of flooding and macroinvertebrate assemblages that were able to persist. This indicates that recent logging and oil palm expansion in Malaysian Borneo, and likely wider Southeast Asian tropical forests, has significant impacts on in-stream conditions and freshwater biodiversity. However, strategies such as riparian buffers strips might go a long way towards mitigating the impacts of catchment land use change and should be developed further.

CAN ORGANIC AGRICULTURE OFFER A SUITABLE SOLUTION TO SUSTAIN THE TROPICAL AGRICULTURE?

Gurbir S. Bhullar[1]

[1]*Research Institute of Organic Agriculture-FiBL, Frick, CH, gurbir.bhullar@fibl.org*

In the past century, conventional agriculture contributed to a net increase in global food availability by intensification of agricultural production. This development was often accompanied by deteriorating natural resources, caused by inefficient use of fertilizers, pesticides and fossil energy. Continuing with the same approach is therefore deemed as unsustainable. A more system-oriented approach like organic agriculture is preferable because it builds on the efficient use of available resources and the use of locally adapted technologies. Especially in the risk-prone tropical ecosystems with burgeoning population the system-oriented approach has a potential. However, organic agriculture has been criticized for not being able to 'feed the world', and further for low labor productivity and high production risks. To establish a scientific basis for discussions on the performance and potential of organic agriculture compared to the conventional production systems in the tropics, FiBL is running the long-term farming systems comparison (SysCom) program in Kenya, India and Bolivia. Since 2007, organic and conventional management systems are being compared in long-term field trials, using country-specific crop rotations and cultivation methods. The main focus in India is on cotton and soybean, Bolivia on cocoa and Kenya on corn and field vegetables. Besides, in Bolivia we compare monocultures with more diverse agro-forestry systems. Data on agronomic, economic and environmental parameters is collected and analyzed to evaluate the sustainability and resilience of each management system. In addition, we use the methodology of participatory on-farm research to involve all major stakeholders particularly the end users of research (farmers) for the development of locally adapted innovative technologies for sustainable agricultural systems. To provide empirical evidence on the advantages/disadvantages of organic agriculture in comparison to conventional farming systems, the major findings from the long-term research trials in the three countries will be presented and the outcomes of participatory research will be shared.

CANOPY OPENNESS AND PHOTOSYNTHETIC ACTIVE RADIATION IN DIFFERENT COCOA PRODUCTION SYSTEMS IN ALTO BENI, BOLIVIA

Wiebke Niether[1], Consuelo Campos[3], Monika Schneider[2], Gerhard Gerold[1]

[1]*Department of Landscape Ecology, University of Göttingen, Göttingen, DE*
[2]*FiBL, Frick, CH*
[3]*Universidad Internacional de Andalucia, Cordoba y Sevilla, ES*

Agroforestry systems are characterized by their different strata and at least one agronomic used species that grows in the shadow of one or several tree species. In this kind of systems light is usually a limiting factor. Cocoa as a tropical perennial tree species produces well under shaded and non-shaded conditions, both having their advantages and disadvantages in terms of production, ecology, and system sustainability. Shaded cocoa agroforestry systems are often described and discussed, but the fact that shade is not a steady-state but a dynamic process in natural and especially in anthropogenic systems is rarely mentioned.

The canopy above the cocoa is influenced by the selection of shade tree species and tree spacing but also by management just as pruning. Pruning is an agronomic tool for tree maintenance, flower and fruit development, and disease control. While a term of "less than 50%" of shade for cocoa is recommended in farmers manuals, this study shows that the canopy openness above the cocoa in agroforestry systems estimated by hemispherical photography with an angle of 180° varies from 24% openness before intervention to 56% openness after a drastic pruning event. Therefore, recommendations have to be interpreted within a broad range depending also on the viewpoint and methodology of estimation. Furthermore, shade trees and cocoa themselves permit growth of vegetation such as leguminous herbs depending from light input. Photosynthetic active radiation was measured below the cocoa layer before and after the pruning showing variations for possible photosynthetic activity of soil covering vegetation in cocoa monocultures and agroforestry systems.

Species selection influences shading since some tropical species are leaf shedding during dry seasons, or have different shape of crown and canopy density. Description of the shading properties of seven shade tree species show the different shading characteristics within the genus *Inga*, used as shade trees in tropical America.

CLASSIFICATION OF ARABICA COFFEE AGRO-ECOSYSTEMS IN MOUNT ELGON, UGANDA - A BASIS FOR TRADE-OFFS ANALYSIS

Eric Rahn[1,2,3], Theresa Liebig[2,3,4], Laurence Jassogne[3], Peter Läderach[2], Piet van Asten[3], Philippe Vaast[5,6], Jaboury Ghazoul[1], Claude Garcia[1]

[1]Department of Environmental Systems Science, Institute of Terrestrial Ecosystems, ETH Zurich, Zurich, CH, eric.rahn@usys.ethz.ch
[2]International Center for Tropical Agriculture, Cali, CO, eric.rahn@usys.ethz.ch
[3]International Institute of Tropical Agriculture, Kampala, UG, eric.rahn@usys.ethz.ch
[4]Institute of Horticultural Production Systems, Departement Phytomedicine, Gottfried Wilhelm Leibniz Universität, Hannover, DE
[5]World Agroforestry Centre, Nairobi, KE
[6]Centre de coopération internationale en recherche agronomique pour le développement, Montpellier, FR

Coffee intensification and its environmental impact has been documented extensively in the last two centuries, particularly in Latin America. Coffee systems of East Africa on the other hand are still under researched, despite their socio-economic and environmental importance in the region. Arabica coffee systems predominate on many East African mountains and constitute a mayor land-use type bordering the remaining tropical montane forest cover. Depending on how coffee is managed it can retain substantial biodiversity and provide many other essential ecosystem services particularly relevant for vulnerable mountain slopes prone to erosion. But if new coffee plantations are set up at the expense of forest, the environmental impact is severe.
In this study we assessed the range of Arabica coffee systems along an altitudinal gradient on Mount Elgon, Uganda. A typology of coffee systems was derived based on extensive field work on 150 coffee plots. A range of variables on vegetation structure was measured, and variables on management, production, and livelihood aspects were gathered through farmer questionnaires. The systems were classified into 3 groups based on statistical analysis of the vegetation structure components, namely coffee open sun, coffee banana, and coffee tree systems. Remote sensing images were used for landscape scale analysis. A literature review allowed for a comparison of the Mount Elgon systems with other systems of East Africa and the world on system structure and a limited set of related ecosystem services.
The results serve as a basis for studying the trade-offs inherent in and between the systems regarding a diverse set of ecosystem services. Furthermore, the altitudinal range enables the exploration of the diverse effects of temperature and precipitation on coffee productivity and other ecosystem services among the identified systems. This is particularly relevant to study the possible impacts of climate change and the relevant measures for adaptation.

POLLINATION DISTRICTS IN KODAGU: COFFEE PRODUCTION, CONSERVATION AND OTHER BENEFITS

Ainhoa Magrach[1], Antoine de Champetier[1]

[1]*ETH Zurich, Zurich, CH, ainhoa.magrach@usys.ethz.ch*

The production of coffee, one of the most valuable tropical export crops, has increased greatly during the past decades mostly at the expense of forested areas. India is the sixth largest coffee producer in the world with Kodagu district accounting for a third of the national production. Here, coffee plantations currently occupy ~ 33% of the landscape. The expanding coffee estate already incurs conflicts with other land uses, especially privately-owned forest fragments, with consequent losses of above-ground biomass. Coffee in the area is always grown under shade cover although there are differences between farms that maintain a native shade cover and those where the native trees are substituted by exotic ones, particularly *Grevillea robusta*. Together with an increased efficiency in coffee production, coffee plantations under exotic shade seem to also offer larger returns to farmers, through lower maintenance costs but also generating greater incomes through side products such as pepper and timber. This coupled with incentives, like low prices for exotic tree seedlings, have led many farmers to slowly move from native to exotic shade at the expense of biodiversity conservation and regulating ecosystem services (e.g., carbon storage). Given the likely increase in surface area occupied by coffee cultivation we ask what would be the most efficient way of achieving it given under different scenarios. In particular, what would be the expected output if we only targeted maximum return for farmers? What could be the potential impact of different decisions taken by farmers on pollination and ultimately on their own coffee production? Would including spatial incentives for contiguous habitat benefit the above objectives? We also explore the potential for such contiguous habitats to be based on sharing pollinator communities and evaluate the implications that the creation of such “pollination districts” might have on plantation management and landscape configuration.

YIELD-DIVERSITY RELATIONSHIPS IN PERENNIAL CROP FIELDS OF NORTH-EASTERN BRAZIL

Arne Cierjacks[1], Maik Pommeranz[1], Jarcilene Cortez[2]

[1]*Universität Hamburg, Biocentre Klein Flottbek, Hamburg, DE, arne.cierjacks@uni-hamburg.de*
[2]*Universidade Federal de Pernambuco, Departamento de Botânica, Centro de Ciências Biológicas, Recife, BR*

The combination of crop production for the nutrition of a growing mankind with the conservation of rapidly declining biodiversity remains a challenging task worldwide. In agro-ecosystems, weed diversity and biomass are frequently assumed to be negatively related to crop yield. However, positive effects of weed species (pollinator and parasitoid attraction) and diverging resource acquisition strategies may reduce the competitive character of weed-crop interactions – a potential which can be used within land sharing approaches (i.e. biodiversity conservation and agrarian production on the same site). This study aimed at analyzing the relationships of weed diversity and biomass to crop yield in coconut and banana fields within an irrigation farming scheme established in former Caatinga dry forest ecosystems at Itaparica Reservoir, Pernambuco, Brazil. Within each of 21 selected crop fields, we collected weed diversity and biomass data on a central and a peripheral study plot along with general information on crop yield, the use of fertilizers and other agrochemicals. We found no evidence for a negative relationship of crop yield or biomass and weed diversity. On the contrary, yield and weed alpha diversity were significantly positively correlated (Shannon and Simpson Index). In contrast, weed biomass showed a significant negative correlation with crop yield. The use of organic fertilizer had a significant positive effect on yield whereas no impact of herbicides and insecticides was detected. In addition, coconut fields harboured a higher species number than banana fields with the field edge providing habitat for more plant species than the field centre. Overall, our data show that in perennial tropical crop rotations high yield is not opposed to high plant diversity. Moreover, the data suggest that organic farming in the area will presumably not lead to yield losses. However, the related plant assemblages inhabited only few typical species of the native dry forest vegetation. Therefore, diverse agro-ecosystems, albeit contributing to biodiversity conservation on the landscape scale, do not compensate for nature reserves in areas with unique biodiversity.

MAXIMIZE PRODUCTION, MINIMIZE SPACE: POTENTIAL BENEFITS OF INTERCROPPING AT HIGH DENSITIES FOR OKRA FARMERS IN CAMEROON

Akanksha Singh[1], Sharon Zytynska[1], Rachid Hanna[2], Wolfgang Weisser[1]

[1]*Technische Universität München, Freising, DE, singhak@tcd.ie*
[2]*International Institute of Tropical Agriculture, Yaounde, CM*

Global food production has been on a steady increase in the last half-century mainly via increases in available agricultural land and extensive usage of fertilizers and pesticides. However, this has proved to be detrimental for the environment as large tracts of forests are cleared for agriculture use and the chemicals used leach into our natural systems. With a growing population, we cannot continue such intensive farming approaches and thus there is a need for knowledge-based ecological intensification.

In Cameroon, West Africa, okra (*Abelmoschus esculentus*) is a commonly cultivated vegetable and many farmers practice intercropping of okra with one or two additional crops. Often these fields are sparsely planted to reduce competition between the crops however, it is unknown if intercropping at higher density has a negative effect on okra fruit yield. Further, regular spraying of pesticides is used to control major okra pests such as the cotton aphid (*Aphis gossypii*). The natural enemies of aphids on okra include parasitoid wasps, syrphid fly larvae and spiders. As part of an integrated pest management scheme, these natural enemies could be used as biocontrol agents. Intercropping in other systems has been shown to increase natural enemy abundance and thus decrease pest abundance;

In a field experiment, we grew okra with maize and bush beans at two densities (high and low) and different combinations (1, 2 and 3 species). We measured okra fruit yield and made observations of okra pests and their natural predators. We discuss our results with respect to the weight of marketable fruit that the local farmer can sell, and further show the potential for increasing yield through ecological intensification. We also explain the effect of intercropping on pests and predators in our system. Our work shows that education at the local level may substantially benefit agricultural sustainability in this system.

TREE COVER EFFECTS ON GRASSLANDS PRODUCTIVITY IN SUBTROPICAL SOUTH AMERICA

Rafael E. Bernardi[1,2], Inger K. de Jonge[1], Milena Holmgren[2]

[1]Aquatic Ecology and Water Quality Management Group. Wageningen University, Wageningen, NL
[2]Resource Ecology Group. Wageningen University, Wageningen, NL, Wageningen, NL, bernardirafael@gmail.com
[3]Wageningen University, Wageningen, NL

Rangelands occupy a third of South America and have varying degrees of tree cover. In many regions there has been a general trend of expansion of shrubs and trees over grasslands, a pattern explained by different hypotheses and with potential consequences on productivity. We aim to understand the consequences of tree cover changes on rangelands and on the resilience of silvopastoral systems. We combined remote sensing and field surveys to assess the role of resource availability, landscape features and disturbance regimes on tree cover distribution and on the mechanisms that may explain tree cover expansion in subtropical South American grasslands. We also analysed the effect of tree cover on the abundance, composition and forage quality of grasses as well as on livestock productivity.

We found that current tree cover increases with mean annual precipitation and is limited by cattle density and fire occurrence. In areas with extensive grasslands, tree cover is concentrated close to rivers. Tree cover is correlated with a higher abundance of C3 than C4 grasses. Since C3 and C4 grasses have different quality as livestock forage and different tolerance to environmental stresses, our results suggest that tree cover may improve forage availability during dry periods and influence how livestock production systems withstand environmental changes.

AGROFORESTRY, COARSE-LEVEL MIXING OF TREES AND CROPS OR MONOCULTURES? LAND-USE DECISIONS UNDER UNCERTAINTY

Carola Paul[1], Ni'matul Khasanah[2], Meine van Noordwijk[2], Thomas Knoke[1]

[1]*Institute of Forest Management, Technische Universität München, Freising, DE, carola.paul@tum.de*
[2]*Wold Agroforestry Center, Bogor, ID*

The increasing food demand of a growing world population, which must be satisfied using limited soil resources, calls for the development of land-use systems that allow for agricultural production while maintaining soil productivity and reducing environmental impacts. Agroforestry could enhance the environmental services of agro-ecosystems while increasing land-use efficiency, as demonstrated by the concept of the Land Equivalent Ratio. Adoption of such land-use systems is particularly driven by economic performance and an ability to reduce financial risks. These aspects have, however, seldom been compared systematically for agroforestry against the mixing of trees and crops on separate fields or monocultures. Thus, this methodological approach combines Modern Portfolio Theory with biophysical modelling of tree-crop interactions. We aim to provide a basis for the selection of tree-crop planting designs from an economic perspective under consideration of risks. The approach is demonstrated by comparing different tree densities of *Tectona grandis* intercropped with maize. Using WaNulCas Software 4.01 and agroforestry trial data from Panama for calibration, tree growth and agricultural production were simulated in different layouts. Uncertainties in prices and yields were integrated by bootstrapping and Monte Carlo simulation. The resulting expected annuities and their standard deviations are illustrated in a risk-return diagram. This reveals that the simultaneous use of labor and inputs by trees and crops in the agroforestry system can increase financial performance compared to monocultures. Agroforestry layouts with medium tree densities and frequent thinnings are particularly efficient in reducing financial risks, while having similar returns as coarse-level mixing. This study demonstrates the potential of this methodological approach for improving land-use decisions under uncertainty.

Merian Award Applicant

OIL PALM PLANTATIONS MAY ACT AS BARRIERS TO THE DISPERSAL OF TROPICAL FOREST SPECIES

Sarah Scriven[1], Jane Hill[1]

[1]*University of York, York, UK, sas550@york.ac.uk*

Improving habitat connectivity by retaining rainforest remnants within agricultural landscapes has been suggested as a strategy for reducing biodiversity losses within tropical regions. However, it is unclear the extent to which species cross forest-agriculture ecotones and hence disperse through human-modified landscapes. We sampled fruit-feeding nymphalid butterflies at rainforest-oil palm (*Elaeis guineensis* Jacq.) plantation ecotones in Borneo and used capture-mark-recapture techniques to examine butterfly movement. A total of 1,665 individuals from 67 species were marked during the study, of which 32% (529 individuals) were recaptured at least once. A total of 100 individuals from 13 species crossed the ecotone, and net movement flow was from forest to plantation. If a butterfly was marked in forest, it was over five times more likely to be recaptured crossing the ecotone than if it was originally marked in plantation. Only two species that crossed the ecotone were forest specialists (i.e. forest-dependent species without larval host plants present in plantations). The remaining 11 species were generalists whose larval host plants occurred in plantation habitats. These results suggest that for some species forest habitats are 'source' habitats, from which individuals 'spill-over' into less productive 'sink' plantation habitats. However, forest-plantation boundaries are impermeable to most forest specialists and we conclude that agricultural areas likely act as barriers to the movement of many forest-dependent species, whose resilience in these human-modified landscapes may decline in future.

Merian Award Applicant

FALLOW RECOVERY AND TREE SPECIES DIVERSITY: BIOMASS RELATIONSHIPS IN TIMBER AGROFORESTRY SYSTEMS IN THE CONGO BASIN

Lindsey Norgrove[1], Stefan Hauser[2]

[1]*University of Basel (Department of Environmental Sciences, Biogeography), Basel, CH, lindsey.norgrove@unibas.ch*
[2]*International Institute of Tropical Agriculture, Ibadan, NG*

There is a global debate about how agricultural intensification in the humid tropics will affect conservation. In the Congo Basin, given high poverty, the top policy priority should be livelihood improvement, ensuring both food security and cash income for the local population. Smallholder timber agroforestry systems might provide an opportunity to achieve both these, plus additional conservation objectives.

We tested the impacts of thinning to different timber densities and compared understorey clearance using fire versus fire exclusion on vegetation dynamics in different timber agroforestry systems in the Congo Basin. We sampled vegetation during both the cropping and fallow phases over an 8-year (y) period in a fully replicated (n=4) experiment. One of these treatments (burn, low timber density) was comparable to traditional farmer management whereby some trees are retained at field clearance. No chemical inputs were applied. Weed vegetation was sampled seven times during the 3-y cropping phase then fallow vegetation was sampled 5 and 8 y after the start of the experiment. Timber and crop growth were also measured.

Initially, burning led to higher weed biomass and dominance of the invasive *Chromolaena odorata* throughout the cropping phase, particularly in low timber density plots. Throughout the cropping phase, *C. odorata* was less dominant in fire exclusion plots and less dominant in high tree density plots, compared with the low tree density burned treatment. After 5 y, *C. odorata* and other weeds persisted in previously burned plots but were rare in fire exclusion plots. Of the pioneer trees, *Musanga cecropioides*, *Ceiba pentandra* and *Macaranga ulifolia* were the greatest contributors to biomass. After 8 y, there was significantly less understorey biomass in low than in high timber density plots. We found significant and positive logarithmic relationships between the number of tree species per plot and their estimated biomass (r^2=0.75). We also found weaker, negative linear relationships between the number of tree species per plot and the previous crop yield (r^2=0.54). Implications for sustainability and nutrient cycling are discussed.

DIVERSITY OF VASCULAR EPIPHYTES IN LOWLAND RAINFORESTS AND JUNGLE RUBBER AGROFORESTRY SYSTEMS IN SUMATRA (INDONESIA)

Arne Wenzel[1]

[1] *Biodiversity, Macroecology & Conservation Biogeography Group, University of Göttingen, Göttingen, DE, arne-wenzel@web.de*

Epiphytes play an important role in ecosystem processes of tropical rainforest and provide resources for tree-dependent fauna. They are very sensitive to changes in their environment and therefore, epiphytes diversity can be used as ecological indicator to determine the effects of deforestation and forest transformation.

In Jambi Province (Sumatra, Indonesia) natural lowland rainforests have been almost completely cleared and turned into the transformation systems jungle rubber, rubber and oil palm plantations. The aim of our study was to investigate the effects of the transformation of rainforest to jungle rubber agroforestry-systems for vascular epiphyte diversity. We conducted plot-based species inventories inside the forest and the jungle rubber by using single rope climbing techniques.

Our results indicate a similarity in species richness and species composition between jungle rubber agroforests and the natural rainforest. Therefore jungle rubber can account as a subset of the broader floral composition of the natural forest. However, this seems only to be true when the structure of the jungle rubber has a forest like appearance. Areas with a high number of native trees, a large basal-area and tall trees were usually high in species richness. On the contrary intensely used jungle rubber areas with a large number of rubber trees were usually impoverished.

These findings suggest that extensively used jungle rubber agroforests could play a vital role in the maintenance of epiphyte diversity and thus could also be a sanctuary for the tree-dependent fauna.

SESSION 6

S6 - TROPICAL BIOCULTURAL RESILIENCE

Chairs: Maximilien Gueze, Manuel J. Macía and Victoria Reyes-García
Contact: maximilien.gueze@gmail.com

LEGACIES OF AMAZONIAN DARK EARTHS ON FOREST COMPOSITION AND DYNAMICS IN AN AMAZONIAN BOLIVIAN FOREST

Estela Quintero-Vallejo[1,2], Frans Bongers[1], Lourens Poorter[1], Marisol Toledo[2], Yannick Klomberg[1], Marielos Peña-Claros[1,2]

[1]*Forest Ecology and Management, Wageningen University, Wageningen, NL, estela.quinterovallejo@wur.nl*
[2]*Instituto Boliviano de Investigacion Forestal (IBIF), Santa Cruz de la Sierra, BO*

Amazonian Dark Earths (ADE) or '*terra preta*' (black earth in Portuguese) is a type of anthrosol characterized by a thick dark or gray top layer with presence of ceramics that indicate past indigenous settlements. The dark color of the soil is due to high concentrations of organic matter and black carbon. ADE have high P and Ca, and higher pH than the natural soils commonly found in the Amazon creating soil patches with high fertility. Currently, soil fertility of ADE is advocated as having positive effect on crops and home-gardens in the Amazon basin, but its effect on natural forest is not well known.

We evaluated if fertility of ADE had an effect on the understory composition, tree seedling growth and forest dynamics of an Amazonian forest in Bolivia. We determined soil chemical and physical properties and performed understory vegetation surveys on ADE patches previously identified in the field. We ran a greenhouse experiment using ADE as substrate to grow seedlings. Finally, we related tree forest dynamics with ADE characteristics on permanent plots following growth of trees higher of 10 cm DBH for 10 years.

Natural soils at this forest are a mosaic of fertile and infertile soils product of the geological history of the site. We found that increases in calcium and pH in ADE extends the fertility gradient of these naturally fertile soils. The increases in calcium and pH changed understory community composition and decreased fern diversity. Similarly, high soil calcium determined tree seedling responses to ADE through calcium physiology. Some species seem to be negatively affected by increases in soil calcium, others show nutrient imbalance, and others seem to regulate calcium to grow well on ADE. On the other hand, ADE did not strongly influenced forest dynamics of adult trees, suggesting that the effect of ADE on forest dynamics could be stronger only in early stages of tree growth.

Our study improves our understanding on the effect of pats human modification in the Amazon forest. Small nutrients increase in the soil, as a consequence of past human inhabitation, modified current forest understory composition and negatively affected early tree establishment, indicating that legacies of past human modifications are maintained for long periods of time.

ANTHROPOGENIC SOILS INFLUENCE PLANT CULTIVATION AND MANAGEMENT BY LOCAL AMAZONIAN PEOPLE

André Braga Junqueira[1,2,3], Tjeerd Jan Stomph[1], Cornelia J. M. Almekinders[2], Charles R. Clement[3], Nathalia B. Souza[3], Paul C. Struik[1]

[1]*Centre for Crop Systems Analysis, Wageningen University, Wageningen, NL, abjunqueira@gmail.com*
[2]*Knowledge, Technology and Innovation Group, Wageningen University, Wageningen, NL, abjunqueira@gmail.com*
[3]*Coordenação de Tecnologia e Inovação, Instituto Nacional de Pesquisas da Amazônia, Manaus, BR, abjunqueira@gmail.com*

Humans have transformed the Amazonian landscapes since they arrived in the region, at least 15,000 years ago. Amazonian Dark Earths (ADE) are anthropogenic soils created by pre-Columbian Amazonian people between 2,500-500 years before present. These soils are widespread throughout the Amazon basin, and due to their relatively high pH and high fertility they contrast strongly with non-anthropogenic upland soils (NAS), which in general are acidic and nutrient-poor. We looked at how these soils have been incorporated into the knowledge of rural Amazonian people and influence their practices related to agriculture, agroforestry and forest management. We used an interdisciplinary approach, combining data from farmers' interviews, soil sampling and floristic inventories of homegardens, shifting cultivation swiddens and old-growth forests on ADE and NAS. We show that farmers recognize different soil-vegetation relationships on ADE than on NAS, resulting in different decisions about cultivation and plant management. Shifting cultivation on ADE is more intensive, with shorter cycles and higher labour requirements. Soil differences between NAS and ADE are also associated with clear differences in the assemblage of crops and landraces grown in homegardens and swiddens, with a prominence of exotic and/or nutrient-demanding short-cycle species on ADE. These differences also persist in old-growth forests on ADE, whose species composition shows a higher abundance of useful and/or domesticated species when compared to NAS. The greater usefulness of these anthropogenic forests is maintained by current management by local people. Our results show that soil modifications created by pre-Columbian Amazonian people influence current knowledge and practices related to plant cultivation and management. ADE provides opportunities for smallholder farmers to intensify and diversify their cultivation systems, and can play an important role in how local people deal with the dynamic context of rural Amazonia. Finally, ADE is an example of how anthropogenic modifications of soil and vegetation can potentially benefit agrobiodiversity and local livelihoods, providing insights to initiatives aiming to support rural populations in Amazonia and beyond.

THE DISTRIBUTION OF DOMESTICATED SPECIES IN AMAZONIAN FORESTS

Carolina Levis[1,2], Flavia R. C. Costa[2], Frans Bongers[1], Charles R. Clement[2], Marielos Peña-Claros[1], Hans ter Steege[3], Amazon Tree Diversity Network ATDN[3]

[1]Wageningen University, Wageningen, NL, carollevis@gmail.com
[2]Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, BR, carollevis@gmail.com
[3]Naturalis Biodiversity Center, Leiden, NL

Amazonian forests were modified by indigenous peoples during the Holocene and they often created domesticated forest landscapes, such as Brazil nut stands. At least 83 species of plants had domesticated populations in this region before European conquest. Although domesticates require human intervention for their maintenance, many Amazonian domesticates are woody species adapted to forest landscapes; consequently forests concentrate populations of numerous native tree crops. Currently the agricultural frontier of exotic crops is destroying forested landscapes, native crop resources and traditional agroforestry practices. Understanding the distribution of domesticated populations in forests is vital to enhance the resilience of biocultural diversity in Amazonia.

This is the first broad scale assessment of the domestication of Amazonian forests using floristic data from more than a thousand plots compiled in the ATDN database. Approximately 16,000 woody species exist in Amazonian forests, of which just 0.4 % contain domesticated populations. On average, however, almost 5% of all individuals in forest plots represent domesticated species and this proportion ranges from 0 to 58% across the Amazon basin. These domestication values increase along the soil fertility gradient from the Guiana Shield to Southwestern Amazonia. Importantly, we found the highest values of domestication in forest plots within archaeological sites. Also, populations of domesticated woody species are concentrated in Southern and Southwestern Amazonia, suggesting important reservoirs of wild genetic resources of these crops. Although large numbers of woody domesticates are hypothesized to have originated in Western Amazonia, we also found high proportions of domesticates in Eastern Amazonia. Many populations of domesticated species found in forest plots may be a result of interactions between natural conditions (e.g., fertile soils) and cultural processes (e.g., past management practices). This study highlights the importance of conserving forests throughout Amazonia for their biocultural diversity, especially for the persistence of genetic resources of native tree crops that still support traditional livelihoods and can contribute to more sustainable land uses.

BIOCULTURAL RESILIENCE ACROSS LAND AND SEASCAPE MOSAICS IN PACIFIC ISLANDS

Eleanor Sterling[1], Georgina Cullman[1], Chris Filardi[1], Erin Betley[1], Sophie Caillon[2], Stacy Jupiter[3]

[1]*Center for Biodiversity and Conservation, American Museum of Natural History, New York, US*
[2]*CNRS-CEFE, Montpellier, FR*
[3]*Wildlife Conservation Society, New York, US*

The current pace of demographic and environmental changes locally and globally poses a challenge for human and natural systems. Local communities in the Pacific are facing a critical time for community-based planning and management. There is a critical need to develop and implement indicators that can be used to manage and monitor resources and effectively plan for the future in the Pacific and beyond. While substantial work has been undertaken to identify indicators of biodiversity and human wellbeing, these systems frequently lack recognition of the role of culture, particularly to communities in the Pacific. “Biocultural” resilience indicators, now in development, differ from conventional indicators of ecosystem health (species richness, nutrient and water recycling, soil productivity, etc.) in that they explicitly capture social dimensions (e.g. harvest schedule for culturally significant species) and can provide a historical view of the interactions between humans and their surrounding land/seascape. Effective management of resilient land and seascapes calls for multidimensional biocultural indicators, with an emphasis on hierarchical sets of indicators, with some relevant to local and others to global scales. We describe a project in the Western Province of Solomon Islands that aims to span the gap between local and global indicator systems.

CULTURAL CHANGE RELATES TO FOREST TREE DIVERSITY: THE CASE OF THE TSIMANE', BOLIVIAN AMAZON

Maximilien Gueze[1], Ana C Luz[2,3], Jaime Paneque-Gálvez[4], Manuel J Macía[5], Martí Orta-Martínez[1,6], Joan Pino[7], Victoria Reyes-García[1,8]

[1]ICTA - Universitat Autònoma de Barcelona, Barcelona, ES, maximilien.gueze@gmail.com
[2]Departamento de Engenharia Florestal, Universidade Eduardo Mondlane, Maputo, MZ
[3]School of Geosciences, University of Edinburgh, Edinburgh, UK
[4]Centro de Investigaciones en Geografía Ambiental, UNAM, Morelia, MX
[5]Departamento de Biología, Área de Botánica, Universidad Autónoma de Madrid, Madrid, ES
[6]Institute of Social Studies, Erasmus University of Rotterdam, The Hague, NL
[7]Centre de Recerca Ecològica i Aplicacions Forestals, Universitat Autònoma de Barcelona, Barcelona, ES
[8]ICREA, Barcelona, ES

Maintaining resilience of socio-ecological systems among indigenous people implies understanding the relation between management practices and biological diversity. However, this relation remains dependent on the current changes faced by indigenous people. In this study, we explore the association between cultural change within a Bolivian Amazonian indigenous group, the Tsimane', and tree diversity in mature forests surrounding Tsimane' villages. To do so, we use both methods from cultural anthropology and tropical ecology. We proxied cultural change as the individual attachment to traditional Tsimane values, measured with interviews to 86 informants in six villages. We estimated tree diversity by inventorying trees in 48 0.1-ha plots in old-growth forests distributed in the territory of the same villages. We used multivariate models to assess the relation between cultural change and alpha tree diversity, estimated with different indices (Fisher's alpha index, Shannon index) and forest structure (basal area, tree density). Cultural change was associated to alpha tree diversity and the relation showed an inverted U-shape, thus suggesting that tree alpha diversity peaked in villages undergoing intermediate cultural change. However, there was no association of cultural change with forest structure, supporting a "cryptic" management, not implying canopy gaps. We propose that cultural change has an impact on tree diversity through the changes in traditional ecological knowledge of Tsimane' communities, that affect practices and behaviours. Our results also find support in the intermediate disturbance hypothesis, and suggest that indigenous management can be seen as an intermediate form of anthropogenic disturbance affecting forest communities in a subtle, non-destructive way.

THE ECOLOGY OF „TIRED LANDS“: CONSEQUENCES OF SWIDDEN-FALLOW INTENSIFICATION IN THE AMAZON

Catarina Jakovac[1], Marielos Pena-Claros[1], Thom Kuyper[1], Frans Bongers[1]

[1]*Wageningen University, Wageningen, NL, catarina.jakovac@wur.nl*

Areas that became unproductive are called by local Amazonian people “tired lands” (*terras cansadas* in Portuguese). Combining data from field surveys and farmers interviews, we investigated the process through which these areas are becoming tired (or degraded), and discussed its implications for the resilience of swidden cultivation systems. To evaluate how these areas become “tired” we evaluated the effects of repeated cycles on fallow regrowth rate and species composition, as well as on swiddens’ crop productivity, weed infestation and labour demand. We also assessed possible drivers of land degradation, based on farmers interviews. Our results show that “tired lands” are being formed by agricultural intensification, which is characterized by increased frequency of swidden-fallow cycles and shortened fallow periods. This leads to a decrease in the recovery ability of the system (decreased fallow regrow rate and changed species composition) and in its agricultural productivity (decreased crop yield and increased labour demand). At the landscape scale, this process of intensification is leading to the spread of “tired lands”, particularly closer to villages. Agricultural intensification, on its turn, is being driven by increased market demand for manioc (*Manihot esculenta*) flour and shortage of easily accessible lands. We conclude that tired lands are no longer able to support agriculture neither to recover ecosystem functions, therefore they represent a decrease in the resilience of the swidden cultivation system as a whole. This has negative implications for both biodiversity and local livelihoods and deserves further attention, as intensification is becoming a reality in many rural areas of the Amazon.

OIL SPILLS INGESTION BY GAME SPECIES IN THE PERUVIAN AMAZON

Mar Cartró Sabaté[1], Pedro Mayor Aparicio[2], Antoni Rosell-Melè[1,3], Victoria Reyes-García[1,3], Martí Orta-Martínez [4,1]

[1]Institut de Ciència i Tecnologia Ambientals, Universitat Autònoma de Barcelona, 08193 Bellaterra, Barcelona, Catalonia, ES, marcartro@hotmail.com
[2]Dept. Sanitat i Anatomia Animals, Universitat Autònoma de Barcelona, 08193 Bellaterra, Barcelona, ES
[3]Institució Catalana de Recerca i Estudis Avançats, 08010 Barcelona, Catalonia, ES
[4]International Institute of Social Studies, Erasmus University Rotterdam, The Hague, NL

The first oil activities in the Peruvian Amazon began more than four decades ago in the north-eastern part of the country. Different studies show the presence of contaminants derived from these activities in the physical environment and human communities in the area. Our project aims to determine whether the species hunted in the region ingest contaminated soil through a camera trap program and the analysis of soil samples. Videos recorded in oil-polluted sites are going to be analysed through a Citizen Science platform, which will aloud the analysis of a big amount of videos and will contribute to generate interest in many countries about one of the problems that the Amazon and its inhabitants have to face nowadays. Moreover, we also study the bioaccumulation of contaminants with the analysis of animal tissues collected through a participatory collection program, considering that some pollutants usually found in oil spills, such as heavy metals and polycyclic aromatic hydrocarbons, are persistent, toxic and can bioaccumulate, having a very harmful effects on animals' health. Furthermore, they may climb through the food chain affecting the human population. Preliminary results show that at least three bird species and six mammal species visit apparently oil-polluted sites to ingest soil. All of them are game species and represent more than the 80% of the meat extracted by hunting in the region. Final results can be very useful for the scientific community, as this phenomenon has never been studied so far, as well as for the inhabitants of the region, who will be empowered by the pos Session of these results. Moreover, considering that oil activities take place worldwide, results will provide a very valuable knowledge of the impacts of this industry on the wild animals and public heath that will exceed the frontiers of the studied area.

IT'S OUR FOREST TOO, - COMMUNITY MONITORING FOR FOREST PROTECTION AND PEACEFUL DIALOGUE IN CAMBODIA

Nerea Turreira-Garcia[1], Søren Brofeldt[1], Ida Theilade[1], Henrik Meilby[1]

[1]*Institute for Food and Natural Resource Economics, Frederiksberg C, DK, ntg@ifro.ku.dk*

Indigenous peoples are increasingly under pressure from land grabs, i.e. large scale acquisition of land for commercial and industrial purposes. Land grabs often deny indigenous peoples access to their primary source of livelihood but also leads to deforestation. Local Ecological Knowledge (LEK) has been employed in monitoring of various forest resources. Local monitoring can improve ownership and access rights and advance decision-making at local level. Nevertheless, most LEK studies have been scientist led and have failed to include LEK in the research design and interpretation of results. Besides, motivations of local communities to engage in forest monitoring have rarely been evaluated.

This study is based on the initiative of indigenous Kuy of the Prey Lang Community Network (PLCN) to patrol their ancestral forests in order to stop illegal logging and deforestation. The aim was to i) investigate which features and functions of a tropical forest landscape, indigenous Kuy see as essential for their survival and ii) assess the motivations of community members to engage in forest patrols.

During two workshops members of the PLCN mapped important forest areas and designed a community-led monitoring program. Patrol members were equipped with smartphones to collect data on illegal activities. Motivation to engage in community monitoring was assessed using a questionnaire survey.

Indigenous communities emphasized monitoring of illegal logging, immigration, land concessions and resin trees. Community members were motivated primarily by the protection of non-timber forest products for their immediate and cultural survival. This included resin trees, rattan, medicinal plants and foods. Community goals differed considerably from the goals of the existing national forest inventory led by FAO as well as UN- and World Bank led monitoring for REDD+, which focus on commodities for export, i.e. timber and carbon stocks. It is hoped that community monitoring can facilitate dialogue between local communities, local authorities, central government, and private sector and reduce forest related conflicts.

TWO-YEAR PARTICIPATORY MONITORING OF EXTRACTIVISM IN BRAZILIAN AMAZONIA

Rodrigo Cámara-Leret[1], Peter Newton[2], Joseph Hawes[3], Rodolfo Salm[4], Henrik Balslev[1], Carlos Peres[5]

[1]Aarhus University, Aarhus, DK, rcamaraleret@gmail.com
[2]University of Colorado, Boulder, US
[3]Museu Paraense Emílio Goeldi, Belém, BR
[4]Universidade Federal do Pará, Altamira, BR
[5]University of East Anglia, Norwich, UK

Sustainable use of nontimber forest products (NTFP) in Amazonia, the World's largest remaining contiguous rainforest, largely rests upon understanding patterns of resource use involving rural livelihoods to better inform conservation science. Brazil encompasses three-quarters of Amazonia, where non-indigenous semi-subsistence groups referred to as *caboclos*, outnumber native Amerindians by a factor of ten. The Brazilian government has committed to supporting participatory programs where monitoring biodiversity and co-management of natural resources are spearheaded by residents of sustainable-use protected areas. Notable among these initiatives is the Programa de Monitoramento da Biodiversidade e do Uso de Recursos Naturais em Unidades de Conservação Estaduais do Amazonas (ProBUC). ProBUC aims to 1) sensitize community residents to the importance of monitoring the state of natural resource use and establish norms for sustainable use, 2) train community residents to lead monitoring programs, 3) monitor species with high market potential (e.g. palms), 4) monitor species of special interest (e.g. red listed by IUCN), and 5) monitor land-use change. Since 2005, ProBUC has developed pilot projects in three conservation units, including two extractive reserves. Extractive reserves, defined as forest areas inhabited by extractive populations granted long-term usufruct rights to forest resources which they collectively manage, are among the most important protected area types, accounting for one seventh of Brazilian Amazonia. Here, we present the results of a two-year participatory monitoring program of extractive activities by *caboclos* inhabiting one of ProBUC's pilot areas, the Uacari Sustainable Development Reserve, as well as the Médio JuruáExtractive Reserve, both within the Juruá River basin of western Brazilian Amazonia. We discuss the most important extractive activities for ~100 households, how socio-economic factors influence NTFP extractive patterns across households, and the benefits and constraints of using participatory approaches to monitor extractivism in Amazonia.

Merian Award Applicant

WHAT DOES CONSERVATION MEAN? GALAPAGOS EXPERIENCE AND METHODOLOGICAL PERSPECTIVES

Francisco Benitez-Capistros[1], Katherine Vande Velde[1], Laura Agusto[1], Nico Koedam[1], Farid Dahdouh-Guebas[1], Jean Huge[1]

[1]*VUB&ULB, Brussels, BE, fbenitez@vub.ac.be*

Biodiversity conservation is a multidimensional concept subject to a wide range of interpretations. If this plurality of interpretations is not considered, conservation initiatives might fail. The integration of multiple actors' perspectives requires innovative methodologies. Based on our experience in the Galapagos Islands, we reflect on the use and applicability of the Delphi technique, the Q methodology and Participatory Rural Appraisal (PRA) in conservation. While each method has its strengths & weaknesses, the outcomes are complementary and have led to the identification of shared conservation perspectives in Galapagos. This in turn ideally leads to an improvement of conservation practices by focusing on consensus points. For example, prioritizing ecosystems conservation over iconic species conservation (i.e. Galapagos giant tortoises). We here report on Galapagos, but given the variation of ecological and social contexts, additional research in Kenya and Malaysia will allow us to move towards a clear understanding of the general applicability of the framework.

Merian Award Applicant

INDIGENOUS PEOPLES AND CONSERVATION IN GUYANA

Logan A. Hennessy[1]

[1]*San Francisco State University, Berkeley, US, loganh@sfsu.edu*

The main thrust of biodiversity conservation has been to preserve threatened and endangered species and maximize species richness. Yet when indigenous communities are part of a conservation agenda, how should the priorities change? Who or what qualifies as the most „threatened"? Guyana is a small country with significant forest reserves and frequent discoveries of new species. It also has a diverse population of indigenous peoples. Conservation concerns have been a part of the policy agenda since the early 1990s, and have advanced in recent years under a nationwide REDD+ „Low Carbon Development Strategy." Implementing these policies on the ground have shown mixed results because pathways to biocultural resilience cover extreme ends of the spectrum. Some regions include trained Amerindian communities collecting data for biodiversity and/or biomass monitoring while others situate Amerindian communities as active participants in a damaging extractive economy. Case evidence from Akawaio villages in the Upper Mazaruni demonstrates the severity of small-scale gold mining as a positive feedback loop of ongoing cultural and environmental destruction. These extremes raise an important challenge for the conservation community. Amerindian mining communities are well-prepared to use traditional ecological knowledge as partners in habitat conservation, restoration, and monitoring, but resilience hinges on expanding the policy framework to prioritize indigenous rights and reversing destructive feedback cycles.

SESSION 7

S7 - CONSERVATION GENETICS AND GENOMICS IN THE TROPICS

Chairs: Aline Finger, Sascha Ismail and Kentaro Shimizu, Soon Leong Lee and Michael Krützen
Contact: A.Finger@rbge.ac.uk, kentaro.shimizu@ieu.uzh.ch

GENOME SEQUENCE AND GENOME-WIDE POLYMORPHISM PATTERN OF AN IMPORTANT SOUTHEAST ASIAN DIPTEROCARP, SHOREA LEPROSULA (DIPTEROCARPACEAE)

Kevin Kit Siong Ng[1,2], Masaki J. Kobayashi[1,2,3], Soon Leong Lee[2], Masaomi Hatakeyama[1,6], Timothy Paape[1], Chin Hong Ng[2], Ang Cheng Choon[1], Lee Hong Tnah[2], Chai Ting Lee[2], Tomoaki Nishiyama[8], Mahardika Putra[4], Iskandar Z Siregar[4], Sapto Indrioko[7], Ayako Izuno[5], Yuji Isagi[5], Kentaro K. Shimizu[1]

[1]*Institute of Evolutionary Biology and Environmental Studies, University of Zurich, Zurich, CH*
[2]*Genetics Laboratory, Forest Research Institute Malaysia, Kepong, MY, kevin@frim.gov.my*
[3]*Computational Biology Research Center, National Institute of Advanced Industrial Science and Technology, , JP*
[4]*Bogor Agricultural University, Bogor, ID*
[5]*Graduate School of Agriculture, Kyoto University, Kyoto, JP*
[6]*Functional Genomic Center Zurich, University of Zurich, Zurich, CH*
[7]*Faculty of Forestry, Gadjah Mada University, Yogyakarta, ID*
[8]*Advance Science Research Center, Kanazawa University, Kanazawa, JP*

The ecologically and economically important timber tree, *Shorea leprosula*, is one of the most widely distributed dipterocarp in Southeast Asia (Malay Peninsular, Borneo Island and Sumatra). On the Malaysian Plant Red List, the conservation status of the species is categorized as least concern for Malaysia. Nonetheless, global assessment by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species has recognized the species as endangered due to its reduced population as a result of extensive logging activity for its light red Meranti timber. The population structure and selection pressure acting on them should be understood to design the conservation and economical utilization strategy. Here we present the draft genome assembly of *S. leprosula*, which contains >40,000 protein-coding genes with approximately 190X coverage of its diploid genome (2n=14; ~450Mbp). Genome resequencing of 17 representative individuals from its distribution range throughout Southeast Asia reveal genomic bases of adaptive variation. Genomic regions showing a signature of recent positive selection are discussed.

GREAT APE DIVERSITY AND POPULATION HISTORY

Tomas Marques-Bonet[1,2]

[1]*ICREA at Institut de Biologia Evolutiva (CSIC/UPF). Dr. Aiguader 88, Barcelona, Catalonia, ES, tomas.marques@upf.edu*
[2]*CNAG, Baldiri Reixac 4, Barcelona, ES, tomas.marques@upf.edu*

Despite great advances in sequencing technologies, our knowledge in population structure, phylogeny and adaptation of great apes is still very limited. To explore these and other questions, we previously studied genomewide diversity patterns based on 79 great ape genomes covering almost all subspecies of great apes. This work has boosted our understanding on diversity, evolutionary genetics and demography to a finescale level that was not possible before. Despite the limited number of individuals analyzed, these species bear an enormous genetic diversity, compared to the shallow genetic diversity in our species. We found extensive structure among all the species with remarkable differences between wild born and captive individuals. Chimpanzees show the most complex demographic history compared to the other great apes. This previous study collected limited information on the geographic origin, so we could not resolve the complex evolutionary history at local level and to what extent genetic diversity is stratified by geography. Following this direction, we have now expanded the project with new sequencing of >40 wild born chimpanzees with the most detailed geographic information possible in the sampling covering 11 countries. By exploring this dataset, we have found remarkable genetic structure within subspecies, showing that geography shapes the recent population history of chimpanzees, also within subspecies. Finally, we will present new data on unexplored subspecies of gorilla and orangutans that covers great ape genetic diversity that was still unexplored.

THE GENOMIC BASIS OF LOCAL ADAPTATIONS IN ORANG-UTANS

Michael Krützen[1], Maja P. Greminger[1], Alexander Nater[1,2], Tomas Marques-Bonet[3], Javier Prado-Martinez[3], Carel P. van Schaik[1], Benoit Gossens[4]

[1]*University of Zurich, Zurich, CH*
[2]*Uppsala University, Upssala, SE*
[3]*Universitat Pompeu Fabra, Barcelona, ES*
[4]*Cardiff University, Cardiff, UK*

A major endeavor of evolutionary biology is to understand how organisms adapt to their environment. Orang-utans, the only Asian great apes, represent a unique model to study adaptive evolution, as they show remarkable geographic variation in functional traits related to morphology, physiology, and social organization. To identify the genetic basis of local adaptations, we re-sequenced whole-genomes of 36 wild orangutans, representing the entire geographic distribution of both species. We followed several different strategies to detect selection, including genome scans and the joint inference of outlier loci and population structure using a hierarchical factor model (PCadapt). We found the strongest signals of positive selection between species for genes involved in neuronal and skeletal development, regulation, perception of taste, and inflammatory response. Among the top 1% FST windows, more than 50% showed reduced genetic diversity in both species, suggesting extensive background selection. PCadapt analyses revealed local adaptations in orang-utans from north-eastern Borneo, for example, in genes related to enamel mineralization and neuronal development. This corresponds with observed phenotypic differences in orang-utans from this area, known for much harsher environmental conditions due to strong El-Nino effects. Our results suggest that the geographic phenotypic variation in functional traits in orangutans may indeed represent unique local adaptations.

NEW GENOMIC TOOLS TO EXPLORE THE PHYLOGEOGRAPHY OF AFRICAN RAINFOREST TREES

Jérémy Migliore[1], Esra Kaymak[1], Cédric Mariac[2], Yves Vigouroux[2], Thomas L. P. Couvreur[2], Gilles Dauby[2], Rosalía Piñeiro[3], Olivier J. Hardy[1]

[1]Evolutionary Biology and Ecology, Université Libre de Bruxelles, CP 160/12, 50 Avenue F. Roosevelt, Brussels, BE, jeremy.migliore@ulb.ac.be
[2]Institut de Recherche pour le Développement, UMR DIADE, 911 avenue Agropolis, BP64501, Montpellier, FR
[3]Evolutionary Genomics, Centre for GeoGenetics - Natural History Museum of Denmark, Øster Voldgade 5-7, Copenhagen, DK

Long-term stability has been considered for long as a prime cause of the remarkable biodiversity of tropical rainforests. However, palaeoecological evidence of substantial change in the vegetation of tropical regions resulting from global climate fluctuation, especially during the Pleistocene, call for a reassessment of the temporal dynamics of biodiversity in tropical rainforests. Through the AFRIFORD research program we aim to understand how past environmental changes have shaped the current distribution and composition of African rainforests and the genetic diversity of their constituent tree species through integrative phylogeography.

In this context, we are developing next generation sequencing (NGS) tools to analyze the genetic polymorphism of representative African rainforest trees at the intra-specific level. The capture and sequencing of chloroplast genomes at deep multiplexing levels have been undertaken on 96 individuals of the rainforest tree *Greenwayodendron suaveolens* (Annonaceae), in which is characteristic of Central African mature forests. Calling SNP variants on the whole chloroplast genomes is expected to provide a higher level of polymorphism and a more reliable phylogenetic signal to infer the evolutionary history of African rain forest populations. This new phylogeographical pattern will be discussed in the light of those already reconstructed through the sequencing of some cpDNA regions and microsatellite genotyping. A critical view of these approaches will therefore be possible.

HOW CAN HYBRIDISING SPECIES REMAIN DISTINCT? INTROGRESSION AMONG SYMPATRIC NEPENTHES PITCHER PLANTS IN SOUTHEAST ASIA

Mathias Scharmann[1], Alex Widmer[1]

[1]*ETH Zürich, Zürich, CH, mathias.scharmann@env.ethz.ch*

Disturbance of ecosystems alters not only species communities and their functions, but it can also have evolutionary consequences. In particular, disturbance can erode extrinsic mechanisms of reproductive isolation and thus lead to increased hybridisation or even "reverse speciation". However, studies from the tropics are widely lacking. Here we investigate wether sympatric populations of Nepenthes spp, a common element of several vegetation types in Southeast Asia, show signs of past and ongoing introgression, i.e. gene-flow across species boundaries by repeated back-crossing. We sampled seven species of Nepenthes from Borneo and Singapore, one of which appeared as a novel, "cryptic" entity. Phenotypic hybrids were recorded predominantly in human-disturbed habitats. Several hundred individuals across four major sites were genotyped using a ddRAD protocol, yielding hundreds of thousands of SNPs across the entire genome. In contrast to previous attempts, we could broadly confirm the agreement of morphological species definitions with genetic structure. After exclusion of genetically detected recent hybrids, we find signatures of introgression across a large range of phylogenetic distances among natural populations both with and without human disturbance. Although human-disturbed sites such as Singapore show more introgression, species integrity was apparently robust. While our study shows that ecological factors do control species boundaries to some extent in Nepenthes, their relative contribution and mode of action remain topics for the future.

Merian Award Applicant

PHYLOGEOGRAPHIC INSIGHTS ON THE ORIGIN OF THE DAHOMEY GAP, THE LONG-TERM IMPACT OF FOREST FRAGMENTATION IN A LEGUME TREE DISTEMONANTHUS BENTHAMIANUS

Boris B. DEMENOU[1], Rosalia PINEIRO[2], Olivier J. HARDY[1]

[1]*EBE/Université Libre de Bruxelles, Brussels, BE*
[2]*Evolutionary Genomics, Centre for Geogenetics - Natural History Museum of Denmark, Copenhagen, DK*

Tropical rain forests of Central and West Africa are separated by a 200 km wide savannah corridor called Dahomey-Gap (DG) which is located in south Benin, south Togo and south-eastern Ghana. Paleovegetation data show that the DG area was forested during the African Humid Holocene period and opened c. 4 kyr ago. A few tree species characteristic of West and Central African rain forests, such as the legume *Distemonanthus benthamianus*, occur nevertheless in the DG, within isolated forest fragments and gallery forests. Therefore, these fragments and their rain forest species populations might be relics after the withdrawal of the forest during the late Holocene. Alternatively, rain forest species might have migrated into these fragments from the West and/or Central African rain forest blocks. The objective of this study is to attempt infer the history of the DG and their forest populations from the phylogeographic patterns and demographic history of *D. benthamianus*.

381 individuals covering the entire range of the species were genotyped with 11 microsatellite loci. Bayesian clustering analysis revealed five gene pools: one in West Africa, one in the DG and three are found in Central Africa. DG populations appear well differentiated from the gene pools of both West and Central African forests (Fst = 0.18 to 0.21) and display a lower genetic diversity (allelic richness Rs = 4.27) than those of forested areas (Rs = 5.46 to 7.29).

ABC analyses infer contrasted demographic histories during the last 190 kys according to the gene pools. While central African gene pools display signature of past bottleneck, the West African one shows traces of expansion, and the Dahomey-gap gene pool has declined, probably during the last glacial maximum or the Holocene. *D. benthamianus* populations found in the DG would originate from the admixture of West and Central African forest, and result from recent colonization. The last decline of population size back to the Holocene climatic pejoration, consistently with paleovegetations data. Comparison with other species should help us reconstruct the history of the forest flora of the DG. The DG might represent a natural situation of forest fragmentation after the mid-Holocene, so that the fate of its forest species can inform us on forest ecosystem resilience in the long term.

ARE MOLECULAR IDENTIFICATION TECHNIQUES HELPFUL TO PROTECT ENDANGERED ROSEWOOD SPECIES FROM MADAGASCAR?

Sonja Hassold[1], Simon Crameri[1], Stefan Zoller[1], Alex Widmer[1]

[1]*ETH Zurich, Zurich, CH, sonja.hassold@env.ethz.ch*

Internationally traded valuable timber species are increasingly in the focus of conservation geneticists because these trees also serves as important food sources in the tropical ecosystem. To ensure conservation and sustainability of these species authorities need to be able to assess the legality of traded wood, which requires methods that allow verification of species identity and origin. The genus *Dalbergia*, better known as rosewood, is an example of a highly sought after tropical timber species and several species are already threatened as a consequence of excessive illegal logging, even in protected areas. Once logged, the different *Dalbergia* species are difficult or impossible to distinguish and identify in the absence of traits typically used for species identification, such as bark, leaves, fruits and flowers. To better characterise and distinguish these rosewood species and to identify the species most affected by logging, we are working towards a DNA-based identification system for Malagasy rosewoods using standard DNA barcoding and nuclear microsatellite analysis.

First results indicate that DNA barcoding allows identifying rosewoods from Madagascar and microsatellites help distinguishing among Malagasy species. Such a method – once fully developed and validated – may be useful as a forensic tool for conservation purposes and international trade regulation. Furthermore, the genetic information can also be used to identify areas of high genetic diversity to establish new conservation zones or serving as a genetic certificate ensuring sustainable trade and legal income in source countries.

Merian Award Applicant

PLEISTOCENE CLIMATIC OSCILLATIONS, NOT RECENT HUMAN DISTURBANCE, CONTROLLED THE PATTERNS OF GENETIC DIVERSITY IN POLYLEPIS TARAPACANA

Yanling Peng[1], Isabell Hensen[1]

[1]*Martin-Luther University Halle-Wittenberg, Halle (Saale), DE, pengyl09@gmail.com*

This study analyses short-term responses to human activities and long-term responses to climate change of the world`s highest forests dominated by *Polylepis tarapacana*, a cold-adapted tree species endemic to the central Andes. We compared genetic diversity and structure of adult trees with those of seedlings (n = 384 in both cases) in 32 forest sites of *P. tarapacana* spanning an altitudinal gradient from 4100 to 5000 m a.s.l. using amplified fragment length polymorphism (AFLPs). For both adults and seedlings, we detected moderate to high genetic diversity, and low genetic differentiation. Four clusters concordant with geographic regions were recovered, with low genetic divergence between them. The genetic diversity increased from north to south for adults and seedlings. In addition, genetic diversity decreased with increasing altitude for adults, indicating historic upslope migration during interglacial periods. The similar levels of genetic diversity and differentiation for adults and seedlings highlight that recent human activities have not affected the genetic structure of this species.

PLANT GENETIC DIVERSITY IN TROPICAL LOWLAND RAINFOREST TRANSFORMATION SYSTEMS IN SUMATRA (INDONESIA)

Natalie Breidenbach[1], Iskandar Z. Siregar[2], Reiner Finkeldey[1]

[1]University Göttingen, Göttingen, DE, natalie.breidenbach@forst.uni-goettingen.de
[2]IPB Bogor, Bogor, ID

Due to the expansion of agriculture tropical rainforests are transformed to other types of land use throughout the globe, at a rate of approximately 14 % in Sumatra and Kalimantan (Indonesia) in the last 15 years (Broich 2011). A common result of the transformation of natural ecosystems to managed systems is a loss of species diversity. In Jambi Province, Sumatra, tropical lowland rainforests are transformed into oil palm plantations, rubber plantations and 'jungle rubber'. The aim of this project is to analyze the intra specific genetic diversity of vascular plants in reference forests compared to the three mentioned transformation systems.

In 32 plots (50m x 50m) of these four different ecosystems, 10 individuals of 10 dominant species were sampled. Based on anonymous AFLP markers the consequences of land use changes on the genetic diversity of plants caused by the different species composition in each system will be analyzed.

Preliminary results indicate that oil palm and other species of the transformation systems have a lower intra specific genetic diversity than the analyzed species of the forest plots, but the genetic diversity is in general very low. Shannon Index and Percentage of polymorphic loci do not show higher results for the forest species compared to dominating jungle rubber trees.

Our results on intraspecific variation will contribute to a comprehensive quantitative assessment of the impacts of tropical forest conversion to other land uses on biodiversity.

CONSERVATION GENETICS OF BOSWELLIA PAPYRIFERA (DEL.) HOCHST IN ETHIOPIA, AN ECONOMICALLY IMPORTANT BUT THREATENED DRY TROPICAL FOREST TREE

B. Addisalem[1,2], Frans Bongers[1], Marinus J.M. Smulders[1]

[1]*Wageningen University, Wageningen, NL, addisalem.bekele@wur.nl*
[2]*Wondo Genet College of Forestry and Naural Resources, Shashemene, ET, addisalem.bekele@wur.nl*

Boswellia papyrifera is an important source of the highly-valued aromatic resin frankincense, which is obtained from the bark of the tree. Frankincense has been a commodity of domestic and international trade since ancient times. In Ethiopia, anthropogenic habitat destruction has degraded B. papyrifera forests: populations have decreased to ever smaller patches, most of which are devoid of seedlings and small recruiting individuals. Only in some areas ample regeneration still exists. Conservation measures are needed to sustainably maintain the genetic resources and the frankincense production from the species. We studied the genetic diversity and population differentiation of B. papyrifera across Ethiopia, and the spatial genetic structure in a few populations that still have natural regeneration. For this we generated the first genomic DNA sequences of B. papyrifera, using Illumina paired-end sequencing, and developed 46 polymorphic microsatellite markers. For 12 populations across Ethiopia high genetic diversity (Ho = 0.67 and He = 0.68) and moderate level of between population differentiation (Fst = 0.089) were found. Three distinct clusters of genetically related populations were detected, in regions that are different in altitude, soil and rainfall. Within population spatial genetic structure (SGS) analysis revealed a significant genetic structure up to a distance of 100 m. We concluded that high levels of genetic variation are still present in B. papyrifera adult tree populations despite the ongoing population degradation process. We recommend that for effective conservation of the species both geographic distances between populations as well as their ecological conditions have to be taken into the design. Reforestation can help re-establish connection between populations and seeds needed for these programmes should be collected from trees separated by distances of over 100 m to avoid reduction of the genetic variability in the planted species, and therewith compromise the long-term conservation of this important natural resource.

Keywords: Boswellia papyrifera, conservation genetics, fine-scale SGS, genetic diversity

UNDERSTANDING LOCAL PATTERNS OF GENETIC DIVERSITY IN DIPTEROCARPS: IMPLICATIONS FOR FOREST MANAGEMENT AND RESTORATION.

Claire Tito de Morais[1], Jaboury Ghazoul[1], Eyen Khoo[2], Colin Maycock[2], Robi Bagchi[1], David Burslem[3], Sascha Ismail[3], Aline Finger[5], Suhei Nanami[4], Akira Itoh[4], Christopher Kettle[1]

[1]ETH Zurich, Zurich, CH, claire.tito@env.ethz.ch
[2]Forest Research Center Sepilok
[3]University of Aberdeen
[4]Osaka University
[5]Royal Botanic Garden Edinburgh

Lowland forests of Southeast Asia are dominated by canopy and emergent dipterocarps trees. This family is characterized by very limited seed dispersal and as a result are likely to display high fine scale spatial genetic structure (FSGS). High FSGS in tree populations is predicted to lead to increased inbreeding levels, particularly in fragmented and logged forests. It might limit potential of forest recovery. Better understanding of FSGS in undisturbed forest is crucial and provides a basis to inform forest management practices. We quantify FSGS for 19 dipterocarp species across four forest sites in Malaysian Borneo, India and Seychelles. We detected fine scale genetic structure in 15 of our study species. Most of which displayed significant inbreeding coefficients. Wood density, population density and flower size are potential predictors of FSGS, allowing their use by forest managers to project FSGS and inbreeding vulnerabilities in dipterocarps populations. The integration of improved understanding of genetic processes into sustainable forest management practices could contribute to the conservation of tree genetic resources.

THE IMPORTANCE OF GENE FLOW FOR SPECIES RESILIENCE IN FRAGMENTED LANDSCAPES

Aline Finger[1,3], Christopher Kaiser-Bunbury[2], Chris Kettle[3], Terence Valentin[4], Jaboury Ghazoul[3]

[1]*Royal Botanic Garden Edinburgh, Edinburgh, UK, a.finger@rbge.ac.uk*
[2]*Technical University of Darmstadt, Darmstadt, DE*
[3]*ETH Zurich, Zurich, CH*
[4]*National Park Authority, Mahé, SC*

Long-distance gene flow is thought to be one prerequisite for the persistence of plant species in fragmented environments. Human influences have led to severe fragmentation of native habitats in the Seychelles islands, with many species surviving only in small and isolated populations. The endangered Seychelles endemic tree *Glionnetia sericea* is restricted to altitudes between 450 m and 900 m where the native forest vegetation has been largely lost and replaced with exotic invasives over the last 200 years. This study explores the genetic and ecological consequences of population fragmentation in this species by analysing patterns of genetic diversity in a sample of adults, juveniles and seeds, and by using controlled pollination experiments. Our results show no decrease in genetic diversity and no increase in genetic structuring from adult to juvenile cohorts. Despite significant inbreeding in some populations, there is no evidence of higher inbreeding in juvenile cohorts relative to adults. A Bayesian structure analysis and a tentative paternity analysis indicate extensive historical and contemporary gene flow among remnant populations. Pollination experiments and a paternity analysis show that Glionnetia sericea is self-compatible. Nevertheless, outcrossing is present with 7% of mating events resulting from pollen transfer between populations. Artificial pollination provided no evidence for pollen limitation in isolated populations. The highly mobile and specialized hawkmoth pollinators (*Agrius convolvuli* and *Cenophodes tamsi*; Sphingidae) appear to promote extensive gene flow, thus mitigating the potential negative ecological and genetic effects of habitat fragmentation in this species. We conclude that contemporary gene flow is sufficient to maintain genetic connectivity in this rare and restricted Seychelles endemic, in contrast to other island endemic tree species with limited contemporary gene flow.

SESSION 8

S8 - DIPTEROCARP ECOLOGY

Chairs: Francis Brearley, Philippe Saner
Contact: f.q.brearley@mmu.ac.uk

SOLUBLE SUGARS AND THEIR RESPONSE TO A CHANGING ABIOTIC ENVIRONMENT IN DIPTEROCARP SEEDLINGS

Philippe Saner[1]

[1] *Philippe Saner, Zurich, CH, philippe.saner@uzh.ch*

Recent studies have shown that dipterocarp seedlings with enhanced non-structural carbohydrates (NSCs) also experienced an extended time to death under a drought scenario. NSCs can be sub-divided into starch and soluble sugars, and–although generally neglected–it was shown that soluble sugars respond strongly to abiotic changes in the tropics, such as under a drought or under varying light conditions. In the light of a changing abiotic environment, for example through expected prolonged drought periods in the tropics, these results indicate that dipterocarps differ in their response which may in turn affect their long-term survival and hence the structure of diverse lowland rainforests.

In this presentation I will summarize on these findings lately and focus on one specific component of soluble sugars–Iditol–that belongs to the wider group of sugar alcohols. Little is known about Iditol and to our knowledge it is the first time that it has been identified in tropical seedlings. Here we show that Iditol allocated to woody tissue (sink tissue) responds to changing abiotic conditions, in particular varying light levels that were simulated with light swapping experiments. We will conclude with some speculations about the role that Iditol may play in the adaptation of tropical dipterocarp seedlings to a changing abiotic environment.

SPATIAL VARIATION IN DENSITY-DEPENDENT RECRUITMENT OF PARASHOREA TOMENTELLA DURING LOW INTENSITY FLOWERING IN BORNEO

Christopher Philipson[1], Colin Maycock[2], Jaboury Ghazoul[1], David Burslem[3]

[1]*Ecosystem Management , ETH Zürich, Zürich, CH, christopher.philipson@usys.ethz.ch*
[2]*Universiti Malaysia Sabah, Kota Kinabalu, MY*
[3]*University of Aberdeen, Aberdeen, UK*

The pre and post-dispersal reproductive success of the emergent rainforest tree *Parashorea tomentella* was assessed in relation to two conflicting hypotheses on seedling recruitment (predator satiation versus Janzen-Connell), in the Sepilok forest reserve, Sabah, Malaysia. We followed the fate and survival of individuals from establishment up to 39 months. Seedling survival was density-dependent. We examine the survival of seeds from clumps of *Parashorea* trees with high background seed densities, compared to isolated trees or clumps with low background seed densities. Seed survival was correlated with the total reproductive output of the cluster of trees. There was an interaction between the distance to nearest fruiting conspecific and density of new recruits. This interaction highlight that the isolation of trees as well as local scale density of seeds are important factors forseedling survival.Our results suggest that the satiation of seed predators may play an important role in determining the recruitment success of the masting fruiting dipterocarp *Parshorea tomentella*.

MICRO-TOPOGRAPHY SEGREGATES DIPTEROCARP SEEDLINGS IN EPHEMERALLY FLOODED HABITAT

Jaboury Ghazoul[1], Julia Born[1]

[1]*ETH Zurich, Ecosystem Management, Zurich, CH, Jaboury.ghazoul@env.ethz.ch*

Niche diversification is prominent among the mechanisms proposed to explain tropical rainforest tree diversity. Less obvious is the differential impact of occasional, ephemeral and often minor disturbances on tree seedling growth and survival. We propose that differential tolerances to soil waterlogging contribute to the distribution of tree seedling communities along microtopographical gradients (on centimetre scales). We tested this hypothesis experimentally by evaluating survival and performance of planted seedlings across microtopographical gradients in a periodically inundated tropical rainforest environment. Survival and relative growth rates were assessed for six Shorea (Dipterocarpaceae) species in Sepilok Forest Reserve (Sabah, Malaysia) over a two-year period, during which seedlings were subjected to two brief flooding events. Seedling performance was related to microtopographic elevation within and among plots, and to soil moisture among plots. Faster growing species, S. argentifolia, S. leprosula and S. parvifolia, had lower survival under high soil moisture conditions than the three species with lower growth rates. Within plots, soil moisture was inversely correlated with microelevation, and seedlings located at higher microelevations had an increased probability of survival. Micro-topographical variation and minor ephemeral flooding events could therefore contribute to species assembly processes.

NO EVIDENCE FOR THE IMPORTANCE OF INCORPORATION INTO A COMMON ECTOMYCORRHIZAL NETWORK ON DIPTEROCARP SEEDLING GROWTH

Francis Brearley[1], Philippe Saner[2], Ayuho Uchida[3], David Burslem[3], Andy Hector[4], Rueben Nilus[5], Julie Scholes[6], Simon Egli[7]

[1]*Manchester Metropolitan University, Manchester, UK, f.q.brearley@mmu.ac.uk*
[2]*University of Zurich, Zurich, CH*
[3]*University of Aberdeen, Aberdeen, UK*
[4]*University of Oxford, Oxford, UK*
[5]*Forest Research Centre, Sandakan, MY*
[6]*University of Sheffield, Sheffield, UK*
[7]*WSL, Zurich, CH*

Transfer of carbon from adult trees to seedlings *via* ectomycorrhizal (EcM) hyphal network connections could have strong implications for seedling growth and survival and the maintenance of high diversity in dipterocarp-dominated tropical rain forests of South-east Asia.

We conducted four independent experiments that prevented contact with an EcM hyphal network by using a series of fine meshes and/or plastic barriers. We measured the growth of seedlings of six dipterocarp species over intervals ranging from 11 to 29 months.

In general, seedling growth was unaffected by exclusion from the EcM network in three experiments and there were no differences in foliar $\delta^{13}C$ values in the fourth.

Our results therefore fail to support the hypothesis that dipterocarp seedlings grown in the shaded forest understory benefit from being connected, through a common EcM network, to surrounding mature trees. We suggest that these results, in contrast to studies in low diversity boreo-temperate or tropical forests, are due to the nature of these high diversity forests lacking host species-specific EcM fungi and therefore providing little opportunity for exclusive support of conspecific seedlings *via* hyphal networks as the transfer of carbon is highly likely to be selected against.

ARE DIPTEROCARPS DIFFERENT? SPECIES TRAITS AND PRODUCTION RATES IN BORNEAN FORESTS

Lindsay Banin[1], David Burslem[2], Reuben Nilus[3]

[1]*Centre for Ecology and Hydrology, Edinburgh, UK, libanin@ceh.ac.uk*
[2]*University of Aberdeen, Aberdeen, UK*
[3]*Forest Research Centre Sabah, Sandakan, MY*

Forest above-ground production (AGWP) rates are reportedly greater in Borneo than elsewhere in the tropical realm. This has in part been attributed to the dominant tree family, the Dipterocarpaceae, which is largely absent in the other tropical regions. Are these trees better able to access resources for growth or do they allocate their resources differently? The research presented here examines above- and below-ground biomass and nutrient allocation in seedlings belonging to dipterocarp and non-dipterocarp families and on range of soil types in the Kabili-Sepilok Forest Reserve, Sabah. 787 seedlings belonging to 39 species were collected from three soil types (alluvial, sandstone hill and white sand). Each seedling was measured, separated into leaf, shoot and root parts, dried and weighed for biomass to determine allometry, above and below-ground biomass allocation and other traits including specific leaf area and stem density. Both plant and soil material were analysed for carbon and key nutrients (N, P, K, Ca, Mg, Mn). Soil fertility was significantly higher in the alluvial forest compared with the sandstone and white sand forests, but did not differ significantly between the latter two. Ratios of above-to-below ground biomass allocation differed both between taxonomic groups and across soils, indicating different growth strategies and environmental limitations. Differences observed may help explain differences in adult tree above-ground growth and production rates and reveal new insight into the role of species community in key ecosystem processes such as carbon cycling.

SEEDLING MORTALITY OF ENRICHMENT-PLANTED DIPTEROCARPS IN THE SABAH BIODIVERSITY EXPERIMENT

Sean Tuck[1]

[1]*University of Oxford, Oxford, UK, sean.tuck@plants.ox.ac.uk*

Enrichment line planting, a technique for replanting dipterocarp species targeted by logging, is an important strategy for restoring selectively logged forest in Sabah, Malaysian Borneo. The success of enrichment planting as a restoration technique hinges on the degree of mortality experienced by planted seedlings. Sabah Biodiversity Experiment is a long-term experiment that manipulates the enrichment-planting technique, principally in the number and identity of species planted, designed to assess its effectiveness for restoring logged-over forest. Here, we present results on the seedling mortality during the establishment phase of this experiment. We explore the sources of variability in seedling mortality to investigate (i) the differences among species, (ii) whether species-level mortality is dependent on environmental context and other initial conditions, (iii) whether species in this experimental community show synchronised responses to environmental context, (iv) the timing of seedling mortality over the 12-year timespan of the experiment, and (v) whether species mortality estimates are associated with key plant traits. Levels of mortality vary widely among species, but species also show a wide range of responses to environmental and initial planting conditions. Mortality estimates of these species were synchronised across the experiment, suggesting that unfavourable conditions for one species tend to be unfavourable for all. Species mortality was correlated with key plant traits, supporting previous work at this site. These insights into seedling mortality highlight what factors may compromise the success of enrichment planting and contribute to a discussion on how the restorative effect of this technique can be improved.

INVESTIGATING THE MECHANISMS OF COMMUNITY ASSEMBLY IN A MIXED DIPTEROCARP FOREST USING FUNCTIONAL TRAITS

Maria Kaye[1], David Burslem[1]

[1] *The University of Aberdeen, Aberdeen, UK, r01mek12@abdn.ac.uk*

The CTFS forest dynamics plots are of great importance in studying the assembly and maintenance of diverse tree communities in tropical forests. This study is based at the CTFS plot in the Danum valley conservation area in Sabah, Malaysia, in an area of primary mixed Dipterocarp forest of great ecological value and scientific interest. Although the Danum valley site has been the subject of much previous research, the establishment of the plot in which every tree stem is tagged and identified, allows community studies of greater detail and scale than have been previously feasible. In this study, we measured functional leaf traits for 300 species in small sub-communities across 20ha of the plot. Trait similarity within the sub-communities was compared with that in a set of artificial communities generated at random from the meta-community species list. By looking at where there are deviations from random in the sub communities, we can draw conclusions about the relative importance of habitat filtering, limiting similarity and neutral mechanisms in community assembly. We then attempt to link these patterns to fine-scale environmental gradients. We go on to compare trait values and similarity in the canopy dominant genus, *Shorea* (Dipterocarpaceae), with those of the entire community.

DOES SEED DISPERSAL GOVERN SPATIAL DISTRIBUTION IN THE DIPTEROCARPACEAE? A BORNEAN CASE STUDY

James Smith[1], Robi Bagchi[2], Chris Kettle[1], Colin Maycock[5], Eyen Khoo[3], Jaboury Ghazoul[1], David Burslem[4]

[1]*ETH Zurich, Zurich, CH, james.smith@usys.ethz.ch*
[2]*University of Connecticut, Storrs, US*
[3]*Forest Research Centre, Sandakan, MY*
[4]*University of Aberdeen, Aberdeen, UK*
[5]*Universiti of Malaysia Sabah, Kota Kinabalu, MY*

Plant spatial patterns are of interest to tropical forest ecologists as they document how ecological processes, including density-dependence, competition, habitat associations and dispersal have shaped the current distribution of the population. The effect of dispersal on spatial patterns is directly relevant to the Dipterocarpaceae, a family of tropical trees that dominate the forests of Southeast Asia. Dipterocarp fruit are composed of a nut with multiple wings which cause the fruit to disperse via gyration. Previous work in our group has confirmed that there are species specific differences in seed dispersal capacity in this family, based on the wing loading (ratio of fruit wing area to fruit mass). In this talk we explore the role wing loading plays in shaping the spatial distributions of dipterocarps in contiguous primary forest, hypothesizing that species with poor seed dispersal capability possess more aggregated distributions. We use a novel methodology to analyse multiple spatial point patterns to assess what life history traits and environmental covariates drive distribution patterns of dipterocarp species in a 160 ha forest plot in Borneo. The results of this analysis are of applied use to forest managers in Southeast Asia as a negative relationship between seed dispersal ability and intensity of spatial aggregation suggests that many dipterocarp species are vulnerable to an erosion of genetic diversity following logging or other forest disturbances, and that this can be predicted by fruit morphology.

ECOLOGICAL GENOMICS OF GENERAL FLOWERING AND DROUGHT RESPONSES OF DIPTEROCARPACEAE

Kentaro K. Shimizu[1], Masaki J. Kobayashi[1], Yayoi Takeuchi[2], Kenta Tanaka[3], Tomonori Kume[4], Bibian Diway[5], Masaomi Hatakeyama[1], Kevin Kit Siong Ng[1], Chow Lih Yew[1], Mark Robinson[6], Malgorzata Nowicka[6]

[1]*University of Zurich, Institute of Evolutoinary Biology and Environmental Studies, Zurich, CH, kentaro.shimizu@ieu.uzh.ch*
[2]*National Institute of Environmental Studies, Tsukuba, JP*
[3]*Sugadaira Montane Research Center, University of Tsukuba, Tsukuba, JP*
[4]*National Taiwan University, Taiwan, TW*
[5]*Botanical Research Center Semenggoh, Sarawak, MY*
[6]*Institute of Molecular Life Sciences, University of Zurich, Zurich, CH*

Next-generation sequencers opened the way to address ecological and evolutionary questions on "non-model" species using genomic tools. We have studied the genome and transcriptome of the family Dipterocarpaceae, which dominates the forests in tropical South-East Asia and comprises more than 400 species. Notably, dipterocarp species, as well as co-occurring ones, predominantly flower synchronously at irregular intervals of less than one year to several years. This 'spectacular and mysterious' phenomenon is referred to as general flowering and is thought to have a considerable impact not only on the reproductive success of the plant, but also on animal populations by facilitating pollination and seed predator satiation and on human economic activity. Recent studies have proposed several proximate factors inducing general flowering, such as drought and falls in minimum temperature. However, limited empirical data on the developmental and physiological processes have been available to test the significance of such factors. To overcome this limitation and test the hypotheses that general flowering is triggered by the proposed factors, we conducted an 'ecological transcriptome' study of a mass flowering species, *Shorea beccariana*, comparing meteorological data with genome-wide expression patterns obtained using next-generation sequencing. We collected the samples during the episode of general flowering in the Lambir Hills Naitonal Park in 2009. Among the 98 flowering-related genes identified, the homologs of a floral pathway integrator, *SbFT*, and a floral repressor, *SbSVP*, showed dramatic transcriptional changes before flowering, and their flowering functions were confirmed using transgenic Arabidopsis thaliana. Expression in drought-responsive and sucrose-induced genes also changed before flowering. These genome-wide expression data support the hypothesis that drought is a trigger for general flowering.

SESSION 9

S9 - APPLIED CONSERVATIONS

Chairs: Ainhoa Magrach and Emma Morgan
Contact: ainhoa.magrach@usys.ethz.ch

THE ASIAN ELEPHANT (ELEPHAS MAXIMUS L) IN SOUTHERN INDIA: A LOCAL SUCCESS IS NOT A LICENSE TO KILL

Priya Davidar[1], Jean-Philippe Puyravaud[2]

[1]*Pondicherry University, Pondicherry, IN, pdavidar@gmail.com*
[2]*Sigur Nature Trust, Mavinhalla, IN*

We assessed the distribution and population estimates of the Asian elephant in the Western Ghats region of India from current literature. We identified 17 contiguous or semi-contiguous populations. Three populations (17%) supported over 1000 elephants, among which the largest (≈ 5000) was in the Nilgiri-Brahmagiri-Eastern Ghats region. Ten populations (58%) had fewer than 100 elephants, of which there were no recent sightings in three. Smaller sites supported signficantly fewer elephants and 10 of the sites were < 1,000 km^2 in area. Protected areas supported significantly more elephants than Reserved Forests despite having equivalent rates of deforestation. A case study from the Nilgiri Biosphere Reserve suggests that the population has not recovered from intense ivory poaching in the past (1980's to 2000's) as indicated by their short life span and skewed sex ratios. We found higher levels of human caused elephant mortality in a Reserved Forest compared with that of a contiguous protected area. The optimistic scenarios proposed by elephant experts to cull populations based on the presumption that they are overabundant are not supported by data. We conclude that the available habitat can support a larger elephant population if connectivity is ensured, Reserved Forests upgraded to higher levels of protection and stringent action against illegal killings.

LEMURS, HABITAT REQUIREMENTS, AND ECOSYSTEM RESILIENCE: COMMUNITY-BASED MONITORING FOR CONSERVATION IN EASTERN MADAGASCAR

Maholy Ravaloharimanitra[1], Lucien Randrianarimanana[1], Hery Nirina Randriahaingo[1], Tianasoa Ratolojanahary[2], Jean Rafalimandimby[2], Youssouf[2], Rainer Dolch[2], Tony King[1]

[1]*The Aspinall Foundation - Programme Madagascar, Madagascar, MG, rrmahooly@gmail.com*
[2]*Mitsinjo Association, Madagascar, MG*

Since its start in 2009, The Aspinall Foundation's Madagascar Programme has focused on the conservation of threatened species, most notably on the Greater Bamboo Lemur (*Prolemur simus*), a critically endangered primate and bamboo specialist with a highly patchy distribution.

With support from the Malagasy conservation organization Association Mitsinjo and in close collaboration with local communities, the sourcing of local knowledge has yielded several previoulsy unknown sites where *Prolemur simus* occurs, leading to a significant increase of the known range for the species.

In all of the sites identified, members of local communities were trained and instructed to lead para-scientific data collection on the behaviour and ecology of *Prolemur simus*. This work was subsequently extended to include community-based ecological monitoring of additional focal animal and plant species.

While community-led faunal inventories mainly focus on other sympatric lemurs and their interactions with *Prolemur simus*, floral inventories of these sites are used to work out resource utilization for these primates in order to better understand habitat requirements, species interactions.

Ecological monitoring does also involve recording ecosystem disturbance and factors of anthropogenic pressure on these habitats and their species, permitting to gain insight into responses to these disturbances and ecosystem resilience.

The ultimate goal of the project is to increase the capacities and involvement of local communities to be able to preserve (lemur) species and their habitats and to better manage the ecosystems where they live.

DISTRIBUTION AND CONSERVATION STATUS OF PHLEGMARIURUS (LYCOPODIACEAE) IN THE STATE OF VERACRUZ, MEXICO

Cesar Carvajal-Hernández[1], Samaria Armenta-Montero[1], Edward A. Ellis[1], Thorsten Krömer[1]

[1]*Centro de Investigaciones Tropicales. Universidad Veracruzana, Xalapa, Veracruz, MX, cesar.carvajalh@gmail.com*

The pteridophyte flora of Mexico contains 13 species in the genus *Phlegmariurus*, of which nine are found in the state of Veracruz (*P. cuernavacensis, P. dichotomus, P. linifolius, P. myrsinites, P. orizabae, P. pithyoides, P. pringlei, P. reflexus, P. taxifolius*). They are located primarily in undisturbed areas of humid montane, pine-oak and tropical humid forests, which are all ecosystems threatened by deforestation and fragmentation. For this reason, the objective of this study was to evaluate and understand the distribution and conservation status of species of this genus in the state of Veracruz, Mexico. Using Maxent, probability distributions were modeled based on 173 herbarium specimens (25% from recent collections by the authors and/or collaborators), considering factors such as climate, elevation and vegetation cover. Additionally, anthropogenic impacts on the original habitat of each species were analyzed in order to assign threatened categories based on IUCN classifications at regional levels. Results show that potential distributions are located in the montane regions of the central and southern parts of the state. All nine *Phlegmariurus* species in Veracruz were found to be in some category of risk, with *P. orizabae* classified as critically endangered, having only a single specimen collected in 1854. The main reasons for species threats are the continuous loss and fragmentation of their natural habitat, uncontrolled harvesting activities and the lack of protected areas that include humid montane and pine-oak forests in the central region of the state.

POPULATION PERFORMANCE AND FUTURE PROSPECTS OF BLACK RHINOCEROS IN TANZANIA

Victor Kakengi[1]

[1]*Tanzania Wildlife Research Institute, Arusha, TZ, kakengi1@yahoo.com*

Historically there may have been as many as 850,000 black rhinos in Africa. However, by 1970 numbers had fallen to approximately 65,000, by that time Tanzania had approximately 10,000 of these animals. By then this was the largest concentrations of black rhinos in Africa. Total numbers continued to decline and by 1980 there were only 14,800 black rhinos left in all over Africa. At this time Tanzania was still a key range state conserving 3,795 or just over a quarter of Africa's black rhinos. Poaching continued and by 1995 numbers of black rhinos in Africa had plummeted to as low as 2,410 with the species coming close to being wiped out in Tanzania with only an estimated 32 animals remaining. However, since 1995, following increased protection, healthy population growth in some populations and a small number of reintroductions, numbers of both black rhino subspecies steadily increased to reach an estimated minimum total of 123 animals by the end of 2007.

There were four black rhinoceros sub-species in Africa, the South – Central subspecies (Diceros bicornis minor) that exists in S. Tanzania, Zambia, Zimbabwe & Mozambique.

South –Western sub-species (Diceros bicornis bicornis) which is adopted to arid and semi arid areas of Namibia, S. Angola, N. Botswana and W. SA

East Africa sub-species (Diceros bicornis michael) which primarily existed Tanzania and Kenya and the West African sub-species (Diceros bicornis longipes) which used to exist in Cameroon but declared extinct in 2011.

Two of the three remaining recognized black rhino sub-species, the southern-central Diceros bicornis minor and the eastern D.b. michaeli, occur in Tanzania. Their historic distribution extended virtually throughout the country to include the dry Acacia savannahs in the north, the Brachystegia woodlands in the south and west, and the coastal forest-savannah mosaics in the east. They additionally occurred in highland forests, swamplands and dry thickets. The Tanzania populations of D.b. michaeli and D.b. minor constitute the respective southern and northern limits of the range of these two subspecies in Eastern Africa, thus, making Tanzania a stronghold for the future survival of Black rhinoceros in the world. This paper presents the challenges and future prospects of Black rhinoceros sub-population revival in Tanzania.

FACING THE HEAT: THERMAL COMPENSATION AND THERMAL LIMITS IN TROPICAL REPTILES

Wiebke Berg[1], Ole Theisinger[1], Kathrin Dausmann[1]

[1] *University of Hamburg, Hamburg, DE, wiebkeberg@gmail.com*

Temperature is a crucial factor in reptile biology because of its great influence on energy budgets. Tropical species are particularly sensitive to climatic changes because they already function at relatively high body temperatures, where they experience greater changes in metabolic rate despite small changes in temperature. To compensate temperature changes in their environment (e.g. through climate change or microclimatic changes through deforestation), reptiles can either adapt their thermal physiology or adjust their behaviour to maintain lower body temperatures.

With the potential to function as early indicators of environmental changes, we used three species of reptiles (*Oplurus saxicola, O. quadrimaculatus* & *Zonosaurus laticaudatus*) from southern Madagascar to investigate the importance of physiological and behaviour adaptations for the resilience of tropical reptiles against climatic changes. We compare data on body temperature, activity time and metabolic rate from different habitats along an environmental gradient from rainforest to spiny forest. Records of metabolic rate show a metabolic shift at temperatures below the preferred body temperature that allow similar performances in colder (rainforest) and hotter (spiny forest) environments. However, data on activity times reveal restrictions in the possible duration of activity that may be the limiting factor for the current and future distribution of these species.

ENDEMIC RADIATION IN FRESHWATER MOLLUSCS OF MOUNTAIN WATERFALLS IN THE WESTERN GHATS, INDIA

Aravind Ananthram Neelavar[1], G. Ravikanth[1], Sandeep Sen[1], N.A. Madhyastha[2], David Reid[3]

[1]Endemic radiation in freshwater molluscs of mountain waterfalls in the Western Ghats, India, Ashoka Trust for Research in Ecology and theEnvironment (ATREE),, Bangalore, Karnataka 560064, IN, aravind@atree.org
[2]Malacology Centre, Poorna Prajna College,, Udupi, Karnataka 576101, IN
[3]1Department of Zoology, Natural History Museum,, London SW7 5BD, UK

The Western Ghats mountain chain runs parallel to the western coast of India and is considered one of the 34 world biodiversity hotspots, with a high degree of endemism. This mountain range has several unique radiations in vertebrate genera such as *Micrixalius, Nyctibatrachus, Raorchestus* and *Indirana*. Among invertebrates, the caenogastropod family Littorinidae is almost exclusively marine, but has a unique freshwater genus, *Cremnoconchus*. This genus is an iconic component of the freshwater fauna of the Western Ghats hotspot. It is not only endemic to India, but is entirely restricted to the waterfalls of the western escarpment of the Ghats. At the global scale this unique freshwater radiation in Littorinidae is one of the only five localized freshwater radiations of predominantly marine caenogastropod families. The inventory of species in this genus is incomplete and so far the nine described species have been recognized only by morphological criteria. The ecology, phylogenetic relationships and evolutionary patterns of *Cremnoconchus* species remain to be investigated. Here we present the first molecular phylogenetic results for the genus and demonstrate the existence of several additional species. New field data provide information on the ecological requirements of these molluscs and highlight threats to their conservation.

ISLAND CONSERVATION MEGAHERBIVORES: NON-NATIVE, NOVEL FUNCTION WELCOME?

Dennis Hansen[1]

[1] *IEU / University of Zurich, Zurich, CH, dennis.hansen@ieu.uzh.ch*

There is a heated debate whether all alien species are 'guilty until proven innocent', or whether some should be accepted or even welcomed. Further fanning the flames, I suggest that introductions of carefully vetted, non-native species can be a good thing. On many tropical and subtropical islands, native megaherbivores (lizards, flightless birds, tortoises) recently went extinct. Here, rewilding with carefully selected non-native species as ecological replacements is increasingly considered a solution, reinstating a 'friendly' herbivory regime largely benefitting native flora. Based on these efforts, I suggest that restoration practitioners working on islands without a history of native megaherbivores that are threatened by invasive plants, should consider introducing a non-native island conservation megaherbivore (ICM), and that large and giant tortoises are ideal candidates. Tortoise-ICMs would be equally useful on islands where eradication of invasive mammals has led to increased problems with invasive plants, or on islands that never had introduced mammalian herbivores, but where invasive plants are a problem. My proposal may seem radical, but the reversibility of tortoise-ICMs means that nothing is lost from trying, and that indeed much is to be gained. As an easily-regulated adaptive management tool, the use of tortoise-ICMs represents an innovative, hypothesis-driven 'innocent until proven guilty' approach.

KEYWORDS: conservation, restoration, invasive plants, control, eradication, giant tortoises, ecosystem function, herbivory

DO CURRENT TRENDS OF RUBBER PLANTATION EXPANSION THREATEN BIODIVERSITY AND LIVELIHOODS?

Antje Ahrends[1], Pete M Hollingsworth[1], Alan Ziegler[2], Jefferson M Fox[3], Huafang Chen[4], Yufang Su[4], Jianchu Xu[4,5]

[1]*Royal Botanic Garden Edinburgh, Edinburgh, UK, aahrends@rbge.ac.uk*
[2]*National University of Singapore, Singapore, SG*
[3]*East-West Center, Honolulu, US*
[4]*Kunming Institute of Botany, Kunming, CN*
[5]*World Agroforestry Centre, Kunming, CN*

Rubber prices have escalated in the last decade. This has led to rapid and widespread land conversion to monoculture rubber plantations in continental SE Asia, where natural rubber production has increased >50% since 2000. Here, we analyze the spread of rubber between 2005 and 2010 (based on maps generated from MODIS 250 m remotely sensed imagery) in combination with environmental data and reports on rubber plantation performance. We show that rubber has been planted into increasingly sub-optimal environments. Currently, 72% of plantation area is in environmentally marginal zones where reduced yields are likely, and 57% is susceptible to diminished water availability, erosion, frost, or wind damage which may make long-term production unsustainable. In 2013 typhoons destroyed plantations worth US$ >250 million in Vietnam alone, and future climate change is likely to lead to a net exacerbation of environmental marginality for both current and predicted future rubber plantation area (analysis based on data from 39 models from the Coupled Model Intercomparison Project Phase 5 across four Representative Concentration Pathways for 2050). Rubber has been extensively planted on lands important for biodiversity conservation and ecological function. For example, between 2005 and 2010 >2,500 km^2 of natural tree cover and 610 km^2 of protected areas were converted to plantations. The on-going conversion of lands important for ecosystem services, biodiversity, or local livelihoods to rubber plantations where they may yield short-term returns before becoming degraded and abandoned is of environmental concern, and may ultimately compromise livelihoods – particularly if rubber prices fall.

A CONTEXT-SPECIFIC AND DATA-EFFICIENT APPROACH FOR QUANTIFYING BIODIVERSITY BENEFITS AND IMPACTS OF LAND-USE POLICIES

John Garcia-Ulloa[1], Jaboury Ghazoul[1], Lian Pin Koh[2]

[1]*Institute of Terrestrial Ecosystems, ETH Zurich, Zurich, CH*
[2]*Environment Institute and School of Earth and Environmental Sciences, University of Adelaide, Adelaide, AT*

In this presentation, we demonstrate the application of a methodological framework that can be used to predict the marginal value of different land-use policies for biodiversity conservation. This methodology combines the use of tailored remote sensing information on changes in land cover and forest connectivity, and taxon-specific ecological data to quantify the biodiversity outcomes of protecting or converting a forest under different land-use scenarios. We present the application of this methodology to REDD+ implementation in Madre Dios (Peru), and discuss the implications of our findings for the implementation of this policy.

SESSION 10

S10 - SEED DISPERSAL

Chairs: Eckhard W, Heymann and Omer Nevo
Contact: eheyman@gwdg.de

INTERACTION BETWEEN WIND AND WATER AS A DRIVER OF PASSIVE DISPERSAL IN MANGROVES

Tom Van der Stocken[1,2], Bram Vanschoenwinkel[1], Dennis J. R. De Ryck[1,2], Tjeerd J. Bouma[3], Farid Dahdouh-Guebas[1,2], Nico Koedam[1]

[1]*Vrije Universiteit Brussel, Brussels, BE, tvdstock@gmail.com*
[2]*Université Libre de Bruxelles, Brussels, BE, tvdstock@gmail.com*
[3]*Royal Netherlands Institute for Sea Research, Yerseke, NL*

Although knowledge on dispersal patterns is essential for predicting long-term population dynamics, critical information on the modalities of passive dispersal and potential interactions between vectors is often missing. Here, we use mangroves as a model to investigate the interaction between wind and water as a driver of passive dispersal. We imposed 16 combinations of wind and hydrodynamic conditions in a flume tank, using propagules of six important mangrove species (and genera), resulting in a set of dispersal morphologies that covers most variation present in mangrove propagules worldwide.Overall, the effect of wind on dispersal depended on propagule density (g l-1). The low-density *Heritiera littoralis* propagules were most affected by wind, while the high-density vertically floating propagules of *Ceriops tagal* and *Bruguiera gymnorrhiza* were least affected. *Avicennia marin*a, and horizontally floating *Rhizophora mucronata* and *C. tagal* propagules behaved similarly. Morphological propagule traits, such as the dorsal sail of *H. littoralis*, explained another part of the interspecific differences. Within species, differences in dispersal velocities can be explained by differences in density and for *H. littoralis* also by variations in the shape of the dorsal sail. A conceptual model of dispersal in a natural mangrove habitat illustrates that different propagule types have a different likelihood of reaching the open ocean depending on prevailing winds and water currents. Results demonstrate that in open water, propagule traits (density, morphology, and floating orientation) appear to determine the effect of wind and water on dispersal dynamics. This has important implications for inter- and intraspecific variation in dispersal patterns and the likelihood of reaching suitable habitat patches within a propagule's viability period.

Merian Award Applicant

IMPACT OF HUNTING AND ROAD DISTURBANCE ON FRUIT CONSUMPTION AND SEED DISPERSAL BY FRUGIVORES IN A TROPICAL RAIN FOREST

Pierre-Michel Forget[1], Aurélie Albert[1], Olivier Boissier[1], Axelle Bouiges[1], Caroline Dracxler[1], François Feer[1], Irène Mendoza[1]

[1]*MUSEUM NATIONAL HISTOIRE NATURELLE - CNRS UMR 7179, BRUNOY, FR, pierre-michel.forget@mnhn.fr*

Ecological processes in tropical forests are being affected at unprecedented rates by human activities. Yet, the continuity of ecological functions like seed dispersal is crucial for forest regeneration. It thus becomes increasingly urgent to be able to rapidly assess the health status of these processes in order to take appropriate management measures. Using a new method that we developed to rapidly assess the level of seed removal and frugivore activity (Boissier et al. 2014), we aimed at evaluating the effect of a national road opened and paved in 2005 on the health status of the nearby mature forest in French Guiana. We studied the level of fruit consumption and seed dispersal for four animal-dispersed tree species (Myristicaceae : *Virola kwatae* and *V. michelii*; Sapotaceae: *Manilkara bidentata* and *M. huberi*) in forest corridor and further away from the road. We counted fallen fruits, fruit valves, and seeds of each focal fruiting tree (N = 30 per genus) in a single 1 m^2 quadrat, and calculated two indices: the proportion of fruits opened and the proportion of seeds removed by arboreal and terrestrial mammals. In addition to direct visual sightings during samplings, we used automatic remote camera to identify the ground-dwelling wildlife during 6-10 days. Our results showed that the proportion of fruits opened and the level of seeds removed in the forest within the vicinity (< 1-2 km) of the road are comparable to the least impacted site of reference. Our indices also confirm that birds and small body-sized primates are the main consumers and seed dispersers remaining in the forest nearby the new road. Therefore, despite effort to preserve forest continuity (vegetation bridge over the asphalted road), hunting pressures is the main driver of defaunation which has affected ecological processus such as seed dispersal less than a decade after the road was opened to traffic. Repeated measures at the same trees within 5-10 years will allow to evaluate how the forthcoming opening of the bridge over the Oyapoque river, the France-Brazil frontier, and the expected greater human pressures, will impact the forest.

HOW TO BENEFIT FROM BEING EATEN? ELEPHANT SEED DISPERSAL EXPERIMENTS WITH DILLENIA INDICA IN SOUTHEAST ASIA

Franziska K. Harich[1], Anna C. Treydte[1], Tommaso Savini[2], John E. Roberts[3], Chution Savini[4]

[1]*Department of Agroecology in the Tropics and Subtropics, University of Hohenheim, Stuttgart, DE, harich@uni-hohenheim.de*
[2]*Conservation Ecology Program, King Mongkut's University of Technology Thonburi, Bangkok, TH*
[3]*Golden Triangle Asian Elephant Foundation, Chiang Saen, TH*
[4]*Sustainability Studies Department, Srinakharinwirot University, Bangkok, TH*

Elephants represent one of the largest living seed dispersers and they play an important role in maintaining tree diversity in forest ecosystems. While several plant species rely on African elephants (*Loxodonta africana*; *L. cyclotis*) as exclusive seed dispersers, no such obligate seed dispersal mutualisms have been recorded for Asian elephants (*Elephas maximus*), thus far. We examined if *Dillenia indica* Linn., a megafaunal fruit tree species, depends on or profits from elephants as seed dispersal agents, and thus will suffer in the absence of these animals. We conducted feeding trials with domestic Asian elephants in northern Thailand and quantified the gut retention time of *D. indica* seeds in order to calculate potential dispersal distances. Furthermore, we undertook germination experiments with a total of 1200 swallowed and unswallowed control seeds to determine any differences in germination rate and time. We further installed camera traps around *D. indica* trees in a natural forest to monitor wildlife consumption of fruits. We found that the germination rate for digested seeds was only 9% higher than for undigested control seeds but that the germination time was significantly faster (> 1 week on average) for digested seeds. The average minimum and maximum gut retention times were 20.4 and 72 hours, respectively. Only rodents were observed visiting the trees in the wild, which might be partly due to a low number of elephants in the protected area and an overall high hunting pressure on other mammals. We conclude that *D. indica* benefits from seed dispersal through elephants without depending on it. However, the declining numbers of megafaunal seed dispersers such as elephants might lead to long-term impacts on the tree populations such as an increase in plant clusters as well as a generally lower geographic distribution.

FROM THE CANOPY TO THE FLOOR - SEED DISPERSAL IN AMAZONIAN FLOODPLAINS

Pia Parolin[1,2], Leandro Ferreira[3], Florian Wittmann[4]

[1]*University of Hamburg, Hamburg, DE, piaparolin@gmx.de*
[2]*INRA, Sophia Antipolis/Nice, FR, piaparolin@gmx.de*
[3]*Museu Paraense Emilio Goeldi, Belém, BR*
[4]*MPI Chemistry, Mainz, DE*

Amazonian floodplain forests are highly diverse, with more than one thousand tree species which are highly adapted to the regular flood pulse. In the present study, we summarize the available knowledge on the dispersal modes of tree species from the floodplain forests of the Central Amazon. The dispersal syndromes of the single species were determined by an extensive literature review, added by personal observations and the analysis of the morphology of the diaspores. Among the studied species, we found that all known means of dispersal common to trees are also represented in Amazonian floodplains. However, most trees display adaptations to take advantage of the seasonal flood pulse for dispersal. A high number of species are dispersed by floatation or water currents. In fact, the peak of fruit maturity occurs during the high-water period. The diaspores possess adaptations which enhance dispersal linked to water and which are not found in species of the surrounding uplands, e.g. spongy tissues, and air filled spaces. Fruits and seeds are the object of dispersal, covering all sizes and types, e.g. pods, capsules, drupes, berries, pyxidia. Besides hydrochory, zoochory is a frequent dispersal syndrome, with a high number of species being dispersed by fish. In light of the fine-tuned relationships between plants and animals, and the imminent threats imposed by human actions to floodplain forests of the Amazon River such as the building of dams, the need to understand the interactions and main modes of dispersal is fundamental for the conservation of the integrity of these forests and the foodchains therein.

IS FRUIT ODOR AN ADAPTATION TO PRIMATE SEED DISPERSAL?

Omer Nevo[1,2], Manfred Ayasse[3], Laura Teresa Hernandez Salazar[4], Matthias Laska[5], Rosa Orts Garri[5], Stefan Schulz[6], Eckhard W. Heymann[1]

[1]German Primate Center, Göttingen, DE, onevo@dpz.eu
[2]Georg-August University of Göttingen, Göttingen, DE, onevo@dpz.eu
[3]University of Ulm, Ulm, DE
[4]University of Veracruzana, Xalapa, MX
[5]Linköping University, Linköping, SE
[6]Technical University of Braunschweig, Braunschweig, DE

Many tropical angiosperms rely on frugivores for seed dispersal and evolved fleshy fruits to attract them. The hypothesis that fruit odor evolved to signal ripeness to dispersal vectors was recently confirmed for bat-dispersed figs, but it is not known whether olfactory signals have evolved in other plant taxa and in the context of communication with other dispersal agents. Primates are important seed dispersers in the tropics and are now known to possess olfactory capacities that are higher than previously thought. It is thus likely that fruits whose seeds they disperse evolved olfactory signals for ripeness, too. This signaling could follow two strategies: more expensive and efficient husk odor, or cheaper ad-hoc pulp aroma. Using gas chromatography coupled with mass spectrometry, we analyzed the odor profiles of intact (husk signaling) and open (pulp aroma), ripe and unripe, fruits of two primate-dispersed (olfactory signal expected) and two bird-dispersed (no olfactory signal expected) Neotropical plant species. Primate-dispersed fruits showed high concentrations of complex odor blends that differ between ripe and unripe fruits either only in the pulp or in both pulp and husk, thus making their odor profiles suitable for signaling ripeness. Bioassays with captive primates confirmed that they are capable of identifying the odor of ripe fruits, discriminate it from the odor of unripe fruits and use this information in food-selection tasks. In contrast, bird-dispersed fruits produce trace amounts of simple odor profiles that are not different between ripe and unripe fruits and thus provide no reliable information regarding fruit ripeness. Our study controlled for phylogenetic inertia. Thus, our results support the hypothesis that fruit aroma is an adaptation for signaling ripeness to seed-dispersing primates.

Merian Award Applicant

SEED DISPERSAL BY AVIAN FRUGIVORES: NON-RANDOM HETEROGENEITY AT FINE SCALES

Ashwin Viswanathan[1], Rohit Naniwadekar[2], Aparajita Datta[2]

[1]WCS India Program, National Centre for Biological Sciences (NCBS-TIFR), Bangalore, IN, ashwinv2005@gmail.com
[2]Nature Conservation Foundation, Mysore, IN

Studies of avian seed dispersal have primarily examined dispersal as a function of distance from the parent tree and/or heterogeneity in dispersal due to animal use of nesting, roosting and sleeping sites (rare sites). Dispersers are largely assumed to homogeneously 'scatter disperse' seeds at any distance from the parent tree. In this study, we characterize variation in seed rain at fine scales due to preferential use of trees within the forest stand by birds. We studied the dispersal curve of Prunus ceylanica, a primarily bird-dispersed species and compared seed rain at conspecifics, heterospecific fruiting trees, emergent trees, and the landscape surrounding these trees. Seed rain of P. ceylanica was found to peak globally under the canopy of conspecifics but to peak locally under the canopy and immediate neighborhood of heterospecific fruiting trees. Our results demonstrate that seed rain is highly clumped at fine spatial scales. A large proportion of seeds are dispersed in specific, localized regions.

Although we used the 'classical' approach to study seed dispersal, we seek to make a case for the modification of the traditional approach to incorporate and capture heterogeneity at fine scales. We suggest that the large scale dispersal kernels that are conventionally modelled may result in the loss of important information. Fine scale patterns of seed rain can have important implications for plant population dynamics and might significantly alter the impact of post-dispersal processes. Seed dispersal models may need to incorporate this heterogeneity to explain manifestations of spatially explicit dynamics like mixed species „orchards".

Merian Award Applicant

LINKING PRIMATE FRUGIVORY AND MOVEMENT ECOLOGY TO TREE RECRUITMENT IN LANDSCAPES WITH HETEROGENEOUS LOGGING HISTORIES

Joanna Lambert[1], Martha Lyke[1], Jerry Jacka[1]

[1] *University of Texas, San Antonio, US, joanna.lambert@utsa.edu*

Frugivore movement ecology and feeding biology generate seed rain patterns in non-random ways, resulting in spatially aggregated landscapes of plant species dependent upon zoochory. Kibale National Park, Uganda, is home to the world's most abundant (2,710.5 kg/km^2) and among the most species-rich (13) primate communities; most species are highly frugivorous. This forest also has a long and complex history of logging, resulting in a mosaic of forest compartments at differing phases of post-logging tree recruitment. Here, we explore how the primate-generated seed rain correlates with tree population structure at a landscape level over a 30 year period. Data on chimpanzees and frugivorous monkeys collected 1993 – 2004 indicate that that in a single day, in 1 km^2, chimpanzees (*Pan troglodytes*) and frugivorous monkey species (*Cercopithecus spp*) can move >40,000 seeds - more than any other vertebrate taxon in the forest. Chimpanzees move most seeds by swallowing and defecating them > 1 km from parent tree in clumps of seeds (mean : 149 seeds >5cm), while smaller-bodied, cercopithecine monkeys spit seeds singly in close proximity to parent trees (<100m). Using Global Positioning System (GPS) and tree demographic data collected between 1972 – 2012, we evaluate how these behaviors may be reflected in the recruitment of an important primate food, *Cordia abyssinica*, a species with seeds dispersed almost entirely by frugivorous primates. We calculated mature (dbh > 20 cm) C. abyssinica tree density (n/ha) and dispersion (Id) in 10 hectare plots of unlogged (K30) and logged (K14) forest compartments. *C. abyssinica* is randomly distributed in both forest compartments (Id=1.11, $\chi 2$=7.88, p>0.05), but density differed significantly (d=5.8/ha, K14; d=0.1/ha, K30; p<0.01), with more trees in the logged plot (K14). We also found a significant increase in *C. abyssinica* density (d= 5.8/ha; p<0.01) since cessation of logging (1992, d=0.2/ha; 1972, d=0.0/ha; Chapman et al. 1997). Microsatellite genotyping and primer optimization are currently underway to determine *C. abyssinica* parentage and relatedness.

SEED AND POLLEN DISPERSAL IN GUINEO-CONGOLIAN CANOPY TREE SPECIES - INSIGHTS FROM GENETIC MARKERS IN MULTIPLE SPECIES

Olivier J. Hardy[1], Jérôme Duminil[1,2], Kasso Daïnou[1,3], Franck Monthé[1,2], Boris Delaide[1], Pauline Gillet[3], Hélène Hainaut[1], David Kombi Kaviriri[2], Davy Tanguy Mendene Abessolo[2], Jean-Louis Doucet[3]

[1]*Université Libre de Bruxelles, Brussels, BE, ohardy@ulb.ac.be*
[2]*Bioversity International, Yaoundé, CM*
[3]*Gembloux Agro-Bio Tech / Université de Liège, Gembloux, BE*

Pollen and seed dispersal are key processes affecting the demographic dynamics and the evolutionary potential of populations. Until recently, few studies had been conducted on this issue in African rain forests. Here we present new results on the mating system and the extent of pollen and seed dispersal obtained in four hermaphrodite canopy tree species from the Guineo-Congolian forests and attempt to derive general patterns. The studied species are *Baillonella toxisperma* (Sapotaceae), *Distemonanthus benthamianus* (Fabaceae), *Entandrophragma cylindricum* (Meliaceae), and *Erythrophleum suaveolens* (Fabaceae), for which direct and indirect methods were applied to estimate mating patterns. *D. benthamianus* and *E. cylindricum* are essentially outcrossing and disperse pollen over large distances (often >1000m). *B. toxisperma* and *E. suaveolens* show c. 20% selfing rate at the seed or seedling stages, though most adult individuals were non inbred due to intense inbreeding depression, and pollen dispersed over relatively short distances (often <500m). Median seed dispersal distances ranged widely according to species: c. 60m in *D. benthamianus*, c. 250m in *E. suaveolens*, probably >500-1000m in *E. cylindricum* and *B. toxisperma*. Preliminary insights from the spatial genetic structure of populations of additional Guineo-Congolian tropicaltree species will also be presented.

PRIMATE SEED DISPERSAL CAN INFLUENCE PLANT SPATIAL-GENETIC POPULATION STRUCTURE

Eckhard W. Heymann[1], Kathrin Lüttmann[1], Inga Michalczyk[2,3], Birgit Ziegenhagen[2], Pedro Pablo Pinedo Saboya[4], Ronald Bialozyt[2,5]

[1]*Deutsches Primatenzentrum, Göttingen, DE, eheyman@gwdg.de*
[2]*AG Naturschutzbiologie, Universität Marburg, Marburg, DE*
[3]*Scratch Pharmacovigilance GmbH, Butzbach, DE*
[4]*Facultad de Ciencias Forestales, Universidad Nacional de la Amazonía Peruana, Iquitos, PE*
[5]*Nordwestdeutsche Forstliche Versuchsanstalt, Göttingen, DE*

Besides birds and bats, primates are the major group of seed dispersal vectors for woody plants in the tropics. A major question in seed dispersal ecology is whether and how dispersal affects the spatial-genetic structure of plant populations. Based on behavioural observations on the feeding and ranging of a mixed-species troop of tamarin monkeys, *Saguinus mystax* and *Saguinus nigrifrons*, at the Estación Biológica Quebrada Blanco (EBQB) in Peruvian Amazonia, and microsatellite analyses of seed coats, embryos, juveniles and adults of the Neotropical legume *Parkia panurensis*, we could show the following:

(1) Genetic analyses (matching of seed coats to potential maternal trees) confirms seed-dispersal distances obtained through behavioural observations. Most seeds are dispersed within 300 m, with a few long-distance dispersal event (up to 700 m).

(2) In the *Parkia panurensis* population, a spatial-genetic structure extends over 300 m in embryos and juveniles and over 100 m in adult plants. While we do not currently know the exact reason for the scale reduction in adults, the scale in embryos and juveniles coincides with the seed shadow generated by tamarins.

Tamarins are the only seed dispersers for *Parkia panurensis* at EBQB; therefore, the observed pattern is not confounded by seed dispersal through other vectors. Our study provides the first evidence that primate seed dispersal can influence the spatial-genetic structure of a plant population.

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SESSION 11

S11 - DROUGHT EFFECTS IN TROPICAL FORESTS

Chairs: Jennifer Pett-Ridge, Tana Wood, Leonor Álvarez-Cansino, Patrick Meir, Lars Markesteijn
Contact: Pettridge2@llnl.gov

RESPONSES TO SEVERE DROUGHT BY TROPICAL FOREST TREES

Patrick Meir[1,2], Lucy Rowland[1], Antonio CL da Costa[3], Maurizio Mencuccini[1], Bradley Christoffersen[1], Steel Vasconcelos[4], Bart Kruijt[5], Leandro Ferreira[6]

[1]*University of Edinburgh, Edinburgh, UK, pwmeir@gmail.com*
[2]*Australian National Unversity, Canberra, AU, pwmeir@gmail.com*
[3]*Universidade Federal de Para, Belem, BR*
[4]*Embrapa, Belem, BR*
[5]*Alterra, Wageningen, NL*
[6]*Museu Paraense Emilio Goeldi, Belem, BR*

Tropical forests responses to drought include reductions in assimilation and growth, but under strong drought significant mortality can occur leading to substantial changes in the cycles of carbon and water, also affecting canopy structure and species composition. Understanding of the drought-mortality process is particularly limited for tropical forests, despite the risk of drought to these ecosystems during the coming decades. We present new findings from the only current long-term 'ecosystem-scale' (1 ha) rainfall manipulation experiment in tropical rainforest, the Esecaflor experiment at Caxiuana National Forest, Para State, Brazil. Throughfall has been partially excluded from experimental forest at the Esecaflor experiment for more than a decade. We have previously demonstrated a capacity to model short-term physiological responses well, but longer term physiology and ecological dynamics remain challenging to understand and represent. In particular, high mortality and increased autotrophic respiration following extended drought are poorly understood phenomena, and their interaction with hydraulic responses and limitations needs to be characterised. We present initial data that combine carbon use and hydraulic metrics, comparing drought-vulnerable and non-vulnerable species that have experienced extended soil moisture deficit, as imposed in the experiment, and discuss modelling implications for this and other tropical forest regions.

CHARACTERIZING DROUGHT SURVIVAL STRATEGIES IN TROPICAL TREES

Louis Santiago[1,2]

[1]*University of California, Riverside, US, santiago@ucr.edu*
[2]*Smithsonian Tropical Research Institute, Panama City, PA, santiago@ucr.edu*

Climate change is predicted to increase the occurrence of extreme droughts, which are associated with elevated mortality rates in tropical trees. Yet, most of the information on mortality during drought comes from demographic studies, raising questions about the physiological mechanisms that plants use to survive drought and how these mechanisms are distributed among the immense diversity of tropical tree species. The strategies that tropical trees may use to survive drought include 1) drought deciduousness, 2) xylem that is resistant to drought-induced cavitation, 3) access to soil water through deep roots, 4) regulation of gas exchange to reduce water loss from leaves during water deficit or to maintain photosynthetic carbon gain at low leaf water potential, 5) high sapwood capacitance that can keep xylem from reaching critically low water potentials, 6) photosynthetic stems which promote carbon gain at greater water-use efficiency than leaves, and 7) low cuticular conductance from exposed tissues during extended drought. I will examine the status of characterizing these strategies in tropical trees using data from long-term efforts in neotropical forest.

THE ROLE OF NONSTRUCTURAL CARBOHYDRATES IN TROPICAL TREE SEEDLINGS UNDER DROUGHT REGIMES: INSIGHTS FROM FIELD AND NURSERY EXPERIMENTS

Mikey O'Brien[1], Annabelle Valtat[1]

[1] *University of Zurich, Zurich, CH, michael.obrien@ieu.uzh.ch*

Nonstructural carbohydrates have a direct effect on prolonging seedling survival in tropical tree seedlings. However, the specific mechanism by which nonstructural carbohydrates contribute to survival during drought remains unclear. In order to better understand the role of nonstructural carbohydrates in seedling drought response, multiple approaches are necessary to assess storage, movement and use of nonstructural carbohydrates before, during and after drought. Additionally, because drought does not function independent of abiotic variables such as light, tracking nonstructural carbohydrate stores simultaneously under light and water gradients is important for disentangling the relative influence of drought in the presence of environmental factors. I used a suite of experiments to demonstrate the role of nonstructural carbohydrates in drought survival. Additionally, I assess the importance of nonstructural carbohydrates relative to other functional traits for predicting seedling response to drought. These experiments were designed around answering three questions: 1) how do plants use and allocate nonstructural carbohydrates during drought, 2) what is the relative role of drought versus light in altering nonstructural carbohydrate storage and 3) what is the importance of nonstructural carbohydrates for improving drought resistance relative to other functional traits?

WATER UPTAKE DYNAMICS AND LEAF CHEMICAL TRAITS IN A CACAO AGROFORESTRY SYSTEM DURING A THROUGHFALL REDUCTION EXPERIMENT

Luitgard Schwendenmann[1], Michael Köhler[2], Hendrayanto Hendrayanto[3], Dirk Hölscher[4]

[1]*School of Environment, The University of Auckland, Auckland, NZ, l.schwendenmann@auckland.ac.nz*
[2]*Northwest German Forest Research Institute (NW-FVA),, Goettingen, DE*
[3]*Department of Forestry Management, Institut Pertanian Bogor, Bogor, ID*
[4]*Tropical Silviculture and Forest Ecology, Georg-August-Universität Göttingen, Göttingen, DE*

Agroforestry is an important land use option in the human dominated landscapes of the tropics. Studies have suggested that agroforestry systems may be more resilient to drought as trees draw water from deeper soil layers while providing shade to main crops. The objectives of our study were to investigate the effects of an experimental drought on cacao (Theobroma cacao L.) water use, water uptake dynamics and leaf chemical traits. The study was conducted in 6-year-old cacao-Gliricidia agroforest in Sulawesi, Indonesia. Net precipitation in the treatment plots (n = 3) was reduced by 71% through the use of a sub-canopy roof for 13 months. Sap flux density was measured using thermal dissipation (Granier) sensors. Soil water uptake was determined using the natural abundance of water isotopes (δ^2H, $\delta^{18}O$) and deuterium labelled water. Leaves were analysed for C, N, P, Ca, Mg, K, lignin, and $\delta^{13}C$. Additionally, soil water content and micrometeorological parameters were measured in the treatment and control plots. Soil water content was reduced by up to 50% across the soil profile (to 2.5 m depth). Average monthly sap flux densities of cacao in the treatment plots decreased linearly with decreasing soil water content reaching a maximum reduction of 21% as compared to control plots. Soil water uptake depth varied considerably among trees and over time. However, we found that cacao trees predominantly relied on soil water from 0-30 cm depth in both control and treatment plots. Lower leaf P and K concentration associated with an increase in C concentration in the treatment plots indicates that the nutrient status of the photosynthetic tissue decreased. Cacao leaf $\delta^{13}C$ values were higher in treatment plots compared to control plots at the end of the desiccation period. This suggests that cacao reacted against a decrease in soil water availability through stomata closure. Overall the effects of the artificial drought on cacao water related traits were not as strong as expected. Overall low stand transpiration rates, high atmospheric humidity, soil water uptake partitioning between cacao and Gliricidia, stomata closure and root osmotic acclimation may have helped cacao trees to cope with the reduction in soil water availability.

SEASONAL STEM DIAMETER DYNAMICS IN A TROPICAL DRY FOREST

Daniel Kübler[1], Daniel Plugge[1], Yedidya Ratovonamana[2]

[1]*Institute for World Forestry, University of Hamburg, Hamburg, DE, daniel.kuebler@uni-hamburg.de*
[2]*Department of Biology and Vegetation Ecology, University of Antananarivo, Antananarivo, MG*

Dry forests comprise around 40 % of tropical forest areas and contribute to the livelihoods of millions of people. At the same time, dry forest ecosystems are increasingly threatened by deforestation, overuse and climate change. Sustainable forest management (SFM) is a promising approach to safeguard and support ecosystem services and functions on the long term. However, for a purposeful SFM, information about dry forest dynamics, growth and potential yield is fundamental. Understanding the effect of rainfall on diameter growth is of particular importance as those ecosystems are often limited by water availability.

Our study was carried out in the Tsimanampetsotsa National Park in south-western Madagascar. The climate in the study area can be classified as semi-arid tropical with an annual mean temperature of 24°C and less than 500 mm of average annual rainfall. Historically, a distinct wet season (December—March) and dry season (April—November) could be observed, but rainfall patterns have changed over the last decades. The total amount of annual rain decreased and intra- and inter-annual rainfall variability increased.

To analyse how rainfall events influence diurnal, intra-seasonal and intra-annual stem diameter dynamics, we selected the species Cedrelopsis grevei, Euphorbia fiherenensis and Delonix adansonioides, as they are important for the local population and cover a gradient from low to high wood density. In November 2013, three trees of each species were equipped with high-resolution band dendrometers which were configured to register the circumference at breast height (1.3 m) at hourly intervals.

Generally, the reactions of stem diameters to rainfall events were characterized by intra-species homogeneity and inter-species heterogeneity. Delonix adansonioides showed a stable diameter increase of 2-3 mm after 200 mm of rain in January 2014. Erratic rainfall events between February and October 2014 had almost no effect on this species. Cedrelopsis grevei on the other hand displayed swelling and shrinking of up to 4 mm as a response to rainfall events, but only little to none actual cambial growth over one year. Similarly, Euphorbia fiherenensis reacted to most rainfall events with swelling, but less intensive than Cedrelopsis grevei.

Our results show that for some species the intra-annual variability in stem diameters can be higher than actual inter-annual growth. This can lead to gross over- or underestimation of growth rates, and consequently to SFM plans that may result in overexploitation. Increased variability of rainfall patterns due to climate change exacerbates this problem.

UNDERSTANDING THE EFFECTS OF RAINFALL VARIABILITY ON TROPICAL TREE COVER

Milena Holmgren[1], Egbert Van Nes[1], Marten Scheffer[1]

[1]*Wageningen University, Wageningen, NL, Milena.Holmgren@wur.nl*

Rainfall variability is expected to increase with climate warming. We used the MODIS remotely-sensed estimations of tree cover (%) at 1 km^2 to explore the patterns of tropical tree cover distribution in relation to rainfall variability. We found that rainfall variability is associated with reduced tree cover in the wet tropics globally. In contrast, high year-to-year variability is positive (South America), neutral (Africa) or negatively (Australia) related to tree cover in the dry tropics. We reflect on long-term observations to identify potential mechanisms that may explain these contrasting responses of tree cover to extreme rainfall events.

FLORISTIC COMPARISON OF DIFFERENT SUCCESSIONAL STAGES OF CAATINGA-FORESTS IN SERGIPE, BRAZIL

Melanie Forker[1], Philip Tafarte[2,3]

[1]Technical University Dresden, Dresden, DE, forker@htw-dresden.de
[2]Helmholtz-Zentrum für Umweltforschung - UFZ, Leipzig, DE
[3]Deutsches BiomasseForschungsZentrum DBFZ, Leipzig, DE

The Caatinga is one of the most extensive contiguous seasonally dry tropical forest (SDTF) areas in South America. The severe drought in 2012 and 2013 emphasized the importance of research on sustainable land-use in SDTFs that withstand climate change. SDTFs received less attention from the scientific and conservation community than moist forests, despite the fact that they are considered to be far more threatened globally. Due to altered precipitation schemes, high pressure of human settlements and exploitation the Caatinga forests are prone to desertification.

There exists little information about regeneration in the Caatinga. Our objective was a) to find floristic differences in older an younger successional stages and to b) determine the above ground biomass in different vegetation-types including young successional stages.

Our study site is the the Grota do Angico Natural Monument, SE, Brazil, located at the São Francisco River, characterized by a megathermal semiarid climate (mean annual temperature: 26-28°C, precipitation: 500-700 mm/year).

We sampled 40 relevés of 20 x 20m, recording species composition, DBH and height of all individuals with DBH >2.5 cm. Sampling design was based on our vegetation mapping of the deciduous hiperxerophilous forest and open vegetation in regeneration stages, differentiating six vegetation-types: 1) driftline communities; 2) shrublands on the dunes along the river; 3) Cactus-dominated rocky slopes; 4) Tall-growing formations along periodic creeks; 5) Older secondary Caatinga stages; and 6) a three-year-old successional stage.

Species numbers and biomass are both significantly lower in the young successional stage. Clear-cutting for pasture impedes regrowth of near-natural Caatinga forests through depletion of late-successional species, even if they occur in the near environment. Future conservation efforts have to include active regeneration measures.

Merian Award Applicant

DROUGHT AS WELL AS HERBIVORES AND NUTRIENTS SHAPE TREE DISTRIBUTION IN TROPICAL FORESTS: IMPLICATIONS UNDER GLOBAL CLIMATE CHANGE

Bettina Engelbrecht[1,2], Julian Gaviria[1], Delicia Pino[1], Richard Condit[2], Benjamin Turner[2]

[1]*University of Bayreuth, Bayreuth, DE*
[2]*Smithsonian Tropical Research Institute, Panama, PA,*
bettina.engelbrecht@uni-bayreuth.de

Understanding which factors shape species distributions, community composition and ecosystem function in tropical forests is one of the most pressing issues in global change vegetation modelling. The most pervasive patterns of tree distributions and diversity in tropical forests worldwide are local, regional and continental scale correlations with rainfall and/or soil moisture. Evaluating the role of potential factors producing these patterns requires a mechanistic understanding of the underlying processes.

Here we directly link extensive comparative experimental data sets on whole-plant responses to drought and fertilization, and on integrated plant defenses to quantitative assessments of species occurrence across a pronounced rainfall gradient at the isthmus of Panama. We show that species' differential drought sensitivity directly shapes plant performance and distributions in tropical forests. Additionally, herbivore defenses and differential nutrient requirements indirectly shape tree distribution patterns. The results underline the importance of incorporating drought as well as species interactions nutrients and nutrients into models predicting species distribution, community composition and ecosystem function of tropical forests under global change scenarios.

DISTRIBUTION OF TREE SPECIES ALONG A TROPICAL RAINFALL GRADIENT: COMBINED EFFECTS OF HERBIVORY AND DROUGHT ON SEEDLING ESTABLISHMENT

Julian Gaviria[1], Bettina Engelbrecht[1,2]

[1] *University of Bayreuth, Bayreuth, DE, julian.gaviria@uni-bayreuth.de*
[2] *Smithsonian Tropical Institute STRI, Panama, PA*

Tree species distributions associated with rainfall are among the most prominent patterns in diverse tropical forests. Beside direct effects of water availability, other factors that co-vary with rainfall may be responsible for this pattern. Herbivory (damage due to herbivores and pathogens) has long been hypothesized to shape tree species distribution and diversity.

We tested the hypotheses that (a) higher herbivory in wet forests prevents less defended dry origin species from growing in wet forests (pest pressure hypothesis) and that (b) drought prevents less drought tolerant wet origin species from growing in dry forests.

In a reciprocal transplant experiment at a wet and a dry forest site in Panama, we planted seeds of 26 species with contrasting origin. Half of the seeds and the resulting seedlings were treated with an insecticide and a fungicide to exclude herbivory. Germination, survival and growth of the seedlings were recorded over one wet and one dry season.

The overall establishment success of dry and wet origin species did not differ in either of the sites. Herbivore exclusion did not affect growth, but significantly increased germination and survival. However, contrary to our expectation, the effect for dry origin species was lower in wet forests than in their home range. The survival of wet origin species at the dry site was reduced during the dry season, as expected. Growth of dry origin species was significantly lower than growth of wet origin species, and significantly lower in the wet than in the dry site.

Our results support that strong dry seasons exclude wet origin species from dry sites. They suggest that inherently lower growth rates rather than herbivory exclude dry origin species from wet sites. Our results thus did not support the pest pressure hypothesis for the seed and early seedling stage, although herbivory is an important factor for establishment success in tropical forests. The differentiation of species may need longer time periods than the one-year frame of this experiment.

SOIL MICROBIAL COMPOSITIONAL AND FUNCTIONAL RESPONSES TO WATER AVAILABILITY IN TROPICAL WET AND DRY FORESTS

Bonnie Waring[1], Christine Hawkes[2], Jennifer Powers[1]

[1]*University of Minnesota, Falcon Heights, MN, US, bonnie.waring@gmail.com*
[2]*University of Texas at Austin, Austin, TX, US*

Background

Quantifying the response of soil respiration to changes in soil water content is crucial for accurate predictions of ecosystem carbon (C) cycling. Soil CO_2 flux is often modeled as a parabolic function of soil moisture. Respiration is limited by substrate diffusion under dry conditions and by oxygen availability under wet conditions. However, the shape of this curve is modified by both abiotic factors, such as soil texture and temperature, and biotic factors, including soil microbial community composition. The goal of this research was to quantify the impact of altered precipitation quantity and seasonality on microbial community structure, and to explore the consequences of these compositional shifts for soil C cycling. This was accomplished via two complementary experiments: an *in situ* rainfall exclusion experiment in an aseasonal wet tropical forest, and a water addition experiment in a tropical dry forest with a 6-month dry season.

Results

In the tropical wet forest, a 6-month experimental drought yielded only subtle shifts in microbial community composition. However, microbial communities that had been exposed to drought exhibited significantly higher mass-specific respiration (CO_2 efflux per unit microbial biomass) than unperturbed communities. In both the wet and dry forests, however, most variation in microbial community structure and soil respiration was driven by fine-scale spatial heterogeneity in soil texture and chemistry. Incorporating this spatial variation into ecosystem models is an important challenge in predicting ecosystem responses to altered rainfall.

CASCADING EFFECTS OF INCREASED DRYNESS AND REDUCED FOREST RESILIENCE IN THE AMAZON REGION

Delphine Zemp[1,2], Carl–Friedrich Schleussner[3], Marina Hirota[6], Henrique Barbosa[4], Gilvan Sampaio[5], Anja Rammig[1]

[1]Potsdam-Institut für Klimafolgenforschung, Potsdam, DE, delphine.zemp@pik-potsdam.de
[2]Humboldt-Universität zu Berlin, Berlin, DE, delphine.zemp@pik-potsdam.de
[3]Climate analytics, Berlin, DE
[4]Universidade de São Paulo, Sao Paulo, BR
[5]Instituto Nacional de Pesquisas Espaciais, Cachoiera Paulista, BR
[6]Universidade Federal de Santa Catarina, Florianopolis, BR

Previous studies suggested that increasing dryness in the Amazon region combined with forest degradation could lead to critical transitions of vegetation states. Typically, it is assumed that tropical evergreen forests may be replaced by seasonal forests or savanna. This process could be amplified by feedbacks in the vegetation-climate system such as moisture recycling. In this way, the tropical rainforest pumps water from the soil and releases it to the atmosphere. This atmospheric moisture returns then to the land as precipitation either locally or over somewhere else after transport by winds. On the way, atmospheric moisture might run through a certain number of re-evaporation cycles (evapotranspiration followed by precipitation) before being transported out of the Amazon river basin.

The degradation of tropical forest affects cascading moisture recycling. Unlike tropical dense forest with deep-rooted trees, a degraded forest experiences water deficit and decreases evapotranspiration rate during the dry season. As a result, the moisture recycling weakens, intensifying the dry season locally and downwind. This in turn affects the resilience of the remaining forested areas.

Here, we examine how perturbations of the hydrological cycle (induced by deforestation or reduced incoming moisture from the ocean) lead to cascading effects of increased dryness and reduced forest resilience. We combine a simple empirical model based on remote sensing data together with an Eulerian moisture tracking model to quantify the probability of cascading vegetation change in present day and future Amazonian rainforest.

SESSION 12

S12 - FREE SESSION

Chairs: Alice Hughes and Heribert Hofer

8000 YEARS OF TEMPORAL PATTERN OF VEGETATION DYNAMICS OF A UNIQUE INLAND PEAT ECOSYSTEM IN JAMBI, SUMATRA

Siria Biagioni[1], Valentyna Krashevska[2], Yudhi Achnopha[3], Asmadi Saad[3], Supiandi Sabiham[4], Hermann Behling[1]

[1]Department of Palynology and Climate Dynamics, Albrecht-von-Haller-Institute for Plant Sciences, University of Goettingen, Goettingen, DE, sbiagio@gwdg.de
[2]J.F. Blumenbach Institute of Zoology and Anthropology, University of Goettingen, Goettingen, DE
[3]Department of Soil Science, University of Jambi, Jambi, ID
[4]Department of Soil Science and Land Resource, Bogor Agriculture University (IPB), Bogor, ID

Despite their importance as global carbon sink, peatlands of Southeast Asia have been rarely studied and our current knowledge of dynamics and ecology of these important ecosystems remains incomplete. Currently, only a small fraction of the large areas of peatlands in Sumatra remains under pristine conditions as vast tracts of peat swamp forest have been subjected to logging, drainage and conversion during the past three decades. As degradation and conversion continue, future studies of spatial and temporal developments of peatlands will become more and more approximate. Palaeoecological and palynological analyses offer a vital contribution showing the ecosystem dynamics as peat developed thought time at a certain site. A 733 cm-long core was taken on the thick inland peat dome in the Sarolangun district in the Jambi province, Sumatra. The chronology based on six AMS radiocarbon dates reveals that the peat formation started ca. 8000 years ago corresponding to the mid-Holocene *climatic optimum*. Combined palaeoecological results reveal that the site was covered by a mixed Dipterocarpaceae-swamp rainforest during the first 2000 years, until the abiotic conditions changed, and swamp elements became more important, in particular *Durio* trees. This lasted until ca. 4000 years ago, when a peat-dome vegetation established with abundant *Pandanus* thickets. For this period, macro-charcoal analysis reveals that fire frequency and pioneer vegetation increased as a consequence of both climate change (late Holocene ENSO-onset) and a change from rheotrophic to ombrotrophic conditions as the peat became thicker. First evidence of human interaction with the landscape in the study area occurred 5000 years ago. A single pollen grain from cultivated Poaceae was found and in the same period macro-charcoal analysis records a high magnitude peak corresponding to a severe fire event, possibly connected to human activities. However, clear human interactions with the landscape started late about 100 years ago when the Dutch arrived in the area.

Merian Award Applicant

LANDSCAPE MOSAICS TO MAP SHIFTING CULTIVATION DYNAMICS IN A GLOBAL BIODIVERSITY HOTSPOT - INSIGHTS FROM NORTH-EASTERN MADAGASCAR

Julie Gwendolin Zähringer[1], Cornelia Hett[1,2], Peter Messerli[1]

[1]Centre for Development and Environment, University of Bern, Bern, CH, julie.zaehringer@cde.unibe.ch
[2]Ministry of Natural Resource and Environment (MoNRE), Vientiane, LA

The north-eastern escarpment of Madagascar has been deemed a global hotspot of biodiversity thanks to its high rates of endemic speciesheavily threatened by accelerated deforestation rates and landscape change. Many blame the deforestation on subsistence farmers in the region who traditionally practice shifting cultivation to produce rice. However, up to date little is known about the dynamics between forest and shifting cultivation systems at a regional level. The few local studies that have been conducted in this area and the general deforestation discourse point to the persistence or even expansion of shifting cultivation. A wide range of stakeholders from various levels and sectors have therefore been involved in trying to slow deforestation, mainly by establishing protected areas and promoting intensification of other land use practices such as irrigated permanent rice production and agroforestry.

Because of their high spatial and temporal dynamics which present significant challenges to commonly used remote sensing techniques, shifting cultivation systems do not appear on recent land cover maps of the region. As long as these regional landscape dynamics are not well understood, the design of external interventions successfully slow forest loss while at the same time improving local land users livelihoods remains challenging. A novel GIS approach termed “landscape mosaics approach”, developed for the assessment of shifting cultivation dynamics in Laos was transferred to Madagascar and adapted to the local context. Through this moving-window approach generalised landscape mosaics were generated and shifting cultivation systems spatially delineated. Change maps of landscape mosaics for three points in time between 1995 and 2011 allow to map changes in land use intensities and to explore the impact of protected area establishment on landscape trajectories. Our results will thus contribute to a better understanding of landscape change within a highly dynamic and widely condemned agroecosystem in a biodiversity- and carbon-rich region of pronounced global interest and to support the planning of more sustainable interventions to slow forest loss.

WHY DOES AN UNEXPECTED SAVANNA OCCUR IN COASTAL AREA OF NORTHERN SOUTH AMERICA?

Kamaleddin Alizadeh[1], Marcelo Cohen[2], Hermann Behling[1]

[1]Department of Palynology and Climate Dynamics, Albrecht-von-Haller-Institute for Plant Sciences, University of Göttingen, Göttingen, DE, kamal.alizadeh@biologie.uni-goettingen.de
[2]Oceanography Faculty, Federal University of Pará, Pará, BR

Despite an annual rainfall which is adequate for rain forest formation, a 2,000 km-long savanna belt occurs in the coastal area from British Guiana to Amapá and Pará States in northern Brazil. To discover when and under which condition(s) this unexpected savanna was formed, we carried out pollen and charcoal analysis on a 750 cm-long, 11,500 years old sediment core taken from Amapá State in the coastal savanna belt. Our results reveal that beside specific arboreal vegetation, savanna was present in the area at least since 11,500 cal yr BP which later (11,200 cal yr BP) expanded markedly due to a drier climatic conditions. The early Holocene rise of Atlantic sea level facilitated the formation of mangrove, swamp forest and later *Mauritia* swamps in the study area. During the mid-Holocene (8,500-5,500 cal yr BP), gallery forest expanded into the savanna area reflecting higher precipitation rates. During the late Holocene (after 5,500 cal yr BP), frequent oscillation between arboreal/non-arboreal vegetation occurred. We suggest that the dry early Holocene is attributed to northern most position of Inter Tropical Convergence Zone (ITCZ) which during the Holocene gradually moved southward and merged with South Atlantic convergence zone (SACZ) and caused moister condition during the mid-Holocene. Unstable late Holocene is ascribed to the intensified El Nino which prevents SACZ to reach the Northern South America. In summary, because of the specific geomorphology, the area was occupied by forest/gallery forest only during the mid-Holocene when probably annual rainfall was higher than today. In addition to climatic factors, which play the major role, high charcoal concentration throughout the studied sediment core together with long history of human settlements in Amazonia, strengthen the suggestion that natural/anthropogenic fire plays also an important role to stabilize the savanna.

THE EFFECT OF GLOBAL WARMING IN ZAGROS MOUNTAINS OF IRAN AS A SUBTROPICAL REGION

Mehrnoosh Ghadimi[2], Tayebeh Akbari Azirani[1]

[1]*Shahid Beheshti University, Tehran, IR, tayebakbari@gmail.com*
[2]*University of Tehran, Tehran, IR*

The Zagros Mountains are of the key water supplies in Iran as a subtropical region; hence withdrawal of their glaciers could be one of the most influential factors on the regional water content. Oshtorankoohis the main mountain and a floristic region by variety of vegetation because it situated in the border of three major vegetation units of the Irano-Turanian phyto-geographical region. Monitoring glacier dynamics in a large scale is necessity not only to alleviate hydrological influences on human societies but also to evaluate glacier-related environmental hazards. Accordingly, characterization of the Zagros glaciers' displacement in terms of rate and quantity is of a high importance. This study mainly due to difficult accessibility of the region has never been done, and accurate glaciological data related to the Zagros Mountains are still missing. In this study, for the first time, we determined location as well as surface kinematics of active rock glaciers in Oshtorankooh in Lorestan province, southwest Iran. This study was performed using remote sensing observations and field measurements. The precise locations of rock glaciers were first analyzed based on aerial photos (1:55000). This analysis was then verified through a fieldwork. The outcome of the mapping and field works proved reliability of the geomorphological map of the region based on aerial images in determination of the precise location of the glaciers. Subsequently, Landsat$_7$ and Landsat 8 images taken in 1999-2013, were analyzed using cross-correlation technique to derive surface kinematics. The results show that rock glaciers in Oshtorankooh are active and displace maximally in July, i.e. the warmest month of year in the region. While the highest displacement rate between 1999 and 2002 was only about 2 cm/yr, it increased to 12cm/day in 2013. The reason could be rise of temperature. The Ground Surface Temperature (GST) observations analyzed using MODIS data show a temperature increase of 0.6° in this time period. Therefore we concluded that the increase in maximum displacement rate of active glaciers of Oshtorankooh as a part of subtropical region over the past decade is due to the global warming.

ENVIRONMENTAL STABILITY AND BIODIVERSITY

Alice Hughes[1]

[1]*Xishuangbanna Tropical Botanic Garden, Chinese Academy of Sciences, Jinghong, CN, dr_achughes@hotmail.co.uk*

Glacial refugial expansions form the basis of many of the biodiversity patterns we see today. These regions, whilst predominantly occurring at lower latitudes will also occur in parts of the landscape that are able to buffer against temperature change. Thus any region, such as a valley which maintains a high degree of hillshade may remain more thermally stable and moister, than the more exposed surrounding environment and thus may retain species which can no longer persist in surrounding areas.

However if temperature change exceeds certain levels, these species which may have adapted to more thermally stable conditions may have a low degree of tolerance to even relatively small levels of environmental change. Here we review the role and contribution of past tropical refugia for modern diversity patterns. We map out different features which contribute to thermal stability at a variety of scales and also discuss how changing vegetation patterns may increase climatic variability and diminish the ability for these regions to buffer against temperature change. Thus with their low levels of resilience, even small fluctuations in climatic conditions may be unsuitable for a proportion of species present, and how with careful planning we can enhance the retention of these climatic refugia and their ability to buffer against changes in climate into the future.

EFFECT OF CO_2 AND TEMPERATURE ON RELATIVE GROWTH RATE OF TROPICAL EPIPHYTE PLANTS

Siouxsie Correa[1], Gerhard Zotz[1,2]

[1]*Carl von Ossietzky Universität Oldenburg, Oldenburg, DE, siouxsie.correa@uni-oldenburg.de*
[2]*Smithsonian Tropical Research Institute, Panama, PA*

Tropical ecosystems are expected to be more seriously affected than temperate environments by climate change. Epiphytic plants have been called "particularly vulnerable" to climate change because of their existence at the interface of vegetation and atmosphere. Higher temperatures and increased CO_2 concentration should affect plant biological processes, ecology and distribution. Even a predicted increase of ca. 3°C may already strongly affect plant performance. However, higher CO_2 could improve the heat tolerance of plants. We performed an experiment to evaluate the effect of a 3°C increase and the possible interaction with CO_2 on growth and physiology in three Bromeliaceae: *Guzmania wittmackii*, *Tillandsia deyeriana* and *Vriesea duvaliana* over one year. We used four custom-built chambers with CO_2 and temperature control. Chambers were either set to 400ppm (ambient CO_2, (A)) or to 800ppm (E), at each concentration temperature was either 27/22°C (LT) or 30/26°C (HT). We expected plants growing at E to have higher relative growth rates (RGR) than the plants at A and higher RGR of plants grown at HT compared to LT. The three species tested responded rather idiosyncratic. While *Guzmania* had 90% mortality at a HT and A already after six months, the other two species had showed hardly any mortality. Only T affected RGR in *Tillandsia* and *Guzmania* after one year of treatment while RGR of *Vriesea* was not affected by any of the factors. Considering the species-specific responses, it is currently impossible to make any reliable predictions of the response of epiphytic bromeliads to concurrent changes in CO_2 and temperature.

RESPONSES TO SIMULATED NITROGEN DEPOSITION AND A STABLE ISOTOPIC ASSESSMENT FOR THE NEOTROPICAL EPIPHYTIC ORCHID LAELIA SPECIOSA

Edison Armando Diaz Alvarez[1], Erick de la Barrera[1]

[1]*National Autonomous University of Mexico, Morelia, MX, ealvarez@cieco.unam.mx*

The accelerated increase of nitrogen deposition is the third cause of biodiversity loss, as a result of saturation of ecosystems worldwide. The effects of nitrogen deposition on the endemic and endangered neotropical epiphytic orchid, *Laelia speciosa*, were evaluated via a dose-response experiment and a stable isotopic field assessment for individuals from a city and from an oak forest, in order to evaluate the potential risk facing this orchid, and record the history of the nitrogen deposition of series of consecutive annually produced pseudobulbs. Lower doses of nitrogen of up to 20 kg N ha yr^{-1} the dose that led to optimal performance of plants, acted as fertilizer. For instance, chlorophyll content and chlorophyll fluorescence (Fv/Fm) peaked at 0.66 ± 0.03 g m^{-2} and 0.85 ± 0.01, respectively. In contrast, toxic effects were observed at the higher doses of 40 and 80 kg N ha yr^{-1}, leading a decrease of 38% of the chlorophyll content and 23% of the chlorophyll fluorescence. For the field assessment, a tissue nitrogen content of 1.2 ± 0.1% (dry mass basis) for the orchids suggested non-toxic deposition rates both at the city and the oak forest. However, their respective isotopic signatures revealed different sources of N at each site. Indeed, in the oak forest $\delta^{15}N$ amounted -3.1 ± 0.3‰, typical of places with low industrial activities, while in the city the $\delta^{15}N$ reached 5.6 ± 0.2‰, typical of sites with some degree of industrial and automobile activity. Under the current rates of atmospheric nitrogen deposition Laelia speciosa preserves its physiological features, even small increases in the deposition rates can enhance the response. However, because the close contact with the atmosphere higher rates of nitrogen deposition can be harmful for this orchid and may lead it to a drastically reduction of its populations and the possibility of extinction.

A GLOBAL ASSESSMENT OF THE EFFECTS OF FOREST DISTURBANCE ON THE REGENERATION CYCLE OF PLANTS

Eike Lena Neuschulz[1], Matthias Schleuning[1], Katrin Böhning-Gaese[1]

[1]*Biodiversity and Climate Research Centre Frankfurt, Frankfurt am Main, DE, elneuschulz@senckenberg.de*

The regeneration cycle of plants consists of different processes, such as pollination, seed dispersal, seed predation and recruitment. Forest fragmentation, logging or hunting can influence plant regeneration and past studies have investigated the effects of forest disturbance on plant regeneration processes in isolation. We here present a comprehensive meta-analysis to investigate the effects of forest disturbance on four processes in the plant reproduction cycle (e.g., pollination, seed dispersal, seed predation and plant recruitment). We identified 116 studies including 190 plant species that resulted in 354 comparisons of plant regeneration processes between near-natural forests and human disturbed forests. We found that forest disturbance significantly reduced plant regeneration processes. In particular the early steps of the plant reproduction cycle, pollination and seed dispersal, were significantly reduced in disturbed forests and both processes were more negatively affected by changes in forest structure than by forest area loss. The later steps of the plant reproduction cycle, seed predation and seedling recruitment, followed no clear pattern under forest disturbance. We also examined the effect of an important plant life history trait, seed size, on plant's responses towards forest disturbance. We found that large-seeded plant species were significantly less dispersed in disturbed forests than small-seeded species, but seed size did not explain the effects of forest disturbance on pollination, seed predation and plant recruitment. Our study identifies pollination and seed dispersal as key processes in the plant reproduction cycle that make plants most vulnerable towards human disturbance. Our findings have important implications for the conservation of global forests, suggesting that a disruption of the early steps in the plant reproduction cycle could cause cascading effects on plant regeneration, threatening the viability of plants in disturbed forests.

PARTITIONING THE CONTRIBUTION TO STAND TRANSPIRATION BY DIFFERENT TREE SIZE CLASSES

Norbert Kunert[1,4], Luiza Maria T. Aparecido[2,4], Stefan Wolff[3,4]

[1]Max planck Biogeochemistry, Jena, DE, nkunert@bgc-jena.mpg.de
[2]Laboratory of Ecohydrology, College of Agriculture and Life Sciences, Texas A&M Universi, Austin, US
[3]Biogeochemistry Department, Max Planck Institute for Chemistry, Mainz, DE
[4]Instituto Nacional de Pesquisas da Amazônia/ INPA, Manaus, BR, nkunert@bgc-jena.mpg.de

Old growth forests in the moist tropics are characterized by amazingly high tree species diversity with diverse species functionality. Despite the high species and functional diversity, tree water relations are commonly assumed to converge mainly with tree size. This relationship has been tested only in few tropical moist forests. Here we present data from a study conducted in the largest remaining and species richest tropical forest, the Amazon. We studied the water use characteristics of 21 trees in a terra firme forest in the Central Amazon, Brazil. We analyzed the variation in water use patterns among three different tree size classes (emerged, sub-canopy and understory trees), for getting a better idea, how much different tree size classes contribute to the overall annual evapotranspiration. Sap flux density was measured for 12 months and annual evapotranspiration rates were calculated from tower based latent heat measurements. Furthermore, we established an interspecific allometric equation to scale down from tree diameter to conductive xylem area. The basal area of the study plot was 26.2 m^2 ha^{-1} and based on the allometric equation we estimated a conductive xylem area of 11.3 m^2 ha^{-1}. Annual rainfall in in 2013 was 2300 mm and after our top down estimates 1360 mm were evapotranspired back to the atmosphere. Combining annual sap flux estimates with xylem area, annual stand transpiration rate reached 1010 mm. Emerged canopy trees (diameter > 30 cm) contributed to 95% of the transpired water. Overall, this study provides further evidence for convergent water use characteristics of tropical trees and highlights the importance of large trees in tropical moist forests. Contributing most of the stand biomass, large trees are also contributing the main part of the water directly returned back to the atmosphere.

SESSION 13

S13 - RESILIENCE OF TROPICAL FORESTS: THE HUMAN FACTOR

Chairs: Dr. Carmenza Robledo, Dr. Claude Garcia
Contact: carmenza.robledo@usys.ethz.ch

SMALLHOLDER PROPERTY RIGHTS AND FOREST REGROWTH IN THE AMAZON: A MISSED OPPORTUNITY FOR FOREST CONSERVATION?

Aoife Bennett-Curry[1], Peter Cronkleton[1]

[1] *University of Oxford/CIFOR, Oxford and Lima, PE, aoife.bennett@gmail.com*

A survey of more than 250 non-indigenous households in 18 villages in the Amazonian department of Ucayali, Peru was done to examine the land titling dynamics of agricultural lands in a forest-farm interface. Rather than taking 'smallholders' as a homogenous group, our focus was on understanding within-group differentiation of land tenure experiences at a landscape level. Particularly we analyze the equity of title distribution based on chosen variables, and evaluate the potential for this demograph – currently ignored by the conservation remit in Peru – to be included in forest conservation and reforestation initiatives, such as REDD+. We find that the current land titling legislation and its associated bureaucratic, administrative and de jour practical title allocation processes encourage deforestation, and significantly favor non-locals, non-native (modern/permanent) crops and accessible villages. Furthermore, with 30% of surveyed ladholdings comprising old growth forest, and 24% in fallow, we argue that this landscape and this citizen group are a missed opportunity for forest conservation, reforestation and PES schemes in the Amazon. Finally, reflective of other studies we find that political instability and poor decentralization mechanisms negatively affect forests and forest user groups.

COMBINING INDIGENOUS AND SCIENTIFIC AGRICULTURAL KNOWLEDGE FOR RESILIENCE BUILDING: LEARNING FROM BOLIVIAN AGROFORESTRY INITIATIVES

Johanna Jacobi[1], Stephan Rist[2], Miguel A. Altieri[1]

[1]*University of California, Berkeley, Berkeley, US, johanna.jacobi@berkeley.edu*
[2]*Centre for Development and Environment, University of Bern, Bern, CH*

Diversified agroforestry systems can significantly increase social-ecological resilience and help farmers adapt to and even mitigate climate change. Taking the example of Bolivia, we argue that resilient and diversified agroforestry results from a combination of different forms of traditional agricultural knowledge (TAK) and scientific agricultural knowledge (SAK) from different parts of the world. While Bolivia has high bio-cultural diversity and TAK, this has been little taken into account in development projects, climate change discourses, and agricultural extension programmes. Despite an increase in research, there is still a weak base of SAK on agroforestry in Bolivia. Drawing on 62 qualitative interviews, field visits, and participant observation, our study explores the role of TAK and SAK on agroforestry to co-create new forms of knowledge in the context of climate change.We show examples where diversified agroforestry has been implemented and further developed, enhancing farmers' resilience to climatic variability: silvopastoral systems with more than 100 fodder tree species in the Bolivian Chaco; coffee and cocoa agroforestry in the Yungas; and tea agroforestry in the Chapare region. These examples represent a process of knowledge co-production by the interaction of local farmers, farmers' organizations, and agronomists working in extension services, enhancing capacity building and knowledge exchange. An important future role of researchers may be to identify TAK and farmers' innovative initiatives, and to facilitate a "dialogue of wisdoms" (*diálogo de saberes*) not only at the farm level, but also at institutional and policy levels.

TENURE SECURITY AS THE MAIN DRIVER OF FOREST COVER CHANGE

Bharat K Pokharel[1], Rabin Raj Niraula[1,2]

[1]HELVETAS Swiss Intercooperation Nepal, Kathmandu, NP
[2]Kathmandu University, Dhulikhel, NP, rabin.niraula@helvetas.org.np

We conducted a forest land tenure and forest cover change study applyingGeographic Information System and Remote Sensing as the major tools of analysis to see the effect of land tenure system to the forest cover change. We compared the coexisting forest management regimes in a watershed namely community managed forest, government managed forest, leasehold forest and privately managed forests in mid hills of Nepal. The study is based on the forest cover change mapping and analysis between 1990 and 2010 and field based demarcation of forest boundaries.

The study was carried out in Sindhupalchok district of central Nepal with a coverage of 5,796 hectares watershed revealed that forests have improved in all tenure regimes.

The findings of the study may surprise those who still believe in the so-called 'Theory of Himalayan Degradation'. This may also surprise the forest planners and academics that still rely on national survey data, which shows that country's forest resources are generally deteriorating, and the trend is even higher in the hills and mountains. However, this study found out that some elements of deforestation and degradation are noticed in the watershed, but the quantum of improved and the new forests far outweigh both deforestation and degradation.

Community forest is the best performer by increasing the new forest area by almost 33% and improving existing forest quality by 20% in 20 years. In comparison, the government managed forest regime increased the new forest area only by 17% and improved the quality of forest by 15%. These changes that occurred in 20 years are the result of tenure reform that made 30 years ago.

All changes that occurred in 20 years are the result of tenure reform that the Government of Nepal made 30 years ago in which all three major actors – government, local communities and private forest owners are made responsible to manage the forests. The result however is different.

The main message of the study indicates that an appropriate forest tenure policy is the main driver of positive change in forest cover that contributed towards forest resilience.

UNDERSTANDING THE SOCIO-ECOLOGICAL LANDSCAPE OF THE ALAOTRA-MANGORO, MADAGASCAR

Patrick Waeber[1], Annick Ravaka[2], Julius Bezandry[2], Arnaud De Grave[3]

[1]ETH, Zurich, CH, patrick.waeber@usys.ethz.ch
[2]ESSA Forets, Antananarivo, MG
[3]BOP, Goncelin, FR

Natural resources management problems typically involve multiple stakeholders with diverse and often conflicting worldviews, needs and agendas, in an environment with growing uncertainty. These are "wicked" problems where there is no common definition of what the problem is. A growing challenge hence is the reconciliation of a continuously increasing demand for agricultural products while balancing a growing number of values and interests such as environmental values for conserving biodiversity, maintaining ecological functions and providing critical ecosystem services for supporting rural livelihoods. The socio-ecological landscape of the Alaotra-Maningory, Madagascar will serve this research to deliver key data and information on drivers and barriers of livelihood opportunities and threats and juxtaposition these factors with biodiversity conservation values to inform policy and decision-makers for the sustainable use and management of the landscape's natural and agricultural resources. The current study is considering the Maningory watershed as scale which is characterized by extended cultivated areas, the biggest wetland in Madagascar, open grasslands, degraded humid forests, and humid forests (usually confined to protected areas). The Alaotra region is the most important rice and freshwater fish producer of the country. This research will co-develop conceptual models of the three prominent ecosystems (wetlands, grasslands, forests) together with the main stakeholders of the Alaotra. This will then be translated into role playing games and a participatory modelling platform for stakeholders to validate our understanding and to test scenarios of alternative resources utilization. We assume that sustainability in resource management and planning of the Alaotra socio-ecological landscape can be achieved if the main resource users see an ownership in the framework that reflects their needs. Increased understanding of the linkages and dynamics of livelihood needs and ecosystem services and functions will allow the development of a socially accepted management and policy framework.

LEARNING BEGINS WHEN GAMING STOPS. ROLE PLAYING GAMES AND COMMUNITY WILDLIFE MANAGEMENT IN THE COLOMBIAN AMAZON

Claude Garcia[1,2], Nathalie van Vliet[2], Nicole Ponta[2], Daniel Cruz Antia[2]

[1]CIRAD, Montpellier, FR, claude.garcia@usys.ethz.ch
[2]ETH, Zurich, CH

In the Amazon Basin most indigenous communities base part of their sustenance on bushmeat. Overharvesting, together with habitat loss, poses serious threats to biodiversity, as well as to the people who depend on bushmeat for food and income.

At the request of the communities of the TICOYA Indigenous Reserve (Colombia) we are developing integrated models of community-based wildlife management that incorporate feedback loops between population dynamics, hunting patterns and strategies.

We first explored the possibility of using role-playing games as tools to define and build these models with hunters and other stakeholders. The games are used to assess the impacts of their action and to investigate alternative scenarios while promoting collective learning.

Using a simple reed management game (ReHab) as support, we organized two workshops on the concept of sustainable management of natural resources. Despite its simplicity and abstraction, ReHab allows exploring these concepts and involving the stakeholders in the research process, through experiential learning. In the first session, hunters and community members of Ticoya went through a phase a slow depletion of the resource, and increasing inequalities. When given time to negotiate and prompted with information, they managed to secure agreements and adjust harvest levels, achieving a measure of sustainability.

The same game was then used with students and academics in the nearby city of Leticia. Despite being aware of the trends, and having time for discussion, the players failed to improve their results. This suggests that information and communication are not sufficient to resolve trade-offs between conservation and development. The comparison of the two sessions opens avenues to define collective management strategies in the TICOYA Indigenous Reserve and suggests the need to develop a standardized protocol for additional sessions to generate a locally meaningful and evidence-based definition of management.

RESILIENCE THINKING CONFRONTED WITH THE GIANTS OF THE ANTHROPOCENE ERA: ARE WE SERIOUS?

Hélène DESSARD[1]

[1]*CIRAD, Montpellier, FR, dessard@cirad.fr*

The African continent is now regarded as the extractive industry's new Eldorado where mineral reserves, vital for the industrial sector as a whole, are currently among the world's largest.

Central African forest countries contribute to most mining supplies, 60% of the mineral deposits being located in the heart of the second largest tropical forest block.

The urban sprawl of this huge social and ecological system (SES) by mining has been spread for some decades over all its geographical area. This would imply an ecological, social, economic and cultural restructuring that would a priori reinforce the planet's limits (Rockström, 2009). In this outlook, pathological evolutionary dynamics (Peterson, 2014) of this SES are anticipated . Given the economic power of the mining industry in a weak regional and national context, can we actually mobilise the resilience thinking concepts and, if so, how can this be achieved in a concrete way ?

We argue that the global resilience of SES in relation to those disturbances is no longer relevant. Its transformation can however be discussed and initially adressed in writing. If there is still time, we can test the generic solutions provided by resilience thinking (Biggs, 2012), not to experiment them in this context but to implement them at the very heart of every means (Feyerabend, 1979) that can turn out to be even slightly effective to avoid a sharp deterioration in the Congo basin in all its dimensions and at best permit a virtuous transformation of the SES.

We therefore invite discussion about the issue of the full utilisation of mutually incompatible resources (mines vs forests) by actors with highly differentiated power.

SESSION 14

S14 - CORAL REEF RESILIENCE AND MANAGEMENT

Chairs: Claudia Pogoreutz, Ulisse Cardini and Christian R. Voolstra
Contact: claudia.pogoreutz@zmt-bremen.de

ELEVATED CO_2 REDUCES PHOTOSYNTHETIC OUTPUT AND LOWERS BLEACHING THRESHOLD OF THE FINGER CORAL PORITES PORITES

Laura Stoltenberg[1], Christopher Langdon[1]

[1] *University of Miami Rosenstiel School of Marine and Atmospheric Science, Miami, US, laurastolten@gmail.com*

Coral reefs are under pressure from a suite of global and local stressors, including ocean acidification and thermal stress. The study of interactions of multiple stressors has been complicated due to constraints in laboratory facilities in manipulating stressors accurately. These studies are vital to the understanding of how coral reefs will respond to future climate change scenarios, where temperature is predicted to increase simultaneously with CO_2 and other factors, such as pollution and over-fishing. The present study investigated the effects of both warming and elevated CO_2 on the physiology of a locally important species, *Porites porites*. Growth using buoyant weighing, net photosynthesis and dark respiration using flow-through respirometry were measured at 4 temperatures x 2 CO_2 levels, subjected to natural light. The effect of CO_2 on corals was temperature dependent. Corals at ambient CO_2 were still growing up to 39-43 days of exposure to extreme thermal stress (31.5ºC), while corals exposed to high CO_2 experienced ceased growth between days 25-32, on average 12 days sooner. Net photosynthesis (Pn) was significantly affected by light, temperature and CO_2. Pn declined on average by 29% at elevated CO_2. No significant effect on dark respiration was detected. The results from this study suggest that not only growth of corals will be impacted in future but also net photosynthesis, and that thermal stress interacts with CO_2 synergistically to accelerate bleaching. However, variations between corals within the same treatment were observed, suggesting that some coral genotypes within the population are resistant to the combination of CO_2 and thermal stress.

CORAL REEFS IN THE FACE OF MULTIPLE STRESSORS: EXPERIMENTS ON COMBINED EFFECTS OF POLLUTION AND GLOBAL WARMING ON POCILLOPORA SP.

Pia Kegler[1], Gunilla Baum[1], Andreas Kunzmann[1]

[1]*Leibniz Center for Tropical Marine Ecology, Bremen, DE, pia.kegler@zmt-bremen.de*

Human influence on coral reefs has led to a multitude of stressors that are negatively affecting this sensitive ecosystem. Especially the possible interactions of global stressors like rising sea surface temperatures with local stressors such as pollution need to be understood in order to propose suitable management strategies for coral reefs. In laboratory experiments *Pocillopora sp*. corals were subjected to increased temperature (+3°C) and the water accumulated fraction of gasoline. Corals were exposed to the stressors for 48h, then effects on respiration and photosynthesis were measured for another 36h during continued exposure. Neither stressor on its own had a significant effect on respiration of the coral holobiont, even though a trend was visible that both temperature and gasoline decreased respiration rates. However, a significant interaction of both stressors was detected; at high temperature and gasoline exposition respiration was significantly increased. Additional experiments with linear alkyl benzene sulfonate (LAS), a surfactant, showed similar interactions, with LAS leading to a more severe tissue loss in the coral at higher water temperature. Photosynthetic yield in *Pocillopora sp*. increased at higher temperature after 48h of exposure to the stressor, but was lowered again after continued exposure. No effect of gasoline on photosynthetic yield or tissue loss was found at any time. The experiments show the suspected increase in severity of pollution in the presence of increased temperatures, indicating a need for action of local coral reef management in face of global warming.

HARD CORAL HOLOBIONT RESPONSES TO ELEVATED DISSOLVED ORGANIC CARBON AND NITROGEN (DOC AND DON) CONCENTRATIONS IN THE CENTRAL RED SEA

Claudia Pogoreutz[1], Nils Rädecker[1,3], Christian R. Voolstra[2], Christian Wild[1,3]

[1]Leibniz Center for Tropical Marine Ecology GmbH, Bremen, DE, claudia.pogoreutz@zmt-bremen.de
[2]Red Sea Research Center, King Abdullah University of Science and Technology (KAUST), Thuwal, SA
[3]Faculty of Biology and Chemistry, University of Bremen, Bremen, DE

Local anthropogenic stressors may negatively affect coral and reef resilience. In this context, the effects of elevated inorganic nutrient (e.g., ammonium, nitrate, phosphate) concentrations on reef organisms have been intensively studied, but there is little information on anthropogenically-derived dissolved organic matter (DOM). These studies indicate that DOM may be more detrimental to corals than inorganic nutrients. The present study therefore addresses the effects of dissolved organic carbon (DOC) and nitrogen (DON) on the common reef-building Red Sea coral *Pocillopora verrucosa* in a holistic approach including several departments of the coral holobiont (i.e. the coral animal, endosymbiotic algae, associated bacteria). This was achieved by carrying out a series of manipulative experiments at the Central Red Sea and using a combination of physiological, biogeochemical, and molecular tools. Such an interdisciplinary approach is urgently needed for a better understanding of coral holobiont responses to DOM, and may contribute to the improvement of water quality and reef management. The present talk discusses the key findings and implications for coral reef resilience.

TANZANIAN REEF BUILDING CORALS MAY SUCCUMB TO BLEACHING EVENTS: EVIDENCES FROM CORAL-SYMBIODINIUM SYMBIOSES

Leonard Chauka[1]

[1]*Nelson Mandela African Institution of Science and Technology, Arusha, TZ, leonard.chauka@nm-aist.ac.tz*

Coral reefs are among the most vulnerable ecosystems to current trends of climate change. Most of the reef systems along the coast of Tanzania have remained severely damaged following the 1997/1998 El-Niño that caused a massive coral bleaching , resulting into a wide spread of coral death. It is important therefore to find out/establish whether reef building corals develop functioning adaptations to current trends of climate change so as to prioritise their conservation. There are evidences that coral-Symbiodiniumsymbioses develop adaptation to current trends of climate change. This review therefore was meant to compare Tanzanian coral-Symbiodiniumsymbioses with others in different parts of the world. Like in most parts of the world, Tanzanias corals are dominated by Symbiodinium clade C3 which is both thermal and irradiance intolerant. However, in the Tanzanian coast, coral species that have been found to host clade D, that is thought to be distributed in warmer environment, also host other Symbiodinium clade . Unlike in most part of the world, most of Tanzania's reef building corals lack polymorphic symbioses, a phenomenon that is hypothetically believed to render environmental tolerance to the holobiont. This is probably due to low seasonal variation in both temperature and solar radiations. Thus, Tanzanian corals become less advantaged in terms of impacts that may be associated with current trends of climate change.

Merian Award Applicant

REVISING THE ROLE OF BIOLOGICAL DINITROGEN FIXATION IN BIOGEOCHEMICAL CYCLING OF CORAL REEF ECOSYSTEMS

Ulisse Cardini[1], Vanessa N. Bednarz[1], Nanne van Hoytema[1], Alessio Rovere[2], Malik M. Naumann[1], Mamoon M. D. Al-Rshaidat[3], Christian Wild[1,4]

[1]Coral Reef Ecology Group, Leibniz Center for Tropical Marine Ecology (ZMT), Bremen, DE, ulisse.cardini@zmt-bremen.de
[2]Sea Level and Coastal Changes Group, Leibniz Center for Tropical Marine Ecology (ZMT) and MARUM - Center for Marine Environmental Sciences and Faculty of Geosciences, University of Bremen, Bremen, DE
[3]Department of Marine Biology, The University of Jordan - Aqaba Branch, Aqaba, JO
[4]Faculty of Biology and Chemistry (FB 2), University of Bremen, Bremen, DE

Biological dinitrogen (N_2) fixation (diazotrophy) relieves marine primary producers of nitrogen (N) limitation in the vast oligotrophic zone of the world oceans. N concentrations are particularly low in tropical waters where coral reefs flourish. Here, N represents a key limiting nutrient to these highly productive ecosystems. However, the role and importance of diazotrophy for primary productivity of coral reef ecosystems is still not resolved. In this study, we present N_2 and carbon (C) fixation rates in a high spatiotemporal resolution for a fringing reef in the northern Red Sea, based on a combination of physiological laboratory measurements and *in-situ* surveys. We found that diazotrophy was omnipresent in space and time. Contribution of fixed N by planktonic diazotrophs was 20-fold lower compared to the contribution by the reef benthos. Benthic N_2 fixation rates were 0.16 to 0.92 mmol N m^{-2} d^{-1}. These results imply that approximately 10% of the overall net reef primary production was supported by autochthonous input of N derived from N_2 fixation. If our findings can be extrapolated to global reef areas, this suggests reef-wide N_2 fixation rates of 1.60 to 2.58 Tg N yr^{-1}, placing coral reef ecosystems among the benthic communities contributing most to marine fixed N inputs.

DISENTANGLING THE EFFECTS OF GLOBAL AND LOCAL STRESSORS ON CORAL REEFS IN THE SOUTH PACIFIC

Amanda Ford[1], Jean-Baptiste Jouffray[2], Albert Norström[2], Bradley Moore[3], Magnus Nyström[2], Sonia Bejarano[1], Franck Magron[3], Christian Wild[1], Sebastian Ferse[1]

[1]Leibniz Center for Tropical Marine Ecology (ZMT), Bremen, DE, amanda.ford@zmt-bremen.de
[2]Stockholm Resilience Centre, Stockholm, SE
[3]Secretariat of the Pacific Community (SPC), Noumea, NC

Coral reefs worldwide are degrading rapidly as a consequence of simultaneous exposure to different global and local stressors. Previous studies focused on a very limited number of stressors that were selected based on assumptions. To effectively address reef degradation by targeted management, studies require a holistic approach that includes measuring both global and local stressors, such as climate change and coastal societies. The close link between society and coral reefs in the South Pacific, where island communities rely heavily on services derived from these ecosystems, makes this area an urgent research priority. Thus, the present study addressed the following key questions: 1) which global and/or local stressors are shaping coral reef status across the South Pacific, and 2) what are the most effective strategies to manage reef status in the South Pacific. This was carried out by analysing a comprehensive multidisciplinary data-set covering 63 sites across the region (from Micronesia to French Polynesia). Data was collected in 2002 to 2008 by the Secretariat of the Pacific Community under the framework of the PROCFish/C/CoFish programme, using identical survey methodologies for all sites. The data-set includes benthic community composition, fish biomass, physical parameters (i.e. latitude, longitude) and local social drivers (i.e. distance to market, fishing methods). Thermal exposure (degree heating weeks from the NOAA Coral Reef Temperature Anomaly Database) was also quantified for the 12 years prior to the survey dates. Based on benthic community composition, principle components analysis (PCA) differentiated sites with undesirable reefs characterised by dead coral, macroalgae and cyanobacteria, from desirable reefs displaying high live coral and crustose coralline algae. Linear models were used to identify dominant drivers of reef status (extracted from PCA) across the region, with an aim to provide important information for effective future management.

CORAL REEF RESILIENCE IN THE MALDIVES

Carlo Nike Bianchi[1], Carla Morri[1], Monica Montefalcone[1], Roberta Lasagna[1], Giulia Gatti[1,2], Alessio Rovere[3], Giuseppe Baldelli[4], Paolo Colantoni[4]

[1]University of Genoa, Genova, IT, nbianchi@dipteris.unige.it
[2]Station Marine d'Endoume, 13007 Marseille, FR
[3]MARUM, Centre for Marine Environmental Sciences, University of Bremen, & ZMT, Leibniz Centre for Tropical Marine Ecology,, 28359 Bremen, DE
[4]DiSTeVA (Department of Earth, Life and Environment Sciences), University of Urbino, 61029 Urbino, IT

Climate change is causing coral reef degradation worldwide. Estimating magnitude, pattern and trajectories of change requires information on previous conditions of coral reef communities, but unfortunately this kind of historical data are rare for most regions of the world ocean. Since 1989 we have been studying the ecology of coral reefs in the Maldives (Indian Ocean). We have therefore collected data on the state of coral reefs before, during and after the big bleaching event of 1998, which caused widespread coral mortality (up to 95% for branching corals). By 2002, the three-dimensional structure of the reef was largely lost due to the destruction of dead colonies, which were reduced to rubble. As early as 1999, recolonization started and many newly settled colonies were recorded. The taxonomic composition of recruits shifted from a dominance of Agariciidae in the early stages of recolonization toward a dominance of Acroporidae and Pocilloporidae by 2009. By 2007, the coral reef community exhibited manifest signs of recovery and in 2014 showed similar to that existing before the bleaching, although *Millepora* had not returned yet. Coral cover, which dropped to less than 10% after the bleaching, returned to pre-bleaching values of >50% by 2013. The recovery of Maldivian coral reefs after the mass-mortality of 1998 may therefore be considered attained after about 15 years, but may also be considered unachieved, as there are species that have not come back yet and reef complexity is still reduced. This capacity of coral reef resilience may not be enough to cope with the expected frequency of climatic events and the increased intensity of local human pressures, due especially to tourism development. Long term monitoring remains the only means to track the future evolution of coral reefs in the Maldives.

HIGHLY DYNAMIC BENTHIC COMMUNITIES IN UPWELLING EXPOSED COSTA RICAN CORAL REEFS

Ines Stuhldreier[1], Celeste Sánchez-Noguera[1,2], Florian Roth[1,3], Jorge Cortés[2], Tim Rixen[1], Christian Wild[1,3]

[1]Leibniz Center for Tropical Marine Ecology (ZMT), Bremen, DE, ines.stuhldreier@zmt-bremen.de
[2]Centro de Investigación en Ciencias del Mar y Limnología (CIMAR), San Jose, CR
[3]University of Bremen, Bremen, DE

Coral Reefs at the northern Pacific coast of Costa Rica are naturally exposed to a highly variable environment caused by seasonal upwelling from December to March. This offers the opportunity to investigate *in situ* effects of pronounced changes in key water parameters (i.e. temperature and nutrient concentrations) on coral reef communities. Therefore, this study monitored cover or abundances of key organisms (corals, algae, fish and sea urchins) in a local reef by weekly observations of permanent quadrats and monthly reef surveys from April 2013 to April 2014. This was accompanied by monitoring of water temperature and nutrient concentrations. Findings revealed a major shift from turf algae to hard coral dominance within the observed year. Cover of the hard coral *Pocillopora damicornis* increased continuously from 22 to 51 % in only 12 months. Turf algae covered around 60 % from April to June 2013 and decreased to 35 % within two weeks in June 2013. Simultaneously, the relative cover of crustose coralline algae that were previously overgrown by turf algae increased from 15 to 30 %. The green macroalgae *Caulerpa sertularioides* covered 15 % of the reef substrate in April 2013, but disappeared almost entirely within one month after their synchronized gamete release in April/May 2013. Upwelling decreased water temperatures by up to 7 °C and increased phosphate and nitrate concentrations by 70 % and 270 % from February to April 2014, but this did not affect the relative cover of benthic reef organisms. High herbivorous fish biomass (11.39 ± 4.21 g m^{-2}) and sea urchins abundances (5.31 ± 0.36 individuals m^{-2}) in the reef were likely able to control algal biomass despite nutrient input during upwelling. These findings hint to very dynamic benthic communities in the investigated reef, with coral recovery faster than previously reported in the scientific literature. Benthic communities were highly adapted to the pronounced changes in water quality and may therefore be able to cope better than expected with local disturbances and future climate change.

SESSION 15

S15 - TROPICAL MOUNTAIN BIODIVERSITY

Chairs: Michael Kessler and Dirk Karger
Contact: michael.kessler@systbot.uzh.ch

SPECIES RICHNESS OF A HYPERDIVERSE INSECT GROUP, THE GEOMETRID MOTHS, ALONG ELEVATION GRADIENTS: A GLOBAL META-STUDY

Jan Beck[1]

[1] *University of Basel, Basel, CH, jan.beck@unibas.ch*

Species richness along elevation gradient tends to follow one of several general patterns, such as a mid-peak, a low plateau, or a declining richness. Many hypotheses aim at explaining these patterns, but due to the variability of patterns for different taxa and different mountains, no conclusions have been reached on generally applicable mechanisms that shape elevational diversity patterns. Among animals, only for vertebrates attempts have been made to analyse not only richness patterns along individual gradients but also the variability between them. We collated, from literature and own field sampling, data on geometrid moth richness along 26 elevation gradients across the globe (ca. 800 sample sites, >315'000 specimens), covering tropical as well as temperate latitudes on all ice-free continents. With ca. 35'000 described species, geometrids can be considered one of the truly hyperdiverse taxa on earth. Using different analytical approaches, we address the question how climate, area variability, and geometric constraints can explain patterns within gradients as well as the variability of patterns between gradients.

PATTERNS AND PREDICTORS OF BIODIVERSITY AT MT. KILIMANJARO ACROSS TAXA

Marcell Peters[1], Andreas Hemp[2], Tim Appelhans[3], Christina Behler[4], Alice Classen[1], Andreas Ensslin[5], Stefan Ferger[6], Maria Helbig-Bonitz[4], Claudia Hemp[1], William Kindeketa[1,7], Ephraim Mwangomo[3,8], Christine Ngereza[3,9], Juliane Röder[3], Gemma Rutten[5], David Schellenberger Costa[14], Giulia Zancolli[1], Connal Eardley[10], Ralph Peters[11], Mark-Oliver Rödel[12], Axel Ssymank[13], Victor Kakengi[15], Jie Zhang[1], Katrin Böhning-Gaese[6], Roland Brandl[3], Elisabeth Kalko[4], Michael Kleyer[14], Thomas Nauss[3], Marco Tschapka[4], Markus Fischer[5], Ingolf Steffan-Dewenter[1]

[1]Zoology 3, University of Wuerzburg, Wuerzburg, DE, marcell.peters@uni-wuerzburg.de
[2]University of Bayreuth, Bayreuth, DE
[3]University of Marburg, Marburg, DE
[4]University of Ulm, Ulm, DE
[5]University of Bern, Bern, CH
[6]Biodiversity and Climate Research Centre (BIK-F), Frankfurt am Main, DE
[7]Tanzania Commission for Science and Technology, Dar es Salaam, TZ
[8]Mount Kilimanjaro National Park, Moshi, TZ
[9]National Museum of Tanzania, Dar es Salaam, TZ
[10]Agricultural Research Council, Pretoria, ZA
[11]Zoological Research Museum A. Koenig, Bonn, DE
[12]Museum für Naturkunde, Berlin, DE
[13]Bundesamt für Naturschutz, Bonn, DE
[14]University of Oldenburg, Oldenburg, DE
[15]Tanzania Wildlife Research Institute, Arusha, TZ

Since nearly two centuries naturalists try to explain the remarkably heterogeneous distribution of biodiversity on earth. Temperature and primary productivity have been suggested as major structuring forces but available results for different taxa provide conflicting support, motivating an intense scientific discussion in the past decade. We compiled the hitherto largest data set on trends in the elevational distribution of biodiversity encompassing data of eight vascular plant and thirteen major animal groups collected at 30 study sites along a 3.6 km elevational gradient at Mt. Kilimanjaro, Tanzania. Here we present patterns of elevational species richness across plant and animal taxa and infer the support for the major drivers of biodiversity.

TEMPERATURE VERSUS RESOURCE CONSTRAINTS: WHICH FACTORS DETERMINE BEE DIVERSITY ON MT. KILIMANJARO, TANZANIA

Alice Classen[1], Marcell Peters[1], William Kindeketa[1], Tim Appelhans[2], Connal Eardley[3], Mary Gikungu[4], Andreas Hemp[5], Thomas Nauss[2], Ingolf Steffan-Dewenter[1]

[1]University of Würzburg. Department of Animal Ecology and Tropical Biology, Würzburg, DE, alice.classen@uni-wuerzburg.de
[2]Philipps University of Marburg. Environmental Computer Sciences, Marburg, DE
[3]University of KwaZulu-Natal. School of Biological and Conservation Sciences, KwaZulu-Natal, ZA
[4]National Museum of Kenya. Zoology Department, Nairobi, KE
[5]University of Bayreuth. Department of Plant Physiology, Bayreuth, DE

The diversity of species is not equally distributed on earth. The most striking patterns described in this context are the species richness changes when moving from the tropics to the poles or from low elevations to mountain tops. However, the mechanisms controlling variation in species richness along climatic gradients are still matter of debate. Resource availability is often considered as the major driver of animal diversity. But in ectotherms, temperature might play a predominant role as it does not only modulate metabolic and speciation rates, but also the access of animals to resources.

We disentangled the effects of temperature and floral resources on bee diversity along a 3.6 km elevational gradient on Mount Kilimanjaro. Floral resources had a weak but significant effect on bee richness, via bee abundances. Temperature had a strong positive effect on species richness that was not mediated by bee abundance and an indirect effect via bee abundances. Furthermore, we observed higher levels of bee-flower-interactions at higher temperatures, supporting the hypothesis that temperature limits diversity by constraining the resource-exploitation in ectotherms.

The optimal foraging temperature range of ectotherms is narrower than their thermal range, which has often been ignored when disentangling the effects of resources and temperature on species richness.We conclude that the consideration of temperature-mediated resource use improves our understanding of how animals, and in particular ectotherms, respond to environmental changes on local and global scales.

ASSEMBLY OF FOREST COMMUNITIES ACROSS EAST ASIA - INSIGHTS FROM PHYLOGENETIC COMMUNITY STRUCTURE AND SPECIES POOL SCALING

Gang Feng[1], Xiangcheng Mi[2], Wolf L. Eiserhardt[1], Guangze Jin[3], Weiguo Sang[2], Zhijun Lu[4], Xihua Wang[5], Xiankun Li[6], Buhang Li[7], Ifang Sun[8], Keping Ma[2], Jens-Christian Svenning[1]

[1]*Section for Ecoinformatics and Biodiversity, Department of Bioscience, Aarhus University, Aarhus, DK, gang.feng@biology.au.dk*
[2]*State Key Laboratory of Vegetation and Environmental Change, Institute of Botany, Chinese Academy of Sciences, Beijing, CN*
[3]*Center for Ecological Research, Northeast Forestry University, Harbin, CN*
[4]*Key Laboratory of Aquatic Botany and Watershed Ecology, Wuhan Botanical Garden, Chinese Academy of Sciences, Wuhan, CN*
[5]*Tiantong National Field Observation Station for Forest Ecosystem, East China Normal University, Shanghai, CN*
[6]*Guangxi Institute of Botany, Chinese Academy of Sciences, Guilin, CN*
[7]*State Key Lab of Biological Control and School of Life Sciences, Guangdong Key Lab of Plant Resources, SYSU-Alberta Joint Lab for Biodiversity Conservation, Sun Yat-sen University, Guangzhou, CN*
[8]*Department of Natural Resources and Environmental Studies, National Dong Hwa University, Hualein, TW*

Local communities are assembled from larger-scale species pools via dispersal, environmental filtering, biotic interactions, and local stochastic demographic processes. The relative importance, scaling and interplay of these assembly processes can be elucidated by comparing local communities to variously circumscribed species pools. Here we present the first study applying this approach to forest tree communities across East Asia, focusing on community phylogenetic structure and using data from a global network of tropical, subtropical and temperate forest plots. We found that Net Relatedness Index (NRI) and Nearest Taxon Index (NTI)values were generally lower with geographically broad species pools (global and Asian species pools) than with an East Asian species pool, except that global species pool produced higher NTI than the East Asianspecies pool. The lower NRI for the global relative to the East Asianspecies poolmay indicate an important role of inter-regional migration and allopatric speciation during the Neogene and Quaternary in shaping the deeper phylogenetic structure of tree communities in East Asia. In contrast, higher NTI for the global relative to the East Asianspecies pool is consistent with recent localized diversification determining the shallow phylogenetic structure.

Merian Award Applicant

SPECIATION MECHANISMS ON GEOLOGICALLY OLD AND YOUNG MOUNTAINS IN EAST AFRICA: A CASE STUDY ON AFROANTHRACITES AND AFROAGRAECIA, (INSECTA: ORTHOPTERA)

Claudia Hemp[1], Klaus-Gerhard Heller[2], Elzbieta Warchalowska-Sliwa[4], Beata Grzywacz[4], Andreas Hemp[3]

[1]*University of Würzburg, Würzburg, DE, claudia.hemp@uni-wuerzburg.de*
[2]*University of Erlangen, Erlangen, DE*
[3]*University of Bayreuth, Bayreuth, DE*
[4]*University of Krakow, Krakow, PL*

A molecular phylogeny on 9 *Afroanthracites* and 3 *Afroagraecia* species using the molecular markers COI, 16S rRNA, and histone 3 is presented together with data on habitat, bioacoustics and chromosomes. The Tettigonioidea and Acridoidea fauna of the East Usambaras and two forest reserves in the West Usambara Mountains are compared. Time scales and mechanisms of speciation of the *Afroanthracites* species of the Usambara Mountains are discussed. Regarding the ecological niche of Orthoptera species, comparing the species composition, considering endemic flightless Orthoptera species in the forests in the geologically old West Usambara Mountains and considering the molecular relationships of the investigated *Afroanthracites* species new light is shed on speciation processes of the area. It is discussed that the observed radiation in the geologically old Eastern Arc chain is young since *Afroanthracites montium* a taxon endemic to the geologically young volcanoes Mts Kilimanjaro and Meru (approx. 1.5 to 2 mio years) is of the same age as species of the East and West Usambara Mountains.

BIOGEOGRAPHY AND DIVERSIFICATION OF THE PLANT GENUS MACROCARPAEA (GENTIANACEAE) IN THE MIDDLE ELEVATION MONTANE FORESTS OF THE TROPICAL ANDES

Julien Vieu[1], Jason Grant[1]

[1]*Université de Neuchâtel, Neuchâtel, CH, julien.vieu@unine.ch*

The humid middle elevation montane forests (MMF) of the tropical Andes house tremendous plant diversity. However, little is known about the diversification dynamic of the MMF plant lineages.

We used the plant genus *Macrocarpaea* (Gentianaceae) as a model to investigate patterns of plant diversification in the MMF.We sequenced 76 of 118 recognized *Macrocarpaea* species for six genetic makers to reconstruct a time-calibrated phylogeny. This tree was used to infer a biogeographical hypothesis and to estimate diversification rate variation through time and among lineages.

We found a pattern of diversification consistent with the signature of a radiation for *Macrocarpaea* in the MMF. Furthermore, analyses support founder-event speciation as an important process structuring the biogeography of the genus. The radiation coincides with a period of rapid colonization and range expansion to all regions of the current range of the genus in the Andes beginning 7.2 Ma when the onset of high precipitation along the eastern flank of the Andes led to the establishment of the MMF biome.

We suggest that high precipitation triggered development of the MMF in the late Miocene providing large new areas of suitable habitat for *Macrocarpaea* to quickly colonize through repeated founder-events. This wave of colonization triggered a burst of diversification and as the range of the MMF became progressively occupied, the diversification rate slowed.

ECOLOGICAL RELEASE, PERENNIALITY AND EVOLUTIONARY PLANT RADIATIONS ON ISLAND SYSTEMS

Guy Atchison[1], Nicolai Nürk[2], Colin E. Hughes[1]

[1]*Institute of Systematic Botany, University of Zurich, Zurich, CH, guy.atchison@systbot.uzh.ch*
[2]*Centre for Organismal Studies, COS, Ruprecht Karls Universität Heidelberg, Heidelberg, DE*

Ecological release has long been considered to be the hallmark of adaptive island radiation and a key driver of species, trait and ecological diversification associated with evolutionary radiations in general. Despite the prominence of this phenomenon in evolutionary thinking, quantification and comparative analyses of ecological release across radiations has lagged behind, especially for plants. With the advent and rapid proliferation of methods to infer trajectories of diversification, it is surprising that there are very few, if any, studies that estimate rates of species, trait and niche evolution for island and island-like plant radiations in the broader comparative context of their mainland relatives. At the same time, the striking parallels between radiations on oceanic islands and those on island-like mountains, and especially tropicalpine mountains have intrigued evolutionary biologists ever since Carlquist's classical studies of island biology. While much emphasis has been placed on insular woodiness or montane perenniality, and how to explain these phenomena, little work has been done to document and understand the rapid appearance of diverse life forms associated with plant radiations on islands and island-like tropicalpine systems. Few studies, if any, have quantified the levels of variation observed, or tested the possible correlations between high rates of morphological changes and high rates of species diversification. This study aims to investigate these issues and the parallels between oceanic islands and tropicalpine island-like systems to understand the phenomenon of ecological release in plant radiation.

ECOLOGY AND EVOLUTION OF TROPICAL MOUNTAIN BIODIVERSITY - CONCLUSIONS

Michael Kessler[1], Dirk N. Karger[1]

[1]*University of Zurich, Zurich, CH, michael.kessler@systbot.uzh.ch*

Tropical mountains harbor some of the richest terrestrial ecosystems worldwide, yet the origin of this biodiversity and the mechanisms by which it is maintained remain poorly understood. A full understanding can only be achieved by linking ecological and evolutionary approaches. In this overarching talk, that will conclude this session, we will address the questions of „What are the roles of geographical (allopatric) versus ecological (adaptive) speciation in tropical mountain ecosystems?“ and „What are the ecological limitations (environmental, biotic) of species numbers in tropical mountain ecosystems?“. We will give both an overview of the general field of research as well as specifically address the conclusions from the individual talks of the symposium. In this way, the symposium will not just to have a series of interesting talks, but will rather be a platform on which new ideas and concepts will be jointly be developed.

SESSION 16

S16 - TROPICAL MONTANE ELEVATION TRANSECTS

Chairs: Gregory Goldsmith, Jürgen Homeier and Yadvinder Malhi
Contact: gregory.goldsmith@psi.ch

CLOUD AND RAINFALL PATTERNS ALONG TWO ALTITUDINAL TRANSECTS AT THE TROPICAL EASTERN ANDEAN SLOPES

Jörg Bendix[1], Katja Trachte[1], Rütger Rollenbeck[1], Kate Halladay[2], Yadvinder Malhi[2]

[1]University of Marburg, Marburg, DE, bendix@staff.uni-marburg.de
[2]University of Oxford, Oxford, UK

For the eastern slopes of the tropical Andes it is intensively discussed how and if spatial cloud/rainfall patterns are responsible for the spatial mosaic of species richness. From the meteorological point of view an open question is if there are any similarities in latitudinal atmospheric dynamics at continental to local scale leading to similar cloud/rainfall patterns (e.g. distinct wet and dry spots) along the eastern tropical Andean slopes. Forcing circulation systems of potential interest are the tropical easterlies, the South American Low Level Jet and local breeze systems. In the talk we compare investigations on spatio-temporal cloud and rainfall dynamics along two transects that are well-investigated in the scope of two interdisciplinary and long-term research programs: (i) A transect at lat ~3°S (San Francisco Valley) in SE-Ecuador ranging from 3500 m asl to the Amazonian foothills (biodiversity hotspot Cordillera del Condor) and (ii) a transect in central Peru at lat ~13°S encompassing the Kosñipata Valley (~3500 – 500 m asl) closing up in the biodiversity hotspot of the Manu National Park (Tambopata). The main focus of the talk will be on comparing the spatio-temporal patterns of cloudiness and rainfall along the altitudinal transects, with special reference to respective formation processes across scales.

INSIGHTS INTO ECOSYSTEM FUNCTION FROM A 3300 M ELEVATION GRADIENT IN THE PERUVIAN ANDES

Yadvinder Malhi[1], Kenneth Feeley[4], Miles Silman[2], Patrick Meir[3], Norma Salinas[1,5], Eric Cosio[5], Javier Silva Espejo[6], Chris Doughty[1], Walter Huaraca Huasco[1,6], Gregory Goldsmith[1], Imma Oliveras[1,7], William Farfan Rios[2], Cecile Girardin[1], Daniel Metcalfe[8], Kathryn Clark[1], Kate Halladay[1]

[1]*University of Oxford, Oxford, UK, yadvinder.malhi@ouce.ox.ac.uk*
[2]*Wake Forest University, Winston-Salem, North Carolina, US*
[3]*University of Edinburgh, Edinburgh, UK*
[4]*Florida International University, Miami, US*
[5]*PUCP, Lima, PE*
[6]*Universidad San Antonio Abad, Cusco, PE*
[7]*Wageningen Agricultural University, Wageningen, NL*
[8]*Lund University, Lund, SE*

We report on results from ten years of studies in 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 is 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 91% of the 3400 mm annual precipitation input comes from rainfall and 9% from cloud water interception. There is significant hysteresis, with substantial amounts of dry season water supply coming from wet season precipitation stored as groundwater in fractured rocks. There is evidence that mean tree species distributions are increasing in elevation over time. However, the treeline seems to have shown no movement in recent decades despite a warming trend, suggesting that invasion of trees into high elevation grasslands is not simple.

CARBON STORAGE AND TURNOVER ALONG A 2000 M-ELEVATION TRANSECT IN ECUADOR

Christoph Leuschner[1]

[1] *University of Göttingen, Göttingen, DE, cleusch@gwdg.de*

This talk summarizes the results of more than 10 years of intensive research on the carbon stores and fluxes in tropical mountain forests in southern Ecuador (provinces Loja and Zamora) along a 2000 m-elevation transect (1000 to 3000 m a.s.l.). Based on a survey a stand properties (stem density, dbh, tree height, LAI, species diversity), the C stores in aboveground and belowground biomass (fine roots, coarse roots) and soil (SOC), and the C fluxes with photosynthesis, stem, root and soil respiration and aboveground (ANPP) and belowground net primary productivity (BNPP, in particular fine root production) were measured. Different plots on exposed ridges, mid slopes and in valleys (54 plots in total) illustrate the great importance of exposition for the carbon balance of mountain forests. Aboveground and belowground biomass and productivity respond differently to the elevation gradient resulting in a large increase in the root : shoot ratio of biomass and productivity from 1000 to 3000 m. This indicates that, besides the temperature decrease, increasing shortage of soil resources (probably nitrogen and phosphorus) are main controlling factors of C storage and turnover along the slope from lower montane to upper montane elevetion in these Andean forests.

EFFECTS OF FIRE ACROSS THE ANDEAN FOREST-PUNA TIMBERLINE

Imma Oliveras[1,2], Yadvinder Malhi[2], Erickson Urquiaga Flores[3], Jose Antonio Quintano[3], Nohemi Lizárraga[3], José Kala[3], Katia Quispe[3], Efrain Lopez[3], David Lopez[3], Nelson Cahuana[3], Cintia Arenas[3], Rosa-María Román-Cuesta[1]

[1]*Wageningen University, Wageningen, NL, imma.oliverasmenor@wur.nl*
[2]*University of Oxford, Oxford, UK, imma.oliverasmenor@wur.nl*
[3]*Universidad San Antonio Abad del Cusco, Cusco, PE*

The Andean forest-puna timberline is a very vulnerable region to both climate and anthropogenic change. Current pressures include an increase on mean annual temperature, changes on cloud dynamics, and an increase of fire frequency and grazing. This study summarizes the results of a four-year study on the role of fire in the structure, composition and ecosystem functioning of the tropical montane cloud forests (TMCFs) and puna grasslands in the south-eastern Peruvian Andes. Fire did not have a significant effect on puna productivity, which was comparable to those of their neighbouring TMCFs. Fire did not have a significant effect on total above- or below-ground carbon stocks, but it had an effect on carbon allocation which were still noticeable in old burned forests (burned 14-28 years ago). Similarly, the tree size distribution of burned and unburned forests was significantly different in old burned forests but not for forests burned less than a decade ago. These slow but long-lasting responses to fire are in accordance with the relatively low productivity and turnover rates of these cold humid ecosystems. However, an increase of the fire frequency and a drier climate may change these dynamics and jeopardize the delicate dynamics of these unique ecosystems.

FLUXES AND FATES OF NITROGEN IN SOILS OF OLD-GROWTH MONTANE FORESTS IN ECUADORIAN ANDES WITH FOUR YEARS OF ELEVATED NITROGEN INPUT

Marife D. Corre[1], Angelica P. Baldos[1], Edzo Veldkamp[1]

[1]*Soil Science of Tropical and Subtropical Ecosystems, Goettingen University, Goettingen, DE, mcorre@gwdg.de*

Nitrogen (N) retention in tropical forest soils and how its mechanisms change with increase in N input are of current interest because of their link to soil carbon dynamics and the presently increasing N deposition in tropical regions. We conducted an in-situ 15N pulse chase study to: (1) assess the net fluxes and fates of mineral N (NH_4+ and NO_3-) in tropical montane forest soils with low N availability, and (2) determine the effects of four years of low N addition on the fluxes and fates of mineral N. Our study sites were located in Ecuadorian Andes at 1000 m and 3000 m elevations, where control (no manipulation) and N-addition (50 kg urea-N ha^{-1} $year^{-1}$) treatments, with four replicate plots (20 m x 20 m each), have been established since 2008. From November 2010 to October 2011, we traced the fates of mineral N in different soil N pools (NH_4+, NO_3-, extractable organic N, microbes, fine roots and soil organic N), using one-time application of either 15NH_4+ or 15NO_3- at very low amounts but 99 % 15N enriched. Both 15N tracers showed similar dynamics: a redistribution phase (i.e. short-term fate) characterized by large fluxes and fast transfers of 15N among N pools, and an equilibrium phase (i.e. long-term fate) depicted by small fluxes and stable transfers of 15N among N pools. The short- and long-term fates of either 15N tracer also showed similar mechanisms of paths and fluxes among different N pools in both forest sites, signifying the lack of preferential retention for either NH_4+ or NO_3-. In control plots of both forest sites, the short-term fate signified a complete recovery of both 15N tracers with the largest sink in the soil organic N pool (52-62 % of the added 15N), which was mainly contributed by microbial N turnover and fine root-related N release. The long-term fate showed a consistent flux into the slowly cycling soil organic N pool, suggesting that internal soil N cycling might not be largely dependent on the recycling of recently incorporated N in the soil organic matter. Four years of low N addition resulted in reduced N retention with long-term fate in soil organic N pool accounting only 30-38 % of the added 15N tracers. This was because the movement of N out of microbial and fine-root N pools did not lead to its accumulation in soil organic N.

MICROBIAL AND ENVIRONMENTAL CONTROLS ON SOIL-ATMOSPHERE TRACE GAS EXCHANGE IN THE TROPICAL PERUVIAN ANDES

Andrew Nottingham[1,6], Jeanette Whitaker[3], Norma Salinas[4], Sam Jones[1], Torsten Diem[5], Yit Arn Teh[5], Patrick Meir[1,2]

[1]*University of Edinburgh, Edinburgh, UK*
[2]*Australian National Unversity, Canberra, AU, pwmeir@gmail.com*
[3]*Centre for Ecology and Hydrology, Lancaster, UK*
[4]*Pontifical Catholic University of Peru, Lima, PE*
[5]*University of Aberdeen, Aberdeen, UK*
[6]*Smithsonian Tropical Research Institute, Panama, PA*

Upland tropical ecosystems are major contributors to regional and global atmospheric budgets of CO_2, CH_4 and N_2O, yet we still know relatively little about the magnitude, range and controls on fluxes of these climatically-relevant trace gases. Here we report on findings from process-based, multi-elevation studies of fluxes from soil of CO_2, N_2O and CH_4 in forested and puna ecosystems in the south-eastern Peruvian Andes/Amazon region. Carbon dioxide fluxes from soil may be constrained by environmental controls such as temperature and soil moisture content, but also by vegetation activity, litter and substrate quality, nutrient availability and the soil microbial community. We examine differences in some of these biological and physical controls on the flux of CO_2 from soil across a 3000 m elevation gradient, also testing for the importance of soil microbial composition in constraining the decomposition of soil organic matter. Additionally we briefly summarise redox and nutrient constraints on other soil trace gas emissions from this study transect, for example showing that measured N_2O emissions exceeded prior model predictions for this region, with N_2O exchange primarily driven by bacterial denitrification and the availability of inorganic N.

SHIFTS IN ARBUSCULAR MYCORRHIZAL RESPONSES TO NUTRIENT ADDITIONS ALONG AN ALTITUDINAL GRADIENT IN SOUTHERN ECUADOR.

Tessa Camenzind[1,5], Karla Dietrich[4], Dietrich Hertel[2], Jürgen Homeier[2], Andreas Krohn[1], Yvonne Oelmann[4], Pål Axel Olsson[3], Matthias C. Rillig[1]

[1]Freie Universität Berlin, Berlin, DE, TessaC@zedat.fu-berlin.de
[2]Georg-August Universität Göttingen, Göttingen, DE
[3]Lund University, Lund, SE
[4]Eberhard Karls Universität Tübingen, Tübingen, DE
[5]Berlin-Brandenburg Institute of Advanced Biodiversity Research (BBIB), Berlin, DE, TessaC@zedat.fu-berlin.de

Arbuscular mycorrhizal fungi (AMF) represent a monophyletic group of obligate biotrophic plant symbionts associated with 90% of land plants. In the tropics AMF represent the dominant mycorrhizal form, though specific characteristics in their diversity and physiology compared to temperate systems are mainly unexplored. The main function of AMF represents enhanced nutrient uptake mainly of nitrogen (N) and phosphorus (P), indicating that this symbiosis gains importance in systems with stronger nutrient limitations. We tested the hypotheses that (1) AMF abundance increases along an elevational gradient associated with decreasing nutrient availability and (2) that nutrient additions will affect AMF abundance depending on the nutrient status of the system. We analyzed intra- and extraradical AMF abundance within the framework of a multidisciplinary nutrient manipulation experiment (NUMEX) - a two-factorial experiment adding N and P in moderate amounts at three altitudinal levels (1000, 2000 and 3000m a.s.l.). Roots extracted from soil cores were used for the quantification of AMF root colonization, extraradical AMF biomass was analyzed by neutral lipid fatty analyses (NLFA 16:1ω_5). We confirmed our first hypothesis: the percentage of AMF root colonization as well as total colonized root length by AMF increased linearly from 1000 to 3000m, extraradical AMF biomass was quadrupled at 2000 and 3000m. Nutrient additions revealed the strongest effects at 2000m, with an increase in AMF abundance following P additions, whereas N additions rather decreased AMF abundance. At 1000m we observed the same trend, whereas at 3000m nutrient additions revealed no significant effects. In conclusion, altitudinal trends in AMF abundance may reflect stronger AMF dependency with decreasing nutrient availability at higher altitudes. Furthermore, effects of nutrient additions change along the gradient with respect to intensity, though there are no shifts in the response to N versus P additions.

PHOSPHOMONOESTERASE ACTIVITIES IN THE ORGANIC LAYER ARE MODIFIED BY NUTRIENT ADDITION IN A TROPICAL MONTANE FOREST IN ECUADOR

Karla Dietrich[1], Yvonne Oelmann[1]

[1]*University of Tuebingen, Tuebingen, DE, karla.dietrich@uni-tuebingen.de*

Continuously increasing atmospheric input of nitrogen (N) into tropical rainforests influence biogeochemical cycles. Not only the N cycle but very likely also the phosphorus (P) cycle might be affected. An increase in biomass production caused by N input will result in an increased demand for other nutritional elements such as P. Therefore, one might expect an increase in P mobilization, e.g. by enhanced enzyme activity that releases inorganic P from organically bond P. Our objective was to study the effect of moderate P and N fertilization on phosphatase activities along an altitudinal gradient in a tropical mountain forest of South Ecuador. The NUMEX experiment comprises altitudes of 1000, 2000 and 3000m a.s.l. each with control and N, P, and N+P fertilization plots to simulate increased atmospheric deposition. We sampled the organic layer and mineral soil of all treatments and determined phosphomono- and diesterase activity. Monoesterase activities in the organic layer of the control plots differed significantly among altitudes following the order 1000 m < 2000 m, 3000 m (mean ± standard error: 1000 m 67,7 ± 27,3; 2000 m 166,56 ± 15,06; 3000 m 178,27 ± 25,72 µg p-NP g^{-1} TS h^{-1}). In the organic layer of all altitudes, monoesterase activities of plots with inorganic P addition only was significantly lower than the control (mean ± standard error: P addition 86,0 ± 13,0 µg p-NP * g^{-1} TS * h^{-1}; control 137,5 ± 19,3 µg p-NP * g^{-1} TS * h^{-1}). An increased supply of inorganic P by fertilization reduces the need to synthesize enzymes for P mobilization. This result is corroborated by a significant lower diesterase activity at the lowest and highest altitude in the organic layer. In contrast, N fertilization stimulates growth and thus generates the need to mobilize P. Our results showed no differences between control and N treatment maybe because of the low amounts of fertilizer added and the small effects observed so far. At the lowest altitude, differences among treatments in phosphatase activities were most pronounced in both organic layer and mineral soil indicating the importance of biological P cycling at lower sites because of warmer and drier climate.

Merian Award Applicant

METHANE UPTAKE BY ANDEAN FOREST SOILS IN SOUTHEASTERN PERU

Sam Jones[1,2], Torsten Diem[3,4], Lidia Prisila Huaraca Quispe[5], Adan Julian Ccahuana Quispe[5], Patrick Meir[1], Yit Arn Teh[3,4]

[1]University of Edinburgh, Edinburgh, UK, sam.p.jones@ed.ac.uk
[2]INRA Bordeaux Aquitaine, Bordeaux, FR, sam.p.jones@ed.ac.uk
[3]University of Aberdeen, Aberdeen, UK
[4]University of St Andrews, St Andrews, UK
[5]Universidad Nacional de San Antonio Abad del Cusco, Cusco, PE

Estimates of tropical atmospheric CH_4 budgets indicate source-sink inventories for such landscapes are inadequate. However, soil-atmosphere CH_4 exchange in humid tropical forests is relatively poorly constrained. This is particularly true of montane forests where limited observations highlight regional variations between emission and uptake of atmospheric CH_4. In the tropical Andes such environments are extensive. As such, a better understanding of the magnitude and drivers of soil-atmosphere CH_4 exchange is required.

We report CH_4 fluxes from premontane (PMF, 1070 - 1088 m asl), lower montane cloud (LMCF, 1532 - 1786 m asl) and upper montane cloud (UMCF, 2811 - 2962 m asl) forest soils in southeastern Peru. Mean annual air temperature and precipitation decrease with elevation from 24 to 12 °C and 5000 to 1700 mm between 1000 and 3000 m asl. The region experiences a pronounced wet season between September and March. Monthly measurements of soil-atmosphere gas exchange, soil moisture, soil temperature and soil O_2 concentration were made from February 2011 in the LMCF and UMCF and July 2011 in the PMF to June 2013.

These soils principally acted to uptake CH_4 with mean net CH_4 fluxes (standard error) for wet and dry season, respectively, of -0.08 (0.13) and -0.20 (0.15) mg CH_4-C m^{-2} d^{-1} in the PMF, -0.97 (0.11) and -1.12 (0.13) mg CH_4-C m^{-2} d^{-1} in the LMCF and -1.04 (0.11) and -1.55 (0.13) mg CH_4-C m^{-2} d^{-1} in the UMCF. Differences in net CH_4 flux among forest types was best explained by positive correlation with water-filled pore space. Drivers of temporal variations in net CH_4 flux varied within forest types with significant seasonality only identified in the UMCF.

Greater CH_4 uptake at higher elevation differs from the pattern previously reported for Andean forests in Ecuador. In this respect, variations in soil-atmosphere CH_4 exchange across such gradients may be driven by interactions between precipitation and soil structure rather than temperature.

TREE SPECIES RICHNESS AND FUNCTIONAL DIVERSITY ALONG AN ELEVATIONAL TRANSECT IN THE ANDES OF SOUTHERN ECUADOR

Juergen Homeier[1], Nixon Cumbicus[2], Jaime Peña[3]

[1]*University of Goettingen, Goettingen, DE, jhomeie@gwdg.de*
[2]*UTPL, Loja, EC*
[3]*UNL, Loja, EC*

Tree species richness is known to decrease along most elevational transects in tropical mountains. But there are still few studies on the effects of elevation on tree functional diversity in tropical forests.

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: premontane forest, 2000m: lower montane forest, and 3000 m asl: upper montane forest). Eighteen plots of 400m^2 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 both species richness and functional tree properties.

All tree stems with dbh ≥ 5 cm were recorded and identified to species. We collected 680 leaf samples and 702 wood samples of trees ≥ 10 cm dbh to characterize their functional properties (e.g. wood specific gravity, specific leaf area, leaf toughness, and foliar nutrients) and to estimate tree functional diversity of the plots.

Highest species numbers were found at 2000m and not as expected at the premontane site at 1000m, at all elevation levels lower slopes and mid slopes were more species rich than neighboring upper slopes.

In addition to the apparent changes in forest structure, we found strong impacts of both elevation and topography on functional tree properties. In most traits the adjustment from lower slope to upper slope was similar to (but sometimes even stronger than) the shift from premontane to upper montane forest.

THE RELATIONSHIP BETWEEN CHEMICAL AND PHYSIOLOGICAL LEAF TRAITS ALONG A TROPICAL MONTANE ELEVATION GRADIENT IN PERU

Lisa Patrick Bentley[1], Roberta Martin[2], Brian Enquist[3], Gregory Asner[2], Tatiana Boza[4], Rosa Castro[5], Eric Cosio[9], Sandra Díaz[6], Patrick Meir[7], Flor María Mullisaca[5], Margot Neyret[8], Gloria Rayme[5], Norma Salinas[1], Alexander Shenkin[1], Miles Silman[10], Yolvi Valdez[9], Yadvinder Malhi[1]

[1]*University of Oxford, Oxford, UK, lisa.bentley@ouce.ox.ac.uk*
[2]*Carnegie Institution for Science, Stanford, US*
[3]*University of Arizona, Tucson, US*
[4]*University of Zurich, Zurich, CH*
[5]*Universidad National de San Antonio Abad, Cusco, PE*
[6]*Córdoba National University, Córdoba, AR*
[7]*University of Edinburgh, Edinburgh, UK*
[8]*École Normale Supérieure, Paris, FR*
[9]*Pontificia Universidad Católica del Perú, Lima, PE*
[10]*Wake Forest University, Winston-Salem, US*

Predicting changes in the structure, function, and diversity of tropical forest communities in a rapidly changing world is a major research challenge in ecology. There is a need to develop a predictive framework that translates changes in community composition to changes in ecosystem biomass, productivity, and biogeochemical function. Recently, a trait-based approach, where the key traits that underlie whole-plant performance are measured within and across species, has been heralded as the basis to develop a more predictive ecology. Traits are properties of an individual that ties its performance (e.g., reproduction, growth, and metabolism) to climatic drivers (e.g., precipitation and temperature) and are allowed to vary within and across species. In particular, the leaf economics spectrum (LES) describes a set of trade-offs among traits related to plant carbon balance and has been adopted as a general explanation of leaf trait variation at all scales and in all plants. While the LES has been an organizing framework of plant functional ecology for the past decade, it is unknown how species along tropical montane elevation gradients fall on the LES. Do leaf chemical and gas exchange traits covary within plots, and vary among plots along the gradient? Are there net trends in leaf traits along the gradient, both in the mean value of traits and in the variance and higher order moments of the leaf-traits spectrum? Here, we investigate these questions through using data collected from a 7-month field campaign conducted along a 3500 m elevation gradient in Peru. In 10 plots along this gradient, we measured photosynthesis, carbon, nitrogen, phosphorus, and leaf mass per area in 5,025 leaves from 605 trees. When analyzing single traits, we found significant differences based on elevation as well as differences in amounts of inter- and intra-specific variance. In accordance with the LES we found strong covariation of leaf traits between species, but significant differences when comparing leaves collected at different canopy positions (sun/shade). In light of these results, we suggest a suite of leaf-level traits (and their respective measurement intensities) that will allow for higher-level (plant-, community-level) properties to be estimated via trait-based modeling approaches along tropical montane elevation gradients.

PLANT BIODIVERSITY ALONG ALTITUDINAL GRADIENTS OF A FOREST ECOSYSTEM IN PALAWAN ISLAND, PHILIPPINES

Lita Sopsop[1], Inocencio Jr Buot[1]

[1]*Western Philippines University and University of the Philippines Open University/ University of the Philippines Los Banos, Aborlan, Palawan/ Los Banos, Laguna, PH*

The forest flora along elevational gradient of Aborlan Guba System was studied to determine the pattern of vegetation distribution and its influencing factors using standard vegetation ecology methods. In the 66 quadrats studied, 324 plant species (trees, shrubs, herbs, ferns and their allies, palms and lianas) in 192 genera and 89 families were recorded. Four vegetation zones named after the dominant species were identified: Zone I, Artocarpus-Ganophyllum forest, Zone IIA, Koordersiodendron-Litsea forest, Zone IIB, Pouteria-Ficus-Neonauclea-Quercus-Syzygium-Tristaniopsis forest, Zone III, Swintonia-Agathis-Magnolia forest, and Zone IV, Pinus forest. Zone IV is the peak of the Aborlan Guba System with massive growth of Pteridium aquilinum. Multivariate regression analysis shows that elevation, temperature, pH, moisture, water holding capacity and human disturbance significantly influenced the distribution of tree species. The Aborlan Guba System seems to follow the unfortunate trend in Mount Pulag, Mount Akiki, Mount Mayon and Mount Makiling of Luzon Island and Mount Tabunan of Visayas Island if large scale human disturbances will continue to accelerate. In these mountain forests, lower elevation dominants encroach in upper slopes displacing original dominants destroyed by farming. In Mount Pulag and Mount Akiki, Pinus ascended and now dominated the areas previously colonized by Lithocarpus. In Mount Makiling, Diplodiscus encroached in habitats previously dominated by dipterocarps. In Mount Mayon and Mount Tabunan, Astronia and Artocarpus respectively, colonized disturbed higher altitudes. In order to minimize severe biodiversity loss, there should be a strong will in protecting core forest zones and in pursuing rehabilitation efforts such as establishment of biodiversity corridors. Additionally, however, there should be sustained community biodiversity education, including massive open online courses for kids, youth and adults, since the internet seems to play a crucial role in meeting the environmental challenges of the 21st century.

TAXONOMIC, PHYLOGENETIC AND FUNCTIONAL DIVERSITY OF TREES RESPOND DIFFERENTLY TO CHANGES IN ELEVATION AND TOPOGRAPHY

Yvonne Tiede[1], Helen Haukamp[1], Jürgen Homeier[2], Birgit Ziegenhagen[1], Jörg Bendix[1], Roland Brandl[1], Nina Farwig[1]

[1]Philipps-University, Marburg, DE, tiedey@biologie.uni-marburg.de
[2]Georg-August-University, Göttingen, DE

Climate change has an increasing impact on the structure and composition of natural ecosystems across the globe. The overall loss of biodiversity affects important ecological functions. As taxonomic diversity ignores almost 89 % of the overall diversity and many traits show a phylogenetic signal, phylogenetic diversity is often a better indicator for functional processes. Beyond that, functional diversity, which quantifies the trait space (trait characteristics) in a community, has been shown to be of greater importance for ecosystem processes than taxonomic diversity per se. It is thus crucial to study reactions of taxonomic, phylogenetic and functional diversity to quantify their contribution to important ecosystem processes.

We analyzed the effects of changes in elevation and topography on the taxonomic, phylogenetic and functional diversity of trees in an Andean Mountain rainforest in Ecuador. Results showed decreasing taxonomic diversity in upslope direction, but no elevational effects. Phylodiversities were clustered at low and high elevations. Furthermore, we found clustered phylodiversities at upper slopes. As a measure of functional diversity we used the two functional traits specific leaf area and wood specific gravity. The values of the specific leaf area of the communities decreased with increasing elevation and were lower at upper slopes. The values of the wood specific gravity of the communities showed no specific pattern along the elevation gradient or with topographic position but the range of the values decreased from low to high elevation. Our results reveal that the filtering effect of the environment plays a major role in shaping the phylodiversity at high elevations as well as the functional diversity at low and high elevations.

Accordingly, changing environmental conditions, such as increasing temperature could lower the filtering effect at high elevations leading to less specialized (less clustered) phylodiversities and a loss of functional traits within the communities at the ends of environmental gradients.

Merian Award Applicant

VARIATION IN LEAF WATER REPELLENCY ALONG A 4000 M ELEVATION TRANSECT IN THE PERUVIAN ANDES

Greg Goldsmith[1,2], Lisa Patrick-Bentley[2], Alexander Shenkin[2], Chris Doughty[2], Rosa Castro-Ccoscco[3], Norma Salinas[2,3], Yadvinder Malhi[2]

[1]*Paul Scherrer Institute, Villigen, CH, gregory.goldsmith@psi.ch*
[2]*Oxford University, Oxford, UK, gregory.goldsmith@psi.ch*
[3]*Universidad Nacional de San Antonio Abad del Cusco, Cusco, PE*

Leaf water repellency is a measure of the hydrophobicity, or wettability, of leaf surfaces. At the scale of the plant, leaf water repellency can affect gas exchange, nutrient exchange, and pathogen growth. At the scale of the ecosystem, it can affect canopy water storage, throughfall, and evaporation. To date, very few studies have measured intra- and inter- community variation in leaf water repellency of tropical forest ecosystems. In the context of a broad survey of plant functional traits, we measured leaf water repellency in nine forest plots occurring across a 4000 m elevation gradient in the eastern Andes of Peru. Observed angles of incidence (63 ±13°) indicate high leaf wettability, with no significant difference between sun and shade leaves. We find no strong evidence for variation across sites, but rather find high variation within a given site. A phylogenetic analysis also demonstrates that leaf water repellency is likely to be a highly plastic trait, with family, genus and species identity accounting for only ca. 30% of the observed variance. Nevertheless, a global meta-analysis of studies indicates that leaf water repellency does vary significantly as a function of climate. Given the number of different functions that leaf water repellency may play in plant, community and ecosystem function, it is critical to consider what drives its variation at different scales. Our results provide new insights into differences in the leaf water repellency of tropical forests at local and regional scales now and how it may be expected to change in the future.

AGAINST THE FLOW? POPULATION GENETIC STRUCTURE OF MONTANE FICUS

Simon Segar[1,2], Martin Volf[1,2], Brus Isua[3], Emol Brus[3], Legi Sam[5], George Weiblen[4], Vojtech Novotny[1,2]

[1]University of South Bohemia, Ceske Budejovice, CZ, simon.t.segar@gmail.com
[2]Institute of Entomology, Ceske Budejovice, CZ, simon.t.segar@gmail.com
[3]New Guinea Binatang Research Centre, Madang, PG
[4]University of Minnesota, Minnesota, US
[5]Griffith University, Brisbane, AU

A large proportion of the world's insect and plant biodiversity is found in tropical and sub-tropical 'hotspots', which frequently include altitudinal gradients. These gradients can function as 'diversity pumps', strongly influencing both regional and local species richness. Climactic conditions on such gradients often change rapidly along short vertical distances, and may result in local adaptation and high levels of population genetic structure in host plants. The cascading effects of isolation by altitude on host plant chemistry, insect herbivore community structure and insect pollination are of wider general interest when understanding insect biodiversity. We investigate the population genetic structure of three species of *Ficus* along a continuous altitudinal gradient in Papua New Guinea. This speciose plant genus is not only associated with species rich communities of insect herbivores but is pollinated by tiny, species specific chalcid wasps. Our results from six altitudes and 11 microsatellite loci show that strong barriers to gene flow exist between 1,000-1,200m a.s.l. for all Ficus species studied, with populations being relatively homogenous above and below this boundary. This is in sharp contrast to previous findings from lowland *Ficus* populations, between which gene flow can occur over tens to hundreds of kilometers. We suggest that the limited gene flow between populations of montane Ficus maybe driven by environmental limitations on pollinator dispersal. Our ongoing efforts to characterize the plant herbivore communities and chemical profiles of these host plants should further add to our understanding of how both plant and insect biodiversity is generated.

SESSION 17

S17 - HUMAN-MODIFIED TROPICAL FORESTS

Chairs: Yit Arn Teh
Contact: yateh@abdn.ac.uk

POLLEN EVIDENCE FOR CENTURY-SCALE COMPOSITIONAL CHANGE IN A TERRA FIRME FOREST IN WESTERN AMAZONIA

Katherine Roucoux[1], Ian Lawson[1]

[1]*University of St Andrews, St Andrews, UK, khr@st-andrews.ac.uk*

Studies of forest inventory plots since the 1970s have shown that, across Amazonia, forests are changing in composition, structure and dynamics, which is relevant to their present and future role as a carbon sink. While anthropogenic increases in resource availability (N, CO_2) may partly account for the changes, the role of other past events (e.g. natural climatic change, blow-down events, anthropogenic deforestation) remains largely untested. The only direct way to access the pre-monitoring history of forests is via a palaeoecological approach. Palaeoecology provides a toolkit for reconstructing past environments from subfossil remains preserved in, for example, peat and lake sediments. However, palaeoecology in the tropics is hindered by a lack of suitable deposits, especially in *terra firme* forests where lakes and mires are extremely rare. Furthermore, the relatively few records typically suffer from very low accumulation rates and are thus unable to provide the decadal- to centennial-scale resolution required. We have followed up reports of small peaty "forest hollows" in *terra firme* forests in northern Peru and located, described and sampled one of these sites. The hollow is 20 x 100 m across and contains up to 70 cm of peat. Two radiocarbon dates show that the peat has been accumulating rapidly since c. AD 660 (c. 20 years/cm). Pollen analysis of the peats was used to test the hypothesis that the vegetation at this site has been stable on decadal to centennial timescales. Our data show that, contrary to expectations, the present Leguminosae-dominated forest is only 400 years old. Earlier changes include an initial period of disturbance and ensuing ecological succession near the start of the record. This demonstration of the variability of the vegetation through time substantially extends our understanding of the dynamics and resilience of the *terra firme* forest at this site.

UNDERSTANDING GLOBAL TRENDS IN SAVANNA TREE COVER.

Caroline Lehmann[1], Nicola Stevens[2]

[1]*University of Edinburgh, Edinburgh, UK, caroline.lehmann@ed.ac.uk*
[2]*University of Cape Town, Cape Town, ZA*

CO_2 is central to plant growth and success. Over the next hundred years, the atmospheric CO_2 concentration is projected to reach 600 ppm - a more than 100% increase on the pre-industrial CO_2 concentration in only 300 years. Tropical savannas cover 20% of the global land surface. With open-canopies and the co-dominance of C_3 woody plants and C_4 grasses that differ in their response to environmental controls the savanna biome is vulnerable to increases in the atmospheric CO_2 concentration. Savanna tree cover and extent are held in balance through a dynamic process of succession and disturbance. Interactions between water availability, temperature, fire and mega-herbivory determine rates of tree growth and recruitment, where either a reduction in disturbance or an increase in resource availability promotes increases in tree recruitment and tree cover. The world over there have been notable changes in the savanna biome, particularly increases in tree cover and an advance of forest into savanna at biome boundaries. While these changes have been apportioned to many factors – changing rainfall, drought, evaporative demands, fire and patterns of human use, several recent studies have apportioned decadal shifts in tree cover across sub-Saharan Africa to increasing atmospheric CO_2 concentrations. This is despite an absence of experimental data examining the effect of increased CO_2 concentrations on tropical savanna plant communities. Here we present the first results of a meta-analysis of savanna vegetation change from across Africa, Australia, North America and Brazil. We asked: Is there a universal trend of increasing tree cover across savanna regions? Are there hotspots of vegetation change? Which plant taxa dominate in regions of increasing tree cover? We hypothesise that the regional differences in the traits of dominant woody plant species, specifically allometry, phenology and N-fixation, governs the sensitivity of savanna regions to future vegetation change.

BIOGEOCHEMISTRY AS AN INTEGRATING FACTOR OF HUMAN IMPACT ON TROPICAL FOREST ECOSYSTEMS

Erika Buscardo[1,2,3], Gabriela Nardoto[4], Maria Teresa Fernandez Piedade[3], Jochen Schöngart[3], Florian Wittmann[3], Helena Freitas[1], Laszlo Nagy[2,3]

[1]Centro de Ecologia Funcional, Universidade de Coimbra, Coimbra, PT, erikabuscardo@hotmail.com
[2]Departamento de Biologia Vegetal, Universidade Estadual de Campinas, Campinas, BR, erikabuscardo@hotmail.com
[3]Instituto Nacional de Pesquisas da Amazônia, Manaus, BR, erikabuscardo@hotmail.com
[4]Departamento de Ecologia, Universidade de Brasília, Brasília, BR

The structure and functioning of ecosystems is reflected by the temporal and spatial characteristics of the biosphere-atmosphere exchanges of matter and energy. Spatially, this is related to the configuration of the landscape - physiography (geology, topo-hydro-pedo sequences) and biodiversity (vegetation type and associated fauna). The conversion of large tracts of forest to other uses the world over is causing radical and immediately visible changes in biodiversity / ecosystems, and the functioning of such altered landscapes manifests itself in changes in their biogeochemistry. This has implications for matter and energy flow, whose impacts may impact local or regional climate, elemental cycles, water yield and quality, and environmental sustainability in general. We present the case of the Amazon Basin where we show qualitative and quantitative differences in the biogeochemistry of the main natural vegetation formations vs. that of anthropic systems. The patterns of fixation, storage and use of nutrients for biomass production, the patterns of internal (re)cycling (leaching of crown nutrients, litterfall, root growth and death, root exudates) and, the patterns of litter decomposition and soil processes (nutrient availability, mineralisation *vs.* immobilization) and gas emissions from soil are used for proposing a biogeochemical accounting system that may be used for quantifying human impact on tropical ecosystem functioning.

THE IMPORTANCE OF BIODIVERSITY FOR MULTIPLE ECOSYSTEM FUNCTIONS IN A HUMAN-MODIFIED LANDSCAPE IN THE TROPICS

Madelon Lohbeck[1], Lourens Poorter[1], Miguel Martínez-Ramos[2], Frans Bongers[1]

[1]*Wageningen University, Wageningen, NL, madelon.lohbeck@wur.nl*
[2]*Centro de Investigaciones en Ecosistemas, Universidad Nacional Autónoma de México, Morelia, MX*

Biodiversity loss is expected to have large negative consequences for ecosystem functioning. Biodiversity is thought to be especially important for the multifunctionality of ecosystems, as different species contribute to different functions, but support for this idea comes mainly from experimental studies. We evaluated the importance of biodiversity for multiple ecosystem functions in a human-modified tropical forest landscape in Chiapas, Mexico. We quantified five key ecosystem functions (standing above-ground biomass, biomass productivity, litter production, wood decomposition and litter decomposition) at the landscape level, and evaluated to what extent individual species contribute to these functions. The species that contributed most to the different ecosystem functions were largely the same small set of dominant species, indicating a limited role of biodiversity for ecosystem multifunctionality. The use of simulations enabled teasing apart the relative importance of species richness, species dominance and species functional traits, and demonstrated that only when minimizing dominance do different species (with different functional traits) contribute to different ecosystem functions. The present study, like most studies on biodiversity-ecosystem functioning, focuses on a narrow range of (biogeochemical) functions. Future studies should address the consequences of biodiversity loss on ecosystem multifunctionality in natural ecosystems, including a wide range of ecosystem functions.

UNDERSTANDING THE DYNAMICS OF MANAGED FORESTS - THE ROLE OF ENVIRONMENT, TRAITS AND DIVERSITY

Masha van der Sande[1,2,3], Marielos Peña Claros[1], Nataly Ascarrunz[3], Juan Carlos Licona[3], Marisol Toledo[3], Eric Arets[2], Lourens Poorter[1]

[1]Forest Ecology and Forest Management, Wageningen University, Wageningen, NL, masha.vandersande@wur.nl
[2]Forest, Vegetation and Landscape Ecology, Alterra, Wageningen, NL, masha.vandersande@wur.nl
[3]Instituto Boliviano de Investigación Forestal, Santa Cruz, BO, masha.vandersande@wur.nl

Tropical forests store large amounts of carbon as they grow, and are therefore important for global climate change mitigation. However, drivers of forest biomass growth are still poorly understood, especially when it concerns managed forests that cover more than half of the area of tropical forests.. During this presentation, I will show how abiotic drivers (logging disturbance and soil properties) and biotic drivers (forest structure, species diversity, and community functional traits) shape biomass dynamics of tropical forests. I focus on three important demographic rates that underlie net biomass growth; growth by recruiting trees, growth by trees that were already established, and mortality. We evaluated 9 years of dynamics for 48 1-ha plots in the tropical moist forest of La Chonta, Bolivia, and applied structural equation modelling to evaluate the (in)direct effects of abiotic and biotic drivers on the demographic rates. Net biomass growth was most strongly determined by mortality, but mortality itself was highly stochastic and was not explained by any of the drivers. For surviving trees, forest structure (e.g., plot basal area) had the strongest positive effect on growth because of more biomass that could grow after logging, whereas forest structure negatively affected growth of recruiting trees due to low availability of light and space. Similarly, disturbance increased growth of recruiting trees because of light and space availability, but did not affect growth of surviving trees. Species richness had a positive effect on growth, and was at least as important as functional composition. Growth of surviving trees was favoured by acquisitive trait values reflecting biomass investment in growth rather than structural defences. Growth of recruiting trees, on the other hand, tended to be favoured by conservative trait values that increase resistance to damage and thereby sustain biomass growth. Soil texture, and not soil fertility shaped stand productivity. We show that simultaneously evaluating multiple possible drivers can provide a better understanding of ecological processes such as demographic rates of managed tropical forests.

ENSURING BIODIVERSITY CONSERVATION WITHIN A REDD+ FRAMEWORK: CASE OF VICTORIA-ANEPAHAN RANGES IN PALAWAN ISLANDS, PHILIPPINES

Minerva Singh[1]

[1]*Minerva Singh, Cambridge, UK, ms2127@cam.ac.uk*

Payments for Ecosystem Services (PES) instruments such as Reduced Emissions from Degradation and Deforestation (REDD+) are potential methods to incentivize tropical forest conservation and avoid deforestation through payment to protect forest carbon stocks. In addition to loss of carbon stocks, loss of valuable biodiversity, including endangered and endemic species is another major threat facing the tropics. Owing to a combination of logging, plantation agriculture, SE Asia potentially faces a biodiversity collapse. However biodiversity conservation and species protection is not explicitly provided for within the existing REDD+ framework. Viewing forest carbon and biodiversity as different ecosystem attributes may hamper the goal of forest conservation in the tropics. This situation is compounded by the fact that it high carbon and high biodiversity areas may not spatially overlap in a tropical forest ecosystem. However in order to operationalize a REDD+ scheme that considers biodiversity co-benefits, it is important to identify AGB distribution in a landscape, along with potential habitats for target species, areas providing important ecosystem services and overlaps between these. Examples abound of using remote sensing data for mapping AGB variation, habitat degradation and habitat suitability. However very little research has been carried out for quantifying the overlaps and parallel co-existence of AGB stocks and biodiversity rich areas in a given landscape. We propose to use free remote sensing data (such as Landsat and Google Earth imagery) to examine variation in AGB and bird species distribution in the Victoria-Anepahan range area, Philipines. We propose to identify areas of high carbon storage and important habitats for endangered birds in the area (and see if there are any overlaps between them).This area is an Important Bird Area and one of the last forest frontiers in the Philippines. Hence it is important to develop a REDD+ mechanism (with biodiversity co-benefits) for areas such as this.

RESOURCES AND ENEMIES, WHICH HAVE BIGGER INFLUENCE ON THE BIODIVERSITY-ECOSYSTEM FUNCTIONING RELATIONSHIP IN THE SUBTROPICAL FOREST?

Yuanyuan Huang[1], Pascal Niklaus[1], Bernhard Schmid[1]

[1] *University of Zurich, zurich, CH, yuansjob@gmail.com*

Aboveground primary productivity is one of the most important ecosystem functions in the forest, and has been found increasing with biodiversity in many studies. Lots of the experiments have been done in the grassland to identify the complementary effect, selection effect and soil microbes' effect on this relationship. However, there is little knowledge about the mechanisms in the subtropical forest. Here, we conducted an experiment in a large biodiversity-ecosystem functioning experiment platform in JiangXi Province, China (BEF-China). We used the plots with 6 biodiversity levels (1, 2, 4, 8, 16, 24), which were designed by the random extinction scenario. Experimental treatments included pathogen exclusion, herbivore exclusion, weeds admission, phosphorus fertilization and control. We wanted to test whether the positive effect of biodiversity on aboveground primary productivity results from a reduced pressure from host-specific predators and pathogens at high diversity, or from the resource-based niche complementarity. Our results contribute to the explanation of the biodiversity-ecosystem functioning relationship's underlying mechanism in subtropical forest.

DEGRADATION AND RESTORATION OF TROPICAL FOREST DIVERSITY AND FUNCTIONING

Andy Hector[1], Dzaeman Dzulkifli[1], Elia Godoong[1], Josephine Haase[1], Michael O'Brien[1], Christopher Philipson[1], Philippe Saner[1], Matteo Tanadini[1], Hamzah Tangki[1], Sean Tuck[1]

[1]*University of Oxford, Oxford, UK, andrew.hector@plants.ox.ac.uk*

We will start by presenting data on the impacts of selective logging on different classes of lowland and upland forest in Sabah, Malaysian Borneo. We will then present experimental evidence for the effectiveness of two restoration techniques – enrichment line planting and enhanced climber cutting. The success of enrichment line planting depends on both the condition of the selectively logged forest, the care of the enrichment planted seedlings and their species identity – levels of mortality vary widely amongst species and are correlated with key plant traits. Enhanced climber cutting is intended to accelerate re-establishment by dipterocarps (the dominant canopy trees) through reduction of competition. However, enhanced climber cutting leads to more open canopies in the short term and could increase mortality from drought. Removal of climbers could also reduce levels of diversity of associated organisms. To date our data supports the success of enhanced climber cutting in increasing dipterocarp growth rates with no increase in mortality. However, removal of climbers may have negative effects on the diversity of associated species.

LAND-USE IMPACTS ON BIODIVERSITY AND CARBON SEQUESTRATION IN GRAZED CAATINGA DRY FORESTS, NE BRAZIL

Katharina Schulz[1,2], Jarcilene Almeida Cortez[3], Ingo Kowarik[1,2], Arne Cierjacks[1,2,4]

[1]Technische Universität Berlin, Berlin, DE, katharina.schulz@tu-berlin.de
[2]Berlin-Brandenburg Institute of Advanced Biodiversity Research (BBIB), Berlin, DE, katharina.schulz@tu-berlin.de
[3]Universidade Federal de Pernambuco Recife, Recife, BR
[4]University of Hamburg, Hamburg, DE

Caatinga dry forests of NE Brazil are characterized by high floristic diversity and endemism and play an important role as carbon sink. The majority of these forests are subjected to grazing by domestic ungulates which may be detrimental to the typical species assemblage and to ecosystem functioning. The BMBF funded INNOVATE project aims at the development of adapted land-use options which are more climate- and biodiversity-friendly. Within this project we investigated the effects of environmental and anthropogenic drivers on plant biodiversity and organic carbon (OC) storage in vegetation and soil of ecosystems near the Itaparica Reservoir. The analyses showed that grazing hat a significant negative effect on the OC stocks of woody plants, herbs and bromeliads as well as on the woody plant diversity. The mean aboveground OC stocks within the study area was at 17,1 t ha^{-1}. Carbon stocks of sampling sites with a high water availability (34.6 t OC ha^{-1}) significantly differed from those of locations with intermediate or low water availability (28.6 and 22.2 t OC ha^{-1}, respectively). Moreover, our data indicate a negative correlation between biodiversity measures and the amount of aboveground biomass which implies a possible conservation conflict. The analysis of soil samples showed mean OC stocks of 16.8 t ha^{-1} in the study area. Due to the good soil air supply, the storage of OC is relatively low. Grazing led to a significant reduction of soil carbon in the first 5 cm of the soil. Our data show that grazing at high intensity (up to 8 animals ha^{-1}) leads to detrimental effects on aboveground carbon stocks in the study area. However, an adapted grazing regime with lower animal load or well-managed rotation schemes may be a component of sustainable land management in semiarid north eastern Brazil.

SENSITIVITY OF SOIL RESPIRATION TO LAND-USE AND THE COMBINED INFLUENCE OF SOIL TEMPERATURE AND MOISTURE IN AGRICULTURAL SOILS FROM THE TROPICS

Viktoria Oliver[1,1], Jose Kala[1], Yit Arn Teh[1]

[1]*University of Aberdeen, Aberdeen, UK, oliver.viktoria@gmail.com*

Tropical soils are one of the largest contributors to global soil respiration and play a critical role in regulating atmospheric CO_2 concentrations. The main controls of soil respiration are temperature, moisture and substrate quality and quantity but despite their synergistic relationship, tropical soil C cycling research has generally explored these factors separately. This study seeks to improve the understanding of differences of soil CO_2 fluxes on four different land uses in the Peruvian tropical Andes (mature forest, cultivated banana, abandoned banana and pasture) by exploring the interactions of soil moisture and temperature. Annual soil CO_2 fluxes were measured bi-monthly using a closed-chamber technique with a Vaisala CO_2 analyser accompanied by a short-term incubation experiment on intact soil cores, using four temperatures (16 °C, 24 °C, 28 °C, 32 °C) and three moisture treatments (25-45 %, 45-65 % and 65-85 % volumetric water content). Respiration data from the field and incubation experiment showed concurring relationships with the environmental drivers measured. Pasture soils were not affected by soil moisture, although there was a trend of a decreasing CO_2 flux at the highest moisture treatment (65-85 %). For mature forest soils, respiration was inversely proportional to moisture, with a more pronounced relationship observed at higher temperatures. Respiration on the abandoned banana soils was positively correlated with moisture, except at the highest temperature (32 °C). The cultivated banana soils showed no significant relationships with either of the experimental variables. This study confirms expected trends in tropical soils: higher soil temperatures result in an exponential increase in CO_2 emissions. However, contrary to theoretical expectations, soil moisture was not the dominant driver of heterotrophic soil respiration unless at higher temperatures, where soil moisture then became the dominant factor. Furthermore, the land-use history of soil is critical in determining how emissions of CO_2 respond to soil moisture and temperature.

EXPLORING THE SPATIAL VARIATION OF SOIL RESPIRATION IN OIL PALM ON PEAT SOIL.

Frances Manning[1], Yit Arn Teh[1], Timothy Hill[2], Kho Lip Khoon[3]

[1]*Institute of Biological and Environmental Sciences, University of Aberdeen, Aberdeen, UK, f.manning@abdn.ac.uk*
[2]*Department of Earth Sciences, University of St. Andrews, St. Andrews, UK*
[3]*Malaysian Palm Oil Board, Selangor, MY*

Tropical ecosystems are globally important carbon stores, with tropical peatlands and forest vegetation acting as major sinks for carbon dioxide. Little is known about the impacts of oil palm cultivation on terrestrial carbon dynamics in tropical peatlands and how management practices influence ecosystem respiration. Here we report findings from a preliminary study exploring the spatial heterogeneity of soil respiration in oil palm plantations established in tropical peatlands in Sarawak (Malaysian Borneo), with a wider view towards quantifying rates of soil respiration from these habitats. These systems are spatially structured due to agricultural management, with vegetation, organic residues, and drainage ditches established systematically and evenly across the landscape. Fine-scale (<1m), spatially stratified measurements of soil respiration were conducted to evaluate the relative contributions of the dominant vegetation (i.e. roots), decomposition of residue, and decay of peat to overall patterns of soil respiration. We found that the variation in the distribution of palm roots explained a large proportion of the variation in soil respiration, with large fluxes near palms and significantly smaller fluxes further away (0.75m). Likewise, significantly greater soil respiration fluxes were observed in ground cover-dominated areas compared with those areas that had been cleared. This spatially stratified sampling approach may represent a simple and effective method to determine rates of microbial decomposition and soil organic matter loss, and may be used – in concert with productivity and decomposition measurements – to assess if these drained peatland soils are net sources or sinks of atmospheric carbon.

THE EFFECT OF NITROGEN FERTILISER ON NITROUS OXIDE EMISSION IN OIL PALM PLANTATION

Norliyana Zin Zawawi[1], Yit Arn Teh[1], Lip Khoon Kho[2], Timothy Hill[3]

[1]*Institute of Biological and Environmental Sciences, University of Aberdeen, Scotland, UK, nzinzawawi@abdn.ac.uk*
[2]*Malaysian Palm Oil Board, Selangor, MY*
[3]*School of Geography and Geosciences, University of St Andrews, Scotland, UK*

Oil palm is the largest agricultural crop in the tropics, accounting for 13% of all tropical land cover. When it is cultivated on marginal or nutrient-poor land, external inputs of N fertiliser are required to achieve high levels of productivity and yield. However, excess N fertiliser use may lead to negative impacts on the environment, including generation of reactive N-gases (e.g. nitric oxide –NO, nitrous oxide –N_2O), tropospheric ozone (O_3) and nitrate (NO_3-); all of which may lead to atmospheric pollution and contamination of surface waters. This study investigates spatial and temporal patterns of N-gas fluxes in peatland oil palm plantations associated with existing fertiliser regimes in Sarawak, Malaysian Borneo. Overall N_2O fluxes from plantations on peat were low relative to fluxes reported elsewhere in the literature. This suggests that N inputs were not greatly in excess of plant demand. N_2O fluxes in these plantations was spatially stratified, and influenced by the presence of herbaceous plants, organic residue (excised palm fronds) management and soil moisture availability. N_2O fluxes were enhanced in areas where herbaceous plants or organic residues were present, presumably because the presence of herbaceous plants or excised palm fronds supply labile C and N for nitrification and denitrification. N_2O fluxes were also enhanced in areas of high moisture content (e.g. near drainage ditches), perhaps because greater soil moisture favoured denitrification.

EFFECTS OF LAND-USE CHANGE AND LANDSCAPE CONFIGURATION ON AVIAN FUNCTIONAL DIVERSITY

Graham Prescott[1], James Gilroy[3], Claudia Medina[4], William Foster[1], David Edwards[2]

[1]*University of Cambridge, Cambridge, UK, grahamprescott@gmail.com*
[2]*University of Sheffield, Sheffield, UK*
[3]*University of East Anglia, Norwich, UK*
[4]*Humboldt Institute, Villa de Leyva, CO*

Large-scale conversion of natural habitats to agriculture decreases both species richness and functional diversity, with important implications for the provision of many ecosystem services. To halt these losses of functional diversity, two inter-related key methods have been proposed: (i) allow the expansion of tropical crops only in degraded lands or low production farmlands, and (ii) better configure landscapes to retain functionally diverse habitat that can export benefits to farmland. I focused on birds, which play key functional roles in systems and have well-known functional ecology, and oil palm, which is a rapidly expanding tropical crop known to support less functionally diverse communities than forest. I did so in the Colombian Llanos, a region highlighted for the sustainable development of oil palm, but where two habitats can be converted: forest remnants and semi-natural cattle pasturelands. I assessed the impacts of converting forest remnants and pasture to oil palm on metrics of bird functional diversity, and then determined how these metrics varied according to proximity and amount of forest in the surrounding landscape. Functional richness (a measure of the amount of multivariate trait space in a community) was higher in forest than in pasture, and higher in pasture than in oil palm. Functional evenness (a measure of the regularity with which multivariate trait space is filled) was highest in oil palm. Functional divergence (a measure of the extent to which species with extreme trait values have higher abundance) was lowest in forest but did not differ significantly between oil palm and pasture. Functional dispersion (the abundance-weighted mean distance of species from the centre of trait space) was highest in pasture and lowest in forest. The proportion of forest in a 250 m radius surrounding study points was positively related and distance from forest was negatively related to functional richness in oil palm and pasture. This suggests that retaining forests in agricultural landscapes is important in preventing large losses of functional diversity during forest conversion and might also play a role in maintaining avifaunal functional richness within farmland.

Merian Award Applicant

IMPACT OF LOGGING ON BIRDS AND MAMMALS IN BORNEO: A META-ANALYSIS

David Costantini[1], Mirre J.P. Simons[2]

[1]*Department of Biology, University of Antwerp, Antwerp, BE, davidcostantini@libero.it*
[2]*Department of Animal and Plant Sciences, University of Sheffield, Sheffield, UK*

A key driver of land-use changes in tropical areas is proliferating commercial logging. Recent assessments of biodiversity have shown that tropical logged forests can retain a high richness of species and a high degree of functional diversity. Logged tropical forests are therefore increasingly recognized as a conservation priority. Although the reduction in biodiversity in logged forests is less dramatic than previously thought, it appears evident that some taxonomic groups are more vulnerable to logging than others. We performed a meta-analysis across the available literature to summarize the effect of logging on the abundance of individual bird and mammal species in forests of Borneo. Our work sought to identify which species, class (birds and mammals) and IUCN Red List category are more negatively impacted by logging, while controlling for any effects of the time elapsed since last logging. In addition, we tested whether in birds, cavity breeders suffered more from logging, possibly due to a decrease in potential nesting sites in logged forests. Our meta-analysis shows that (i) species classified by IUCN as 'vulnerable' or 'near-threatened' are generally less abundant in logged forests than those classified as 'least concern', (ii) there is large variation in how 'near-threatened' species are affected by logging, suggesting that some 'near-threatened' species can flourish in logged forests, and (iii) cavity-nesting birds suffer significantly more from logging than species that do not nest inside natural cavities. Moreover, there is large variation in effect size of logging among species with similar ecologies. The results of our study highlight the importance of species-based approaches in identifying which aspects lead species to flourish or suffer in logged forests.

AMPHIBIAN DIVERSITY CHANGE IN DEGRADED HABITATS IN SUMATRA, INDONESIA

André Jankowski[1], Alexander Haas[1], Djoko Iskandar[2], Julian Glos[1]

[1]Universität Hamburg; Biozentrum Grindel & Zoologisches Museum, Hamburg, DE, andre.jankowski@zoologie.uni-hamburg.de
[2]Institut Teknologi Bandung, Bandung, ID

Despite their outstanding importance, tropical forests face severe loss throughout the world. This loss is caused by extensive logging which leads to forest degradation and often large scale landscape conversion into monoculture plantations. Although Indonesia is identified as one of the world's biodiversity hotspots its biodiversity remains poorly studied.

Studies on the impact of disturbance of tropical forest habitats on their biodiversity have shown controversial results depending on the degree and type of landscape alteration. General patterns of disturbance effects on the ecosystem are difficult to identify due to a multitude of variables. It is assumed that tropical forest degradation has generally negative impacts on biodiversity.

We studied the impact of tropical rainforest disturbance on species richness and patterns of assemblage composition using amphibian assemblages as model organisms. We established 48 transects in both stagnant and running waters along a disturbance gradient of tropical lowland forest. We compare species assemblages in pristine forest at Bukit Barisan Selatan National park to selectively logged forests of two different logging regimes at Harapan Rainforest, as well as to monoculture oil palm plantation at Asiatic Persada Company in Sumatra.

In total we recorded 64 amphibian species, some for the first time in this region. We hypothesize that species richness and composition of amphibian assemblages correlates the degree of habitat disturbance in the areas examined.

Merian Award Applicant

SESSION 18

S18 - FOOD WEBS IN TROPICAL LANDSCAPES

Chairs: Michael Staab and Alexandra-Maria Klein
Contact: michael.staab@nature.uni-freiburg.de

DRIVERS OF PARASITISM AND HOST-PARASITOID NETWORKS IN A SUBTROPICAL FOREST

Michael Staab[1], Alexandra–Maria Klein[1]

[1] *University of Freiburg, Freiburg, DE, michael.staab@nature.uni-freiburg.de*

Host-parasitoid interactions are important trophic interactions in terrestrial ecosystems. Parasitoids are crucial regulators of their host species' population dynamics, thus making parasitism an often neglected ecosystem service. While such interactions have been widely studied in agricultural ecosystems, little is known about which environmental factors drive parasitism and host-parasitoid interactions in natural ecosystems. We used cavity-nesting Hymenoptera (bees and wasps) and their parasitoids (various arthropod taxa) reared from reed-filled trap nests as a model system to investigate if and how host-parasitoid interactions were affected by a comprehensive set of biotic (e.g. tree diversity, forest stand age) and abiotic (e.g. elevation) environmental variables. Trap nests were exposed for 14 months in 27 study plots in the highly diverse subtropical forests of South-East China. In total, we collected almost 3000 bee and wasp brood cells belonging to 25 species. Those species were parasitized by 29 species, mainly parasitoid wasps, with an average parasitism rate of 12%. The parasitism rate was negatively related to plot elevation but had a strong positive relationship to increasing tree community evenness. Host-parasitoid interaction networks were always specialized and not related to any environmental variable. In conclusion, our results demonstrate that parasitism rates can be dependent on the diversity and composition of the tree community in forests. Consequently, more diverse forests with a more even tree community may support more abundant and more stable parasitoid populations which in turn may provide better control of pest herbivores. Such knowledge could have implications for forest restoration strategies, particularly in regions where the very species rich original forests have been degraded and reforestation programs are currently under way.

HIGH LOCAL TREE DIVERSITY PROMOTES FUNGAL SPECIES RICHNESS AND SHIELD YOUNG SUBTROPICAL FORESTS FROM FUNGAL INFESTATION

Lydia Hönig[1], Steffen Bien[1], Uwe Braun[1], Helge Bruelheide[1,2]

[1]*Martin-Luther-University Halle-Wittenberg, Halle, DE,*
lydia.hantsch@botanik.uni-halle.de
[2]*German Centre for Integrative Biodiversity Research (iDiv), Leipzig, DE*

Trees in natural forests and plantations are exposed among others to infections by leaf microfungi. These often overlooked organisms are able to harm and weaken their hosts by diminishing photosynthesis and removing nutrients. Since most foliar fungal pathogens exhibit a narrow host range, fungal species richness is expected to accumulate with increasing host tree species in a community. Furthermore, leaf fungi need specific microclimatic conditions to infect a host and to develop within their specific microhabitat. Thus, high local tree diversity around a host tree may offer more heterogeneous microclimatic crown niches and might result in higher fungal species richness. In contrast, high tree diversity is expected to reduce fungal infestation, since fungal transmission is less effective with increasing distance among host individuals and barrier effects by non-host tree individuals.

We analysed leaf microfungi for eight tree species of the BEF-China tree diversity experiment in subtropical Southeast China. Leaf harvest of 40 tree individuals per species has been done in August 2013. Ten leaves per tree individual were macroscopically screened for microfungi, thereby estimating fungus specific infestation per leaf. All fungal species were microscopically determined up to species level if possible.

Statistical models for all tree individuals revealed an accumulation of fungal species with increasing local tree diversity, whereas fungal infestation decreased. In addition to the latter effect, we tested the relationship between local host tree proportion and fungal infestation. We have found such dilution effects, indicating higher fungal infestation in monocultures. However, in general, tree species identity showed the strongest impact on fungal species richness and fungal infestation. Thus, the presence of particular tree species within a forest community seemed to be more effective regarding infection and infestation by leaf microfungi than species diversity per se.

Merian Award Applicant

LAND USE INTENSIFICATION AND LANDSCAPE SIMPLIFICATION REDUCE COMPLEXITY OF PLANT-POLLINATOR INTERACTION NETWORKS IN RICE PRODUCTION LANDSCAPES

Catrin Westphal[1], Svenja Bänsch[1], Mátyás V. Farkas[1], Annika L. Hass[1], Markus Franzén[2], Finbarr Horgan[3], Kong L. Heong[4], Nguyen Van Sinh[5], Hong Thai Pham[5], Josef Settele[2], Teja Tscharntke[1]

[1]Georg-August-University Göttingen, Göttingen, DE, cwestph@gwdg.de
[2]UFZ, Helmholtz Centre for Environmental Research, Halle, DE
[3]International Rice Research Institute (IRRI), Los Baños, PH
[4]Centre for Agricultural Bio Sciences International (CABI), Serdang, MY
[5]Vietnam Academy of Science and Technology (VAST), Hanoi, VN

The structure of plant-pollinator interaction networks can be altered by land use intensification and changes in landscape heterogeneity. However, structural changes in plant-pollinator interaction networks have rarely been studied in relation to land use intensification, in particular with regard to intensified agricultural systems in the tropics. Increasing demand of rice currently leads to intensified rice production with high inputs of agro-chemicals, which affects local biodiversity, species interactions, and potentially ecosystem services. Traditionally, many rice farmers grow animal-pollinated fruits and vegetables in agroforestry systems surrounding their paddy fields and plant-pollinator interactions might be affected by land use changes at local and landscape scales.

We hypothesize that the structure of plant-pollinator interaction networks is changing with local land use intensity and landscape heterogeneity. Local land use intensification and landscape simplification will reduce structural complexity of these networks, potentially deteriorating pollination services provided by bees.

Flower-visiting bees were recorded in 28 agroforestry systems located in 5 rice production regions (lowland and upland (terraced) rice production on the Philippines and in northern Vietnam) representing different levels of local land use intensity and landscape heterogeneity.

Plant-pollinator interaction networks were more complex in heterogeneous landscapes with low intensity of rice production. Increasing land use intensification and landscape simplification lead to simplified plant-pollinator networks. Structural and potentially functional changes in plant-pollinator interaction networks in rice production landscapes can potentially decrease yields and quality of fruits and vegetables that are grown by rice farmers. To conserve plant-pollinator networks in intensified rice production landscapes, local resources (food plants and nesting sites) and landscape heterogeneity need to be restored or conserved.

TROPHIC SHIFTS OF OMNIVOROUS ANTS ALONG ENVIRONMENTAL GRADIENTS IN TROPICAL AGROFORESTRY

Pierre Gras[1], Teja Tscharntke[1], Yann Clough[2]

[1]*Agroecology, Department of Crop Sciences, Georg-August University of Göttingen, Göttingen, DE, pgras@gwdg.de*
[2]*Centre for Environmental and Climate Research, Lund University, Lund, SE*

Tropical agroforests host abundant and highly diverse insect communities, which are usually dominated by ants. Many omnivorous ants feed honeydew or plant saps for carbohydrate gain, but consume arthropods to gain nitrogen. The carbon vs. nitrogen resource-use of ants can vary with species-identity as well as plantation management or landscape context. At community level, the ant species assemblage may change along environmental gradients, and thereby the relative importance of the ants' carbon vs. nitrogen-use. We hypothesize that both, ant community composition and resource-use of single ant species change along gradients such as decreasing canopy cover (plantation management), and increasing distance to rainforest margins (landscape context). We used stable isotope analyses ($\delta^{15}N$, $\delta^{13}C$) to quantify resource-use, and found that trophic interactions depend on both gradients. At ant community level, species turnover as well as trophic plasticity of abundant and competitively strong omnivorous species (e.g. *Anoplolepis gracilipes*) preserved ecological functioning of the ant communities over both gradients. However, trophic positions ($\delta^{15}N$ signature) of subdominant omnivorous ant species (e.g. *Tetramorium pacificum*, *Polyrhachis dives*, *Camponotus reticulatus*, and *Monomorium floricola*) dropped under intensive management (low canopy cover) or far from rainforest margins. These intensively managed or remote located habitats usually host less arthropods. Moreover, subdominant ants used vegetation other than the predominant crop (*Theobroma cacao* L.) for carbon gain ($\delta^{13}C$), possibly to avoid competition. In a wider context, omnivorous and dominant ant species seem to be able to stabilise trophic functions of predator communities in disturbed habitats which are less suitable for many other predator species.

Merian Award Applicant

UNMASKING THE TROJAN HORSE: LEAF-CUTTING ANTS LEARN THE GROWTH-INHIBITORY EFFECTS OF HERBIVORE INDUCED PLANT VOLATILES ON THEIR SYMBIOTIC FUNGUS

Daniela Marenco Hurtado[1], Flavio Roces[2], Christian Kost[3], Rainer Wirth[1]

[1]Department of Plant Ecology and Systematics, University of Kaiserslautern, Kaiserslautern, DE, daniela_marenco@yahoo.com
[2]Behavioural Physiology and Sociobiology, Biocenter, University of Wurzburg, Würzburg, DE
[3]Department of Bioorganic Chemistry, Max Planck Institute for Chemical Ecology, Jena, Jena, DE

Despite decade-long research efforts, the mechanisms underlying food choice in leaf-cutting ants (LCAs) are still not entirely understood. While recent studies have provided evidence for odor-based avoidance learning of LCAs towards plant-emitted volatile defense, the precise role of the fungus in avoidance learning is still unclear. According to theories of antagonistic coevolution,LCAs should be able to identify substances that are harmfulto their fungus without previous experience. However, naïve LCAs do not reject induced leaves, although their emitted herbivore induced plant volatiles (HIPVs) seem to inhibit fungal growth. Therefore, we established the following "masking hypothesis": Simultaneously produced diverse plant volatiles mask each other, affecting the foraging preferences of LCAs. To investigate this, we performed dual choice assays with Acromyrmex ambiguus foragers, using an artificial blend of the lima bean volatiles (Phaseolus lunatus) and the blend´s single compounds. Furthermore, some of the HIPVs (cis-Jasmone, Ocimene) and the HIPV-mix were tested for growth-inhibitory effects on in vitro isolates of the fungal symbiont. HIPVs moderately to severely inhibited the growth of the fungus, and some of them limited gongylidia formation. Naïve LCA rejected HIPVs that were harmful to the fungus, while they accepted the also harmful HIPV-mix, supporting our "masking hypothesis". However, after three days of experience, foragers were able to unmask some compounds within the HIPV-mix, changing their response towards them, going from rejection to acceptance or reinforcing the rejection. We demonstrated for the first time that harmful substances are masked by high variable plant emissions, driving naïve foragers to accidentally carry a "Trojan Horse" full of fungal growth-inhibitory HIPVs into their fungus garden. The ants´ ability to change their foraging preferences might enable them to cope with the great variety of HIPVs in their diverse environment. Our findings contribute to a better understanding of avoidance learning and of the interaction between LCAs and their symbiotic fungus.

Merian Award Applicant

OPTIMAL FORAGING BEHAVIOUR IN THE TERMITE HUNTING ANT SPECIES MEGAPONERA ANALIS

Erik T. Frank[1], K. Eduard Linsenmair[1]

[1]*University of Würzburg, Würzburg, DE, erik.frank@uni-wuerzburg.de*

The termite hunting ant species *Megaponera analis* is well known for forming highly ordered march columns while approaching and returning from a potential termite feeding site. These raids occur 2-4 times a day and are always initiated and led by a scout ant that previously found and inspected the feeding site. Since there is a large variation in the number of ants participating in a raid (200-600 ants) it was hypothesized that some sort of optimisation is present in their raiding behaviour, which could potentially be explained by optimal foraging theory. During this study, conducted in the Comoé National Park (North-eastern Ivory Coast), a clear positive relation between distance, raid size, time spent at the feeding site and termites gathered could be shown. This supports central place foraging theory, in particular the central place prediction hypothesis and the marginal value theorem. Since the scout ant is the only ant with qualitative and quantitative information about the feeding site before the raid takes place, it has to be able to assess and pass on vital information about the feeding site to the rest of the colony, so that the appropriate raid can be initiated. Further optimisation occurs in the work division during the raid, in which there is a clear exponential relation between majors and minors carrying back termites, with majors being normally responsible for this task and minors only starting to contribute when the majors are oversaturated with termites. This plasticity in the work division makes sense, since majors are able to transport larger loads more economically when compared to minors. Ultimately there seems to be a high degree of optimisation present in the foraging behaviour of *M. analis*, which helped them survive in such an extreme habitat while hunting such well-defended prey.

SWEAT BEES ON HOT CHILIES: POLLINATION SERVICES PROVIDED BY NATIVE BEES IN SLASH-AND-BURN TROPICAL AGRICULTURE IN YUCATAN, MEXICO

Patricia Landaverde-Gonzalez[1], Tomás E. Murray[1,2], J. Javier Quezada-Euán[3], Pangiotis Theodorus[1], Robert Paxton[1]

[1]*Martin-Luther Universität, Halle-Wittenberg, Halle (Saale), DE, patylandavr@yahoo.com.mx*
[2]*National Biodiversity Data Centre, Waterford, IE*
[3]*Department of Tropical Apiculture - Universidad Autonoma de Yucatan, Mérida, MX*

The Yucatán Peninsula has a history of approximately 2000 years of rotational tropical agriculture, known in this region as 'Milpa', the traditional Maya slash-and-burn form of subsistence agriculture. However, the potentially detrimental impact of this system of agriculture for biodiversity and ecosystem service provision has rarely been evaluated. Habanero chilli is one of the main crops and important products of this tropical agricultural ecosystem; chilli requires pollination to set fruit and is therefore dependent upon provision of the ecosystem service of pollination. Previous studies have determined the diversity of flower visitors and their efficiency as pollinators of habanero chilli and suggested that bees play the most important role, in particular small species like sweat bees and stingless bees. However, little is known about the interactions between bee species composition, pollination service provision (PSP) and environmental variables such as land cover that are a consequence of Milpa agriculture.

Here, we study 21 agro-ecosystem sites to evaluate the effect of land use on bee community composition. Within these sites, 11 were chosen to test the provision of pollination services and their relation with land use and bee community composition using causal modelling. We found a strong negative influence of habanero crops on the community composition of bees, suggesting that Milpa agriculture plays an important role in shaping bee species composition and distribution. In contrast to other bee species, *Lasioglossum* (*Dialictus*), a subgenus of sweat bee, seems to be the most abundant and most probable pollinator of chilli that apparently takes advantage of the resources provided by chilli crops and thus is not negatively impacted by Milpa agriculture. Yet because other important bee pollinator species, such as members of the Apidae, show a positive response to other land use variables, particularly forest, special attention should be taken to conserve the diversity of land, particularly forest, around crops for the sustainable provision of pollination services to other crops and wild plant species.

ANT-REPELLING POLLINATORS OF THE ANT-PLANT MACARANGA WINKLERI (EUPHORBIACEAE)

Eri Yamasaki[1], Yoko Inui[2], Shoko Sakai[3]

[1]*Institute of Evolutionary Biology and Environmental Studies, University of Zurich, Zurich, CH, eri.yamasaki@uzh.ch*
[2]*Department of Arts and Sciences, Faculty of Education, Osaka Kyoiku University, Osaka, JP*
[3]*Center for Ecological Research, Kyoto University, Otsu, JP*

Many plants have mutualistic relationships with ants: they provide foods and/or nesting sites for the symbiotic ants and the ants in turn protect the host plants by excluding herbivores. While the ants are useful as guards, they may negatively affect host reproduction by excluding pollinators. To prevent pollination interference by ants, many plants have evolved diverse strategies for deterring ants from their flowers by modifying their own characters. Among these are ant-repelling floral chemicals, toxic nectar, slippery waxy shoots, and so on. Here we studied this potential conflict in the ant-plant *Macaranga winkleri* (Euphorbiaceae) pollinated by thrips *Dolichothrips* sp. Ant-exclusion experiment on inflorescences revealed that thenumber of pollinator thrips did not differ between in the presence or absence of ant guards. When the guard ants encountered pollinator thrips, the ants often escaped from the thrips. In many of the cases pollinator thrips raised their abdomen and produced droplets from their anuses. Chemical analysis and behavioural experiments confirmed that one of the constituents, n-decanoic acid, have ant-repelling effects. This is the first report of insect pollinators repelling guard ants to perform pollination, and it is a novel strategy of host plant to avoid pollination interference by ant-guards in ant-plant mutualism. The acquisition of a pollination system resistant to ant attacks may have predisposed the evolution of ant-plants in the genus *Macaranga*.

SESSION 19

S19 - MANGROVE CONSERVATION

Chair: Martin Zimmer
Contact: martin.zimmer@zmt-bremen.de

MANGROVE CRABS VULNERABILITY TO CLIMATE CHANGE

Marco Fusi[1], Folco Giomi[3], Simone Babbini[2], Daniele Daffonchio[1], Christopher McQuaid[4], Francesca Porri[5], Stefano Cannicci[2]

[1]KAUST King Abdullah University of Science and Technology, Thuwal, SA, marco.fusi@kaust.edu.sa
[2]Department of Biology, University of Florence, Florence, IT
[3]AWI, Bremerhaven, DE
[4]Rhodes Univeristy, Grahamstown, ZA
[5]SAIAB, Grahamstown, ZA

Rapid climate change has a strong impact on marine ecosystems, through warming, acidification and hypoxia of sea water. Marine ectotherms are mostly affected by changes in temperature, which directly influences oxygen availability and the ability to utilise oxygen affecting their overall fitness. As a consequence, understanding the thermal response of organisms is crucial to forecast the effects of climate change on ecosystem functionality. Here we focus on the thermal tolerance of adult males of four key stone species inhabiting the east African mangroves: The bimodal crab P*erisesarma guttatum*, *Neosarmatium africanum* (Sesarmidae) and *Uca urvillei*, (Ocipodidae) and the swimming crab *Thalamita crenata* (Portunidae). In order to assess their sensitivity to environmental stressors across a wide latitudinal gradient, we studied the physiological performance of Kenyan and South African populations of the species. The metabolic rate and haemolymph oxygen saturation were measured in the laboratory along a temperature ramp (17-37 °C) in water and in air. Additionally, we characterised the environmental temperature range which the animals are subjected and their behaviour. In order to evaluate the species sensitivity, we fit the environmental data with the thermal model constructed by our experiments. The results show different responses for the species illustrating a very diverse resilience along such latitudinal gradient. Sesarmid crab are resulted the most physiologically weak to stressor such the temperature and this is likely to lead to a loss of fitness with serious consequences for the persistence of such populations and the overall mangrove ecosystem functioning, since their fundamental role. Ocypodid crabs instead reveal a stronger resilience to changes and exhibit a behaviour closely related to tidal cycle. Portunids crabs instead seem well adapted to the extreme condition with stable physiological response to harsh condition. In this study we highlighted the complex and multiple macrobenthos response to climate change, providing baseline data for future prediction in mangrove modelling and management.

OCCURRENCE OF WIDE RANGING INSECT INFESTATION ON THE PIONEER MANGROVE SONNERATIA ALBA J. SMITH ALONG THE KENYAN COAST.

Elisha Mrabu[1,2,5], Elisabeth M.R. Robert[2,6], Ingo Lehmann Lehmann[3], Esther Kioko[4], Jared O. Bosire[1], Noah Mansinghe[1], Farid Dahdouh-Guebas[2,5], Nico Koedam[2]

[1]*Kenya Marine and Fisheries Research Institute, P.O. Box 81651,, Mombasa, KE, elishamrabu@gmail.com*
[2]*Laboratory of Plant Biology and Nature Management (APNA), Vrije Universiteit Brussel, Pleinlaan 2, B-1050 Brussels, Belgium., Brussels, BE*
[3]*University of Bonn, Zoological Research Museum Alexander Koening (ZFMK) Adenauerallee 160, 5311 Bonn, Germany., Bonn, DE*
[4]*National Museums of Kenya (NMK), P.O. BOX 40658-00100, Nairobi, Kenya., Nairobi, KE*
[5]*Laboratory of Systems Ecology and Resource Management, Département de Biologie des Organismes, Université Libre de Bruxelles -ULB, CP 169, Avenue Franklin D. Roosevelt 50, CPI 264/1, B-1050 Brussels, Belgium., Brussels, BE, elishamrabu@gmail.com*
[6]*Royal Museum for Central Africa (RMCA), Laboratory for Wood Biology and Xylarium, Leuvense-steenweg 13, 3080 Tervuren, Belgium., Brussels, BE*

Insect infestation is an understudied problem in mangrove ecology and management. In Kenya, *Sonneratia alba* is an important fringe-forming pioneer mangrove species, usually occurring along the waterfront in diverse mangrove settings. Insect infestation of *S. alba* results in dying branches or trees, sometimes killing entire sections within a mangrove. This research aimed to confirm the identity of the pests infesting *S. alba* and to record the extend of the insect infestation on *S. alba* in Kenya. A trap was devised to catch emergent insect followed by laboratory rearing of larvae and pupae in order to identify the pest insects. A survey of 9 sites was conducted noting the presence or absence of the infestation along the *S. alba* zone. The percentage of insect infestation in two sites was quantified which had been reported to have two different insect infestations. Taxonomic identification done by National Museums of Kenya and the Zoological Research Museum Alexander Koening Germany identified the adult insects as *albicilia* sp. The genus of this species is currently undescribed. The beetle was identified as *Bottegia rubra*. The survey showed that *albicilia* sp. infects *S. alba* in the entire coastal strip with an exception of two sites. In contrast *B. rubra* appeared in low densities in the south coast, but in high density in some sites in the north and as the only woodborer on *S. alba* in the two sites. Infestation level was 18 % in Gazi Bay and 25% in Mida Creek. Results suggest *B. rubra* is expanding its habitat range southwards. Conservation and management efforts need to focus on *B. rubra* which is more mobile and kills all branches that it infects. *B. rubra* infests young *S. alba* trees in plantation thus posing a threat to reforestation efforts.

HOW TO GUARANTEE SUFFICIENT WATER TRANSPORT IN MANGROVE TREES IN THE CHALLENGING CONDITIONS OF THE INTERTIDAL ZONE?

Elisabeth M.R. Robert[1,2], Silvia Lechthaler[1], Nathalie Tonné[1], Jorien Oste[1], Nico Koedam[1]

[1] *Vrije Universiteit Brussel, Brussel, BE*
[2] *Royal Museum for Central Africa, Tervuren, BE*

A mangrove tree copes with roughly all demands a tree water transport system could possibly be challenged with: high salt concentration in the soil water, making water uptake difficult, a tropical climate with high temperature and high relative air humidity, thwarting the atmospheric pulling needed for water transport, high solar radiation, requiring dissipation of excess energy through evaporation, and an extreme dynamic in these environmental variables, asking for a set of adaptations in order to guarantee continued water supply to the tree's internal tissues. We found that closely related Rhizophoraceae seedlings have different internal development patterns related to their location in the mangrove forest. In addition, their hypocotyl and leaves have buffering capacity allowing internally stored water to support the transpiration flow. When compared to their respective sister taxa, mangrove tree species of all families show numerous small water conducting vessels, known to safeguard water transport when air enters the system. Within the mangrove forest, *Avicennia* appears to be the genus that can cope with the extreme of the extremes due to its high proportion of internal living tissue and its particular way of growing (patchy growth through successive cambia). Overall, we can conclude that the water transport system of mangrove trees is highly adapted to the environmental conditions within the mangrove forest and to the temporal and spatial variations in these conditions. Since not every mangrove tree has the flexibility to adapt its water transport system to all possible within-mangrove forest environments, the water relations of mangrove trees need to be taken into account for protection and conservation actions.

DISPERSAL LIMITATION OF AVICENNIA MARINA AMONG DEEP INLETS OF SOUTH AFRICAN COASTLINE IN CONTRAST TO HIGH CONNECTIVITY AMONG EAST AFRICAN MANGROVES

Dennis De Ryck[1,2], Nico Koedam[1], Tom Van der Stocken[1,2], Rosa van der Ven[1], Janine Adams[3], Ludwig Triest[1]

[1]*Vrije Universiteit Brussel, Brussels, BE, dennis.de.ryck@gmail.com*
[2]*Université Libre de Bruxelles, Brussels, BE, dennis.de.ryck@gmail.com*
[3]*University of Port Elisabeth, Port Elisabeth, ZA*

Understanding the genetic composition and dynamics of mangrove species along a latitudinal range, could provide insight as to how their biogeographical range evolved. In this study we investigate the genetic composition of the widespread mangrove species *Avicennia marina* in its core region and southern range limit along the East African coast.

We hypothesized that we would find a panmictic signature in the core region and a genetically depauperate and dispersal-limited situation at the southern range limit due to the geographical location and coastal geomorphology.

A total of 388 *A. marina* individuals from six sites in Kenya and Tanzania (core region) and six at the southern range limit in South Africawere sampled and genotyped for eight microsatellite loci. Genetic diversity and structure was inferred from several allele-frequency and genotypic analyses.

A high genetic differentiation was found within and between the core and range limit populations. Comparisons between the core region and range limit highlighted significant lower genetic diversity and higher genetic structure at the range limit. *A. marina* showed strikingly high between as well as within population inbreeding with consequent high fixation and very low heterozygosity of alleles.

Our study demonstrates more inbreeding and lower genetic diversity at the range limit as compared to core populations. Despite the fact that *A. marina* propagules may have the capacity to disperse between populations, the gene flow was found to be moderate to high within the core populations and extremely low within the range limit populations. This study provides a remarkable example of a genetically depauperate situation in peripheral populations, most likely as a consequence of historical epic arrival of founders with subsequent inbreeding/dispersal limitation due to the coastal geomorphology. The dynamics of South African coastal water bodies and their connectivity to the ocean strongly depend on both natural events and on management of the respective catchments (e.g. increasing siltation). The insight gained from the genetic structure of the predominant mangrove species in this area indicates that at the range limit of this important ecosystem land management may exacerbate natural genetic impoverishment.

MAPPING OF THE BRAZILIAN MANGROVE FOREST WITH ENVIRONMENTAL DRIVERS

Arimatéa Ximenes[1,2], Nico Koedam[2], Farid Dahdouh-Guebas[1,2]

[1]*Université Libre de Bruxelles, Brussels, BE, adecarva@ulb.ac.be*
[2]*Vrije Universiteit Brussel, Brussels, BE, adecarva@ulb.ac.be*

Identification and delineation of geographic areas which comprise similar environmental drivers to structure biota and communities have been facilitated by computational developments in pattern recognition and classification algorithms. This paper presents a methodology for selection of variables and mapping of mangrove ecological regions. The regions are identified based on a Self-Organizing Map (SOM) neural network that is initially configured to work over a set of 23 variables, including 19 bioclimatic variables, 3 derivates of sea surface temperature, and salinity. The correlations between variables are identified based on PCA ordination analysis and a reduced set of variables are chosen.

The Brazilian mangroves under study comprise the full latitudinal range from the northernmost coastal state Amapá to the Southern state of Santa Catarina. Hence the study covers a 6786 km with approximately 25,000 km^2 of mangrove forests (50% of South America's mangroves). Santa Catarina is the latitudinal limit of mangroves along the Atlantic coast of South America. The mangrove map is converted into points that represent the location of mangrove forests totaling 390 points and representing all mangrove locations. The k-means algorithm is used for identification of the clusters.

A mangrove ecological regions map is drafted with a reduced set of variables (minimum sea surface temperature, precipitation seasonality and salinity). The methodological approach shows to be consistent with several available maps and can be reproduced over different areas. We intend to extend and improve this methodology in order to map the global structure of mangrove biogeographical areas from an ecological point of view.

MIND THE GAP: MANAGING CROSS-ECOSYSTEM FLUXES AS KEY FOR PRESERVING AND RESTORING TROPICAL COASTAL SEASCAPE.

Lucy Gwen Gillis[1,2], Clive G Jones[4], D van der Wal[2], AD Ziegler[3], Tjeerd J Bouma[2]

[1]Leibniz-Zentrum für Marine Tropenökologie GmbH, Bremen, DE,
lucy.gillis@zmt-bremen.de
[2]Royal Netherlands Institute for Sea Research (NIOZ), Yerseke, NL,
lucy.gillis@zmt-bremen.de
[3]University of Singapore, Singapore, SG
[4]Cary Institute of Ecosystem Studies, New York, US

Ecosystem engineers within key coastal ecosystems can have spatially extended positive influence on adjacent ecosystems, and this would generate reciprocal relationships between adjacent engineering ecosystems. These positive interactions originate from so-called engineering-donor ecosystems that modify the physical environment. Modifications can be achieved by a reduction of wave height or sediment and nutrient concentrations, and is important for the persistence and establishment of recipient ecosystems. Hence, such positive interactions at the landscape scale should be included in successful management schemes and in the creation of ecosystems for coastal defence purposes. Thus, they should be a key focus for environmental monitoring. In practice, this means that management programs should include assessment of (1) the strength of the flux from the engineering-donor to the recipient ecosystems, and (2) the habitat modification by the engineering-donor in order to detect in what situation they can control fluxes. If monitoring shows that ecosystem engineers are so degraded that they cannot alter physical fluxes, restoration efforts may be more beneficial at larger scales, when specifically aimed at those ecosystem engineers that rapidly change specific physical/chemical fluxes. Hence it is possible to specifically indicate fast growing engineering species as target for restoration, as they could quickly fulfil physical functions for other habitats. We present a conceptualised outline of parameters that should be monitored for landscape-scale based management and we suggest novel methods suitable for such monitoring in addition to providing recommendations for restoration of specific species. Thereby presenting a promising opportunity to use the physical aspect of ecosystem engineers for efficient preservation towards the restoration of a highly connected seascape.

MANGROVE CONSERVATION FOR LOCAL COMMUNITIES: A CASE STUDY TO ESTIMATE THE VALUE OF MANGROVE-ASSOCIATED FISHERY RESOURCES

Gesa Dickhof[1], Claudia Raedig[1], Sabine Schlueter[1]

[1]*Cologne University of Applied Sciences, Cologne, DE, gesa.dickhof@fh-koeln.de*

Mangrove forests are providing a wide range of ecosystem services (ES) like the protection of coastal zones from tsunamis or the provision of breeding grounds and habitats for fish or shrimps. At the same time, mangrove forests are being lost at drastic rates worldwide. While their importance and value has already been acknowledged, the prospect of success of conservation efforts will remain low, as long as legislative support is missing or economic loss of the local communities at stake. While several studies have already been conducted on the value of the protective function of mangroves, this study focuses on the value of fishery resources associated with mangrove with a focus on local economies.

The study was carried out in the province of Bac Lieu, Vietnam, where mangroves are highly threatened by expansion of aquaculture as well as coastal erosion. Data were acquired in a rapid assessment approach using a combination of household interviews and satellite image analysis. In contrast to other studies, this study did not only rely on statistical data but was, amongst others, based on actual catch sizes while taking into account all kinds of aquatic resources – not only fish or shrimp. While the main focus of the study was, to derive estimates for the monetary value of this specific ES of mangroves, further objectives of the study were to highlight the importance of fishery resources for local communities.

With values found in the upper range of comparable studies, this study undermines the significance of protecting mangrove forests for the benefits of local communities and at the same time for biodiversity conservation. It furthermore highlights the importance of finding consistent and reliable ways to value ES as well as to include more ES that are provided by an ecosystem which then could serve as a more integrating and powerful argument for mangrove protection.

SCIENTIFIC POSTER SESSION – ABSTRACTS

SILVICULTURAL INTERVENTIONS IN A TROPICAL MOUNTAIN FOREST IN SOUTHERN ECUADOR - DYNAMICS OF TREE REGENERATION

Johana Muñoz[1], Patrick Hildebrandt[1], Sven Günter[2], Bernd Stimm[1], Michael Weber[1], Reinhard Mosandl[1]

[1]*Institute of Silviculture, Technische Universität München, Freising, DE, johanaec@gmail.com*
[2]*Thünen Institute of International Forestry and Forest Economics, Hamburg, DE*

Tropical mountain forests contain a high biodiversity and provide a variety of ecosystem services. However, they are also affected by unsustainable management, degradation and land use change. Therefore, concepts for sustainable management are urgently needed but little is known so far about the dynamics of tropical mountain forests and the impacts of management activities.

In 2004, a silvicultural experiment has been installed on an area of 13 ha in the tropical mountain forest of Southern Ecuador. Promising individuals of selected tree species have been released from their competitors in order to investigate the effects on the individual increment and stand dynamics. Moreover, improved light conditions are supposed to enhance the regeneration of trees and the development has been monitored over a period of ten years on 255 plots (2 x 2m) within the experimental area.

In general, the results show an increased abundance of tree regeneration after management activities, especially for different species of the genera *Inga* and *Miconia*. Other species like e.g. *Schefflera* sp. or *Dictyocaryum lamarckianum* showed a reduced abundance over time. However, no effects on the diversity of species have been detected and the increment rates (height and basal diameter) of tree regeneration have been positively affected by silvicultural treatments.

THIRTY YEARS AFTER SELECTIVE LOGGING DISTURBANCE: ARE LOGGING IMPACTS STILL VISIBLE ON ANURANS AND THEIR HABITAT?

Gwendolyn Landburg[1]

[1]*Martin Hermy, Leuven, BE, g.landburg@uvs.edu*
[2]*Bart Muys, Leuven, BE*

Selective or reduced-impact logging in natural forests has proven to impact anuran community species composition negatively on the short term, but little is known about the effect of past logging activities on the long term. This study analyzed the species composition of an anuran community, forest structure and vegetation composition in selectively logged tropical rainforest plots in Suriname using the CELOS Management System after approximately 30 years of recovery. We predicted that (1) after a recovery period of approximately 30 years, the forest conditions in the experimentally logged plots are similar to the forest conditions in the control plots, reflecting similar habitat conditions for anurans, and that (2) the anuran diversity resembles that of the pre-logging state. A total of six plots were selected, three in an experimentally logged forest block and three in undisturbed forest, where the undisturbed forest was assumed to reflect the conditions of the experimentally logged forest block prior to logging. In these plots forest structure and vegetation composition, which dominantly make up anuran habitat, were measured, as well as the diversity and composition of the anuran communities.

Forest structure variables recorded included litter cover, vegetation density in different strata, canopy openness, dbh distribution and palm abundance, while vegetation composition was assessed in trees, saplings and seedlings. A comparison in tree diversity between assessments carried out just after logging in 1983, seventeen years after logging in 2000 and twenty-nine years after logging in 2012 was also made. Anurans were surveyed by standardized transect walks during day and night.

Significant differences in vegetation density and palm abundance between logged and control plots were found. Also non metric dimensional scaling showed differences in tree composition between logged and control plots and differences in tree composition between 1983, 2000 and 2012. Differences in anuran diversity between logged and control plots could not be detected and also no correlation could be found between anuran diversity and vegetation diversity. This indicates that even though habitat requirements for anurans have not recovered to the state of the control plots, the anuran community in the logged plots have adapted to the changed forest conditions over time.

IMPACTS OF GRAZING ON BIODIVERSITY AND STAND DYNAMICS OF ECUADORIAN DRY FORESTS

Jorge Cueva[1,2], Carlos Ivan Espinosa[2], Patrick Hildebrandt[1], Bernd Stimm[1], Michael Weber[1], Reinhard Mosandl[1]

[1]*Institute of Silviculture, Technische Universität München, Freising, DE*
[2]*Departamento de Ciencias Naturales UTPL, Loja, EC*

Dry forests are among the most threatened tropical ecosystems worldwide. The Tumbesian dry forest is considered to be one of the most biodiverse ecosystems in the world but it is also affected by land use change and conversion to e.g. crop lands. For this reason, suitable forest management strategies are needed, which are able to provide income and take into account the effects of silvicultural interventions on species diversity or contain biodiversity forcing measures. Currently, the Tumbesian dry forests are mainly used for production of Non Timber Forest Products (NTFPs) or for goat grazing, both affecting their structure and biodiversity.

Installations of terrestrial sample plots in two different forest types (deciduous and semi-deciduous) and three different intervention levels are used in this study in order to assess the impact of grazing on the diversity of vascular plants and stand dynamics. 72 plots of 60m x 60m are used to identify different stand structures, each plot including smaller fenced and unfenced areas (20m x 20m) for monitoring of tree regeneration under natural and disturbed conditions. First results are expected to provide an insight on the impact of grazing on the current status of both forest types.

THE ECOLOGICAL STATUS OF THREE SPECIES OF PRIORITY NON TIMBER FOREST PRODUCTS AROUND THE LOBEKE NATIONAL PARK IN CAMEROON.

Gusua Roseline Caspa[1], Isaac Roger Tchouamo[1,2], Jean Pierre Mate Mweru[1], Mbang Joseph Amang[1]

[1]*ERAIFT, Kinshasa, CD, rcgusua@gmail.com*
[2]*University of Dschang, Dschang, CM*

Non timber forest products (NTFPs) are very important for the livelihood of most human communities in forest areas. They are sources of food, income, medicine, building materials and also have cultural and spiritual values. When the monetary value of NTFPs increases, their exploitation tends to be more intense. This study aimed at assessing the status of the resource base of *Irvingia gabonensis*, *Ricinodendron heudelotii* and *Gnetum buchholzianum* in three forest systems including agroforest (active farm land/fallow), production forest (community forest) and protected area. An inventory was carried out in six hectares per forest system making a total of eighteen hectares. Data was analyzed using the SAS statistical package Version 9.0, with the General Linear Model Procedure (GLM) and the Student-Newman-Keuls test to separate the means. There was no significant difference in the diameters at breast height (DBH) of *I. gabonensis* trees in all forest systems. More *I. gabonensis* trees were observed in the agroforest and protected area unlike in the production forest although the difference was negligible, with a density of 3.6 trees per hectare. There was also no significant difference in the mean number of fruits produced by *I. gabonensis* trees in all forest systems. There were more trees of *R. heudelotii* in the production forest and agroforest than in the protected area but there was no significant difference in mean DBH of *R. heudelotii* trees in all forest systems. R. heudelotii had a density of 3.4 trees per hectare overall. Mean number of fruits was significantly higher for trees in the agroforest than for those in the production forest and protected area. A significantly higher number of *G. buchholzianum* vines was observed in the production forest than in the agroforest and protected area while the growth of *G. buchholzianum* seedlings were significantly lower in the agroforest than in the protected area and production forest which showed no significant difference. The presence of mostly productive individuals of *I. gabonensis* and *R. heudelotii* is an indication that the resource will be available for some time but the near absence of younger individuals is unfavorable for the perpetuity of the species. It is recommended that the local population be sensitized on the importance of domesticating these species and trained on appropriate techniques to propagate and incorporate them into suitable agro systems.

Key words: Resource base, *Irvingia gabonensis, Ricinodendron heudelotii, Gnetum buchholzinum*, Forest system

Merian Award Applicant

HOW TO ACHIEVE EFFECTIVE PARTICIPATION OF FOREST COMMUNITIES IN REDD+ MECHANISM IN THE DEMOCRATIC REPUBLIC OF CONGO: CASE OF MEASUREMENT-REPORTING-VERIFICATION (MRV) PROCESS

Joëlle MUKUNGU[1]

[1] *University of Freiburg, Freiburg, DE, joellemukungu@yahoo.fr*

The Democratic Republic of Congo (D.R.Congo) has a forest area estimated at about 155 million hectares, which represents up to 61% of the entire Congo Basin forest area. More than 70% of the population of the country depend on forests for their survival and livelihoods. Through the Reducing Emissions from Deforestation and forest Degradation (REDD+) mechanism, the D.R.Congo has committed to manage its rich forest resources sustainably and reduce poverty, as stated in the second generation document of the Growth and Poverty Reduction's strategy (DSRP2). With its REDD+ frawork strategy presented at the COP 18 in Doha, the D.R.Congo enter in the second phase of the REDD+ process (the investment phase). There are already several pilot projects on the ground to implement the frawork strategy, and thus acheive the emission reduction in the country.

The United Nations Framework Convention on Climate Change (UNFCCC) encourages the participation of all stakeholders, including local communities in all REDD+ activities including monitoring and reporting. But up to now, there is limited knowledge of the role of local communities in the Measuring, Reporting and Verification mechanism (MRV) in the D.R.Congo. The particular aim of this project is to carry out a case study in two REDD+ project's regions in order to investigate the role of local communities in the implementation of the MRV of carbon in the D.R.Congo : the REDD + pilot project around the Luki Biosphere Reserve in the province of Bas-Congo to the southwest of the D.R.Congo, as well as the "Integrated Logged IFM to Conservation Concession" project, in the territory of Inongo, district of Mai-Ndombe in the province of Bandundu. The common point of these two projects is the fact that they host within them and around them, communities most of which are poor and still largely dependent on the forest for their survival (agriculture, non-timber forest products, pharmacopoeia ...). It is expected that a participation guide on MRV practices will be designed on the basis of the research findings, as a tool for ecosystem management transformation in the interest of local communities".

ABUNDANCE AND WATER USE OF EVERGREEN AND DECIDUOUS TREES IN A DRY FOREST OF SOUTH ECUADOR

Philipp Butz[1], Hannah Bettac[1], Eduardo Cueva[1], Dirk Hölscher[1], Sophie Graefe[1]

[1]*Georg-August-Universität, Göttingen, DE*

Tropical dry forests are characterized by a distinct dry season and low annual rainfall volumes. Deciduous trees are the predominant phenological type encountered, but to a certain degree also evergreen tree species occur. Small scale environmental differences along altitudinal gradients may influence the abundance of evergreen tree species, as well as the associated tree water use for transpiration. Such differences plus some fluctuations in rainfall may be indicative for changes in the forest water cycle associated with climatic changes. In a dry forest of South Ecuador we assessed the abundance of evergreen tree species along an altitudinal gradient and quantified tree water use rates of an evergreen and a deciduous species from the early to the advanced dry season. By means of line transect sampling from 600 to 1200 m asl. the abundance of evergreen tree species was recorded. In total nine evergreen species were found, and their abundance increased with increasing altitude. The dominant species at lower altitudes was *Capparis scabrida*, whereas at higher altitudes *Geoffroea spinosa* was most prevalent. We think these changes are due to environmental differences, e.g. more foggy conditions at higher altitudes. However, the abundance of deciduous trees was much higher than that of evergreen trees at all elevations studied. At mid-elevation, sap flux was measured with thermal dissipation probes on the evergreen species *Capparis scabrida* and the deciduous species *Ceiba trichistandra*. For the evergreen species, there was little to no difference in water use between the early and the advanced dry season. In contrast, the deciduous species *Ceiba trichistandra* reduced water use for transpiration by leaf shedding. However, a short intermittent rain spell of 26 mm in 8 days led to the flushing of new leaves for about 10 days and consequently also a pronounced increase in tree water use. In conclusion, we think that monitoring the tree leaf phenological characteristics along with measurements of tree water use can reveal even subtle changes in moisture availability, and thus may have indicative value for an assessment of possible impacts of climatic changes on characteristics of the hydrological cycle in a dry forest. This seems particularly interesting as leaf phenology can be assessed by remote sensing.

EVAPOTRANSPIRATION MEASUREMENTS IN THE MOUNTAIN TROPICAL FOREST

Paulina Alava[1], Brenner Silva[1], Jörg Bendix[1]

[1]*Marburg University, Marburg, DE, alavanun@staff.uni-marburg.de*

Evapotranspiration (ET) is an ecosystem function which is related to the healthy state of vegetation. As the environment changes there is a need to understand what can be aplied for monitoring environmental change effect. Thus, ET might be used as an indicator for operational monitoring of ecosystems status in the tropical Andean forest of Ecuador. Remote sensing techniques and Geographical Information Systems have facilitated ET estimations. For instance band combinations which relate spectral characteristics of vegetation known as Vegetation Indexes (VIs) have been integrated to calculate ET rate. Glenn et al. (2011) use VIs in relation to reference evapotranspiration (ET0) in order to estimate ET. This approach has been applied in this research by using the Enhanced Vegetation Index (EVI). EVI correlates the properties of the Near Infrared with the Red band to highlight vegetation properties. Also mixes the blue band to reduce atmospheric and soil background effects. The study are is located in the mountain tropical forest located in the Rio San Francisco valley – south Ecuador. Results are spatilly explicited in the RendezWUE block (defined as the area of influence around the equipment's measurements ex. Scintillometer towers). This results are later contrasted with ET stimation from Scintillometer calculation for comparison.

POTENTIALS OF REMOTE SENSING AND IMAGE TEXTURES FOR PREDICTING ECOSYSTEM FUNCTIONS IN THE ECADORIAN ANDES

Isabel Pérez Postigo[1], Christine Wallis[1], Yvonne Tiede[1], Birgit Ziegenhagen[1], Roland Brandl[1], Nina Farwig[1], Jörg Bendix[1]

[1]*Philipps-Universität, Marburg, DE, Perezpos@students.uni-marburg.de*

All over the world ecosystems are evolving constantly. In the last decades those changes have been accelerated by climate change and an increasing impact of land use, leading to a decline of biodiversity and modifications in ecosystem functions. Remote sensing is a promising technique for monitoring the state of ecosystems. In order to detect changes in focal functional processes of a tropical mountain forest ecosystem in southern Ecuador a system-based approach was chosen and is presented in the poster. We assume that herbivory as a focal function is linked directly to the diversity of relevant organisms. Therefore we tested if forest habitat structure which is detectable with remotely sensed data might act as a suitable proxy. The sites are located at elevations ranging from 1000m to 3000m a.s.l. considering both, disturbed and undisturbed forest areas. As an indicator for herbivory we chose the leaf area loss of the forest canopy and of understory plants. Structural parameters that indicate inter- and intra-habitat heterogeneity have been calculated using texture metrics derived from air-borne high-resolution multi-spectral ortho-photographs (Sigtierras). We expect to show the relation between forest structure and herbivory making it possible to predict herbivory rates with remote sensing data. Hence, our results will provide an enhanced understanding of the spatial behavior of ecosystem functioning at a landscape scale.

Merian Award Applicant

DO FUNGI NEED SALT LICKS? SODIUM SHORTAGE IN TROPICAL FORESTS AFFECTS DECOMPOSITION PROCESSES

Andre Velescu[2], Tessa Camenzind[1,3], Leonard Herpich[1,3], Wolfgang Wilcke[2], Matthias C. Rillig[1,3]

[1]Freie Universität Berlin, Berlin, DE
[2]Karlsruhe Institute of Technology, Karlsruhe, DE, andre.velescu@giub.unibe.ch
[3]Berlin-Brandenburg Institute of Advanced Biodiversity Research (BBIB), Berlin, DE

Sodium in soils is mainly investigated in the light of high salinities in arid regions. In contrast, recent studies in tropical forests raise the hypothesis that Na shortage restricts decomposition processes and affects the carbon cycle if soils have low Na concentrations, the stands are far from the Sea and do not receive substantial Na inputs from the atmosphere. Terrestrial plants have little need of Na, whereas soil animals involved in decomposition need far higher amounts. However, little is known on Na demands of fungi, while Na limitations have only been found at very low concentrations.

In our study on Na limitation in a tropical montane forest on the eastern cordillera of the Andesin South Ecuador, we tested the hypotheses that (1) the study area is characterized by low Na concentrations because of low deposition rates, (2) decomposition processes are limited by Na and (3) Na additions will increase the number of soil microorganisms, though fungi will only be stimulated indirectly via increased decomposition rates.

Na concentrations were measured in rainfall, throughfall, stemflow, litter leachate, organic layer and stream water, allowing for the calculation of Na fluxes and deposition rates since 1998. Effects of Na limitation on decomposition were tested by degradation of cellulose filter papers soaked in different Na solutions (NaCl, NaH_2PO_4, Na_2SO_4), each containing 0.1 M Na. Differential effects on soil microfauna and fungi were tested in a litter bag experiment set up as a factorial design including Na (NaCl, 42 mg $month^{-1}$) and soil fauna (two mesh sizes: 38 µm including only fungi and 4 mm including fungi and soil fauna) as factors.

First results show that Na accumulates both in the canopy and in the organic layer, indicating strongly that the studied ecosystem is limited by Na. The thick organic layer is characterized by low mean stocks of Na (6.7 t ha^{-1}). Leaching from the organic layer decreased within the past 15 years from 20 kg ha^{-1} a^{-1} to 3 kg ha^{-1} a^{-1} and mean Na concentrations in stream water were below 3 mg L-1. These values are comparable to tropical lowland forests far-off the coast. Interestingly, total Na deposition decreased within the same period from 40 kg ha^{-1} a^{-1} to 10 kg ha^{-1} a^{-1}, suggesting a potential future role of Na in regulating ecosystem processes.

FUNCTIONAL FEEDING GROUPS OF AQUATIC MACROINVERTEBRATES AND ENVIRONMENTAL INTEGRITY IN HEADWATER STREAMS OF A TROPICAL HIGHLAND.

MIREILE REIS DOS SANTOS[1,2,3], PAULO AUGUSTO ZAITUNE PAMPLIN[2,3], ERIKA MAYUMI SHIMABUKURO[2]

[1]IFSULDEMINAS - CÂMPUS POÇOS DE CALDAS, POÇOS DE CALDAS, BR, mireile.santos@ifsuldeminas.edu.br
[2]UNIVERSIDADE FEDERAL DE SÃO CARLOS, SÃO CARLOS, BR
[3]UNIVERSIDADE FEDERAL DE ALFENAS, POÇOS DE CALDAS, BR

The presence and abundance of functional feeding groups (FFG) is an important approach to evaluate environmental integrity. Regarding aquatic macroinvertebrates, the main categories of FFG are: shredders, collectors, scrapers and predators. The main source of nutrients in low order streams comes from allochthonous origin, the role of these organisms in the decomposition and bioavailability of nutrients is essential for the maintenance of ecological relationships in these ecosystems. Thus, we evaluate the correlation between the FFG of aquatic macroinvertebrate community and the environmental integrity on a headwater area located in a highland in southeastern Brazil. Some physical and chemical parameters of the water were evaluated and a visual diagnostic analysis was taken in each sampling site. The waterbodies were sampled with D net (mesh 250 microns), and the material was fixed with 10% formalin. In the laboratory, the organisms were identified up to the taxonomic level of family, except Chironomidae (genus and morphotype). The taxonomic units (Utos) were grouped in FFG (MERRITT, CUMMINS, 2006). A Canonical Correspondence Analysis (CCA) was applied in the data. FFG and its occurrence frequency in the study area were represented by the folowing Utos: Collectors (69.65%) - Chironomidae, Tubificidae and Simulidae; Predators (22.98%) - Hirudinida, Ceratopogonidae, Dytiscidae, Libellulidae and Tabanidae; Shredders (7.36%) - Tipulidae, Calamoceratidae, Leptoceridae and Odontoceridae. We found a correspondence between FFG and the environmental integrity in the CCA, highlighting two major groups (CCA - Axis 1 = 91.97% - Axis 2 = 8.03%). The abiotic variables that best explained the environmental quality of the study area were pH, tds and current velocity.The most preserved environments showed higher abundance of predators and shredders, while in the most impacted collectors organisms predominated. Exception to site 2, that although visually preserved, showed low environmental quality and the sitie 6 that, despite representing the most disturbed environment, showed high habitat heterogeneity in the sediment which may have supported the highest abundance predators and shredders. Therefore, ecosystems with better environmental quality can withstand communities with greater functional diversity.

MONITORING BIRD DIVERSITY ACROSS ELEVATIONAL AND LAND-USE GRADIENTS IN SOUTHERN ECUADOR

Vinicio Santillán[1,2], Marta Quitián[1,3], Edwin Zárate[2], Matthias Schleuning[1], Katrin Böhning-Gaese[1], Eike Lena Neuschulz[1]

[1]*Biodiversity and Climate Research Centre (BiK-F) Frankfurt*
[2]*Universidad del Azuay (UDA) Cuenca*
[3]*Universidad Técnica Particular de Loja (UTPL)*

Birds are among the most species-rich and abundant groups in the tropical Andes. They play a key role in the ecosystem as pollinators and dispersers of multiple species of plants as well as for pest control. The underlying mechanisms that shape avian assemblages across elevational and disturbance gradients are however only poorly understood so far. In this study we explored how elevational and land-use gradients affect bird communities and resource availability in Tropical Montane Forest in the Southern Andes of Ecuador. We conducted our study at three elevations (1000 m, 2000 m, 3000 m a.s.l.). At each elevation, we installed three plots in continuous near-natural forest and three plots in human-disturbed forest. We replicated the study in the wet and dry season. We recorded all birds seen or heard within a radius of 20 m in nine 10-minute point counts at each study plot. Fruit and flower availability, vegetation heterogeneity and canopy closure was estimated in the same circular plots. Invertebrate biomass was sampled along a 100 m transect within each site. A total number of 2143 individual birds belonging to 189 species were recorded across all study plots and seasons. Bird species richness decreased with increasing elevation and was lower in disturbed forest sites. We recorded a higher number of birds in the dry season (161 species) compared to the wet season (130 species). The bird community composition strongly changed across the elevational gradient. Frugivores and insectivores were the most important feeding guilds at mid and low elevations, while nectarivorous birds increased at high elevations. This could be explained by changes in fruit availability and habitat heterogeneity. We conclude that resource availability and habitat heterogeneity act as strong filters to shape avian assemblages across elevational and land-use gradients.

Merian Award Applicant

MAPPING ABOVE-GROUND BIOMASS IN A TROPICAL FOREST IN CAMBODIA USING CANOPY TEXTURES DERIVED FROM GOOGLE EARTH

Minerva Singh[1]

[1] *University of Cambridge, Cambridge, UK*

Tropical forest loss has been severe in SE Asia, esp in some continental SE Asian countries that have had turbulent political histories and have faced several decades of war (e.g., Cambodia, Laos, and Vietnam). Post-war periods in these countries have seen a sharp rise in forest loss and illegal logging. Cambodia, in particular, has experienced some of the highest percentage rates of deforestation globally. Instruments such as Reduced Emissions from Degradation and Deforestation (REDD+) are potential methods to incentivize tropical forest conservation and avoid deforestation through payment to protect forest carbon stocks. However operationalizing these schemes involves landscape monitoring of forest parameters, especially above ground biomass (AGB). Aerial imagery is a valuable tool for forest monitoring in tropical countries, offering the potential to characterize forest canopy cover, crown size distributions, AGB, and other forest structures at landscape scale. However commercial aerial imagery is often expensive and out of reach of most forestry managers in poor countries such as Cambodia. This study develops a modelling framework for utilizing very high resolution (VHR) aerial imagery for fine scale AGB stock monitoring in a tropical forest ecosystem. Three different texture-based methods (Grey Level Co-Occurrence Metric (GLCM), Gabor wavelets, and Fourier-based textural ordination (FOTO)) were used in conjunction with two different machine learning (ML)-based regression techniques (Support Vector Regression (SVR) and Random Forest (RF) regression). These methods were implemented on both 50-cm resolution Digital Globe data extracted from Google Earth™ (GE) and 8-cm commercially obtained VHR imagery. This study further examines the role of forest biophysical parameters such as ground measured canopy cover and vertical canopy height in explaining AGB distribution. Three models were developed using (i) horizontal canopy variables (i.e., canopy cover and texture variables) plus vertical canopy height, (ii) horizontal variables only, and (iii) texture variables only. It was discovered that through the implementation of texture based and ML algorithms, both commercial aerial and GE imagery provided robust AGB estimates. Further GE based AGB estimates were comparable to commercial aerial imagery based AGB estimates. This research demonstrates that novel use of this array of methods on GE imagery can help promote the wider use of freely available imagery for low cost fine scale AGB monitoring at landscape scale.

LOCOMOTIF - LOCAL COMMUNITY MONITORING AND TERRESTRIAL INFORMATION FACILITATION

Sebastian Brackhane[1], Mirko Mälicke[1], Sally Haddad[1]

[1] *University of Freiburg, Freiburg, DE*

The LOCOMOTIF project aims to develop an intuitive and easily understandable software for biomass and biodiversity assessment. The objective is to enable local community members to assess, process and visualize their community lands to facilitate sustainable forest management and to enable participation in conservation and climate change mitigation projects such as REDD+ and A/R. The project seeks to help balancing the different demands on community forests, hence increasing forests´ resilience towards destructive measures like deforestation, forest degradation, and poaching; but can also reduce human-wildlife conflict. On one part LOCOMOTIF identifies easily assessable and comparable biodiversity indicators based on literature review, field surveys and statistical data analysis. The first phase of research focuses on deadwood, tree species composition, pollinators and umbrella/keystone species. Biomass inventories are based on manuals for REDD+ and A/R projects. A first field study was conducted in December 2014 in Lautem (Nino Konis Santana National Park) and Viqueque district in Timor-Leste to identify appropriate key species for biodiversity monitoring. Maps of community lands were prepared with ArcGIS and QGIS and provided to two pilot communities in order to mark umbrella and keystone species. For developing a database with biodiversity indicators we initiated a collaboration with the Universidad Nacional de Timor-Leste (UNTL) and the National Working Group on Agro-Biodiversity of Timor-Leste in December 2014. The software is developed based on a field scenario conducted in the agroforestry trial in Breisach, Germany. Final results for the first phase of research are expected by February 2015.

RESILIENCE OF TROPICAL FORESTS TO HUMAN IMPACT: A DATA-DRIVEN COMPLEX SYSTEMS APPROACH

Bert Wuyts[1], Alan Champneys[2], Jo House[3]

[1]*Bristol Centre for Complexity Sciences, Bristol, UK, bert.wuyts@bristol.ac.uk*
[2]*Engineering Mathematics, Bristol, UK*
[3]*School of Geographical Sciences, Bristol, UK*

In complex environmental systems such as tropical rainforests, it is often not feasible run ecosystem-scale experiments. Additionally, there will be always variables that cannot be fully controlled. Therefore, environmental scientists usually rely on simulation models, data analysis or a combination. Earth system simulation models can be seen as our best attempt to synthesize environmental processes in a computer model under computational constraints but their complexity can make their output often difficult to interpret. Likewise, the idea that complex behaviour can emerge from a limited set of simple rules suggests that at least for some cases we do not need such advanced models to understand system behaviour.

In this study, we make an attempt to analyse and model the core complexity of the world's tropical forest's dynamics from a complex systems perspective. We start from recent insights in savanna ecosystem theory, that sees the local environment as in three possible stable tree cover states (forest, savanna or treeless). We estimate the bifurcation diagram from high-resolution remote-sensed tree cover data and merged remote sensed - gauge rainfall and find that human impact considerably affects the derived hysteresis and resilience.

We finally set up an ecosystem-scale model, derived from tree cover data by a reconstruction of the system's potential using the steady state solution of its Fokker-Planck equation. We estimate model structure and parameters for human-impacted and natural dynamics separately.

DEVELOPMENT OF INDICATOR SETS FOR MONITORING AND BETTER MANAGING COASTAL ECOSYSTEMS: A CASE STUDY OF VIETNAMESE MANGROVE AND DUNE AREAS

Claudia Raedig[1], Hoang Ho Dac Thai[2], Trung Nguyen Duc[1], Udo Nehren[1]

[1]*Cologne University of Applied Sciences, Cologne, DE, claudia.raedig@fh-koeln.de*
[2]*Hue University, Hue, VN*

Tropical coastal ecosystems are under severe pressure by anthropogenic activities such as land conversion to aquaculture or agriculture, urban sprawl, pollution. The pressure will be aggravated by climate change impacts. Both developments will accelerate the loss of resilient coastal ecosystems, and therefore lead to a loss of ecosystem function and ecosystem services. In general, for mangrove areas, ecosystem function and services are better known, while for coastal dune systems, both are under-researched.

Quang Nam is a province in Central Vietnam, where services of coastal ecosystems are largely unexplored. Mangrove stands can be found mostly in the south, where a large lagoon provides enough shelter at an otherwise rather exposed coastline, whereas dunes are more frequently found along the coast. Based on a study carried out in Tam Hai commune in Nui Thanh District, the provided ecosystem services and the environmental status are assessed in form of a rapid assessment approach. In addition, the legal framework for use and management of mangroves and coastal dunes is analysed. Subsequently, for both ecosystems, we (a) categorize the ecosystem services provided, (b) develop a ranking scheme for assessing the environmental status, and (c) provide policy recommendations for their efficient management.

The ranking system, which is based on evaluation by experts, is an initial step to set up an indicator system for assessing ecosystem services and environmental status of coastal dunes and mangroves. We will provide a first indicator set for rapid assessment, but also want to motivate future research to develop a set of robust and quantitative indicators, to allow for monitoring and better comparison of the environmental status of different coastal areas.

EXPLORATION OF THE LANDSCAPE STRUCTURE IN THE AREA OF A BIODIVERSITY RESTORATION PROJECT BY MEANS OF AN UNMANNED AERIAL VEHICLE (UAV)

Robin Naumann[1], Dirk Hölscher[1], Anne Gérard[1], Miriam Teuscher[1], Bambang Irawan[2], Holger Kreft[1]

[1]Georg-August-Universität, Göttingen, DE, robin.naumann@stud.uni-goettingen.de
[2]Universitas Jambi, Jambi, ID

Many tropical landscapes are undergoing rapid transformations. In case of the establishment of oil palm plantations on former rainforest land, this is associated with a strong decline in animal and plant diversity. In order to restore biodiversity and to study successional dynamics in an already largely depleted oil palm landscape, 52 experimental tree islands of varying size, tree species composition and diversity were established in an oil palm plantation in the lowlands of Jambi province (Sumatra, Indonesia). However, the successional dynamics in the experiment may be strongly influenced by the wider landscape context and the beta diversity in the vicinity of the tree islands. UAV-based remote sensing enables a cost-effective autonomous aerial image acquisition and bridges the gap between ground observations and imagery taken from conventional manned aircrafts or satellites. Hence, we used a fixed-wing UAV equipped with an autopilot and a compact system camera, to capture aerial photographs of 317 ha covering the tree islands and their surroundings. The photogrammetric image processing enabled the creation of 3D Digital Surface Models and ortho-rectified 2D photomosaics with a sub-decimeter level resolution. We used the obtained data to identify landscape characteristics and terrain features, directions and distances between tree islands and possible source habitats such as remnant trees or forest fragments. The results reveal the large dominance of mono-specific oil palm plantations in this landscape, which cover about 80% of the area. However, we also identified some broad-leaved trees and shrubs in topographic depressions. Further, we encountered single trees outside the forest, small forest remnants and early secondary forests. We find the results very promising and intend further flights to monitor changes in landscape structure and the succession in the tree islands.

SUCCESSIONAL AGROFORESTRY SYSTEMS IN BOLIVIA: CHALLENGES AND OPPORTUNITIES IN A CONTEXT OF CLIMATE CHANGE

Johanna Jacobi[1], Stephan Rist[2], Miguel A. Altieri[1]

[1]University of California, Berkeley, Berkeley, US, johanna.jacobi@berkeley.edu
[2]Centre for Development and Environment, University of Bern, Bern, CH

Agroforestry, especially in the tropics, can render agricultural systems more resilient to climate change. By sequestering atmospheric carbon, it can contribute to climate change mitigation. 'Successional' or 'dynamic' agroforestry systems (SAFS) are designed to mimic the natural succession of plants with crops and trees, benefiting from the highest possible plant density and diversity and associated ecosystem services. Starting with pioneer plants, these systems can provide production already in the first year, thus avoiding a 'hunger gap' before the main crops start producing. SAFS can be highly productive and resilient if well managed, but are knowledge and work intensive as they require frequent and rigorous pruning. We analyse obstacles to the adoption of SAFS in a sub-humid and a semi-arid zone in Bolivia, interviewing farmers, organizations, and politicians. Results indicate that farmers are interested in SAFS mainly for their contribution to their families' food security, and their potential for soil restoration and resilience to climate change impacts. However, economic incentives are low: markets for diversified products are improving but remain difficult to access, while credit programmes, agricultural insurance, and governmental technical support and extension services are tailored to monocultures or cattle rearing. A positive aspect is the traditionally strong social self-organization of farmers and the presence of several organizations in Bolivia which promote and implement SAFS. With their wide knowledge and experience, these organizations could be the key actors in a much-needed agroecological transformation. They can represent platforms of knowledge exchange, provide technical support, and play an important role in political advocacy to ensure support for polycultures and more resilient and sustainable farming systems.

EXPERIMENTAL GAP ENRICHMENT WITH NATIVE TREES IN AN OIL PALM PLANTATION IN JAMBI, SUMATRA - INITIAL SURVIVAL AND GROWTH

Anne Gérard[1], Miriam Teuscher[1], Bambang Irawan[2], Yann Clough[3], Ulrich Brose[1], Hölscher Dirk[1], Kreft Holger[1]

[1]*Georg-August-Universität Göttingen, Göttingen, DE*
[2]*University of Jambi, Jambi, ID*
[3]*Lund University, Lund, SE*

Transformation of rainforest into large-scale mono-cultural oil palm plantations has led to dramatic losses in biodiversity and ecological functions. There is an urgent need to re-establish diverse habitats and restore ecological multi-functionality in oil palm dominated landscapes, but there is a lack of knowledge about ecological and economical processes that hamper or facilitate biodiversity enrichment and restoration.

To bridge this gap, we established 48 experimental tree islands within a large-scale mono-cultural oil-palm plantation in the province of Jambi (Sumatra, Indonesia) in December 2013. We systematically varied plot size (5x5 m, 10x10 m, 20x20 m, 40x40 m) as well as species diversity and composition of a total of six multi-purpose tree species native to Sumatra. We applied a random partitions design with four partitions series (tree diversity levels of six, three, two and one) plus four plots without planting subject to natural succession and four control plots, resulting in 56 plots in total. After the first year, we investigated the effects of 1) species identity, 2) diversity level and 3) plot size, and 4) abiotic conditions on the establishment success of the trees. Specifically, we investigated mortality as well as increment in diameter and total height of the planted trees.

In general, we can report a successful establishment of the experiment. After 10 months of constantly replacing dead individuals, we replanted 1482 (23.3%) of the 6354 initially planted trees. Preliminary results indicate an influence of species identity on the establishment success, whereas the effects of species composition and plot size does not seem to be pronounced at this stage of the experiment. Based on our results, we will evaluate the suitability of the different tree species for an enrichment planting in oil palm plantations after the critical establishment phase.

Merian Award Applicant

DOES WEED DIVERSITY INFLUENCE HERBIVORY RATES ON COCOS NUCIFERA L. FIELDS IN NORTH-EASTERN BRAZIL?

Susanne Marr[1], Jarcilene Cortez[2], Arne Cierjacks[1]

[1]*University of Hamburg, Hamburg, DE, marrsue@hotmail.de*
[2]*Universidade Federal de Pernambuco, Recife, BR*

Coconut (*Cocos nucifera* L.) is cultivated in more than 90 countries with Mexico and Brazil as the main producers in South America. In north-eastern Brazil, coconut yield is challenged by an array of pests such as herbivores, weeds, and diseases caused by viruses or bacteria which reduce the potential income of farmers. Most studies on the productivity of *C. nucifera* relate to abiotic factors like light, water and nutrient availability, whereas little is known about the biotic interactions between weed biodiversity, pests and crop yield. This study investigated the effect of herb biodiversity on the level of pest infestation and crop yield. In *C. nucifera* 'white fly' (*Aleurodicus* spec.), a sucking insect, causes mechanical damage to the leaves and provokes the infestation with sooty mould (*Capnodium* spp.) which reduces photosynthesis rate and yield. We assessed 'white fly'-infestation level and yield per hectare and year on 22 coconut fields and relate these data to herb species richness on two plots per field. The results indicate that yield was negatively affected by a higher presence of 'white fly'. Moreover, yield was higher on fields with higher weed diversity. However, we found no evidence that weed diversity directly influenced the abundance of 'white fly'. Consequently, positive biodiversity effects seem not being mediated by increased herbivore control. Still, our data show that the use of herbicides is not necessary in this perennial tropical production scheme whereas 'white fly' control is justified by our data. Further studies will be carried out on possible defence strategies in *C. nucifera* and on the mechanisms of biodiversity effects.

DIVERSITY OF VASCULAR EPIPHYTES IN LOWLAND RAINFORESTS AND JUNGLE RUBBER AGROFORESTRY SYSTEMS IN SUMATRA (INDONESIA)

Arne Wenzel[1]

[1]*Biodiversity, Macroecology & Conservation Biogeography Group, University of Göttingen, Göttingen, DE, arne.wenzel@stud.uni-goettingen.de*

Epiphytes play an important role in ecosystem processes of tropical rainforest and provide resources for tree-dependent fauna. They are very sensitive to changes in their environment and therefore, epiphytes diversity can be used as ecological indicator to determine the effects of deforestation and forest transformation.

In Jambi Province (Sumatra, Indonesia) natural lowland rainforests have been almost completely cleared and turned into the transformation systems jungle rubber, rubber and oil palm plantations. The aim of our study was to investigate the effects of the transformation of rainforest to jungle rubber agroforestry-systems' for vascular epiphyte diversity. We conducted plot-based species inventories inside the forest and the jungle rubber by using single rope climbing techniques.

Our results indicate a similarity in species richness and species composition between jungle rubber agroforests and the natural rainforest. Therefore jungle rubber can account as a subset of the broader floral composition of the natural forest. However, this seems only to be true when the structure of the jungle rubber has a forest like appearance. Areas with a high number of native trees, a large basal-area and tall trees were usually high in species richness. On the contrary intensely used jungle rubber areas with a large number of rubber trees were usually impoverished.

These findings suggest that extensively used jungle rubber agroforests could play a vital role in the maintenance of epiphyte diversity and thus could also be a sanctuary for the tree-dependent fauna.

FROM ABANDONED SITES TO VALUABLE PASTURE LAND: IMPLEMENTING THE STORY OF SUCCESS IN THE ANDES OF SOUTH ECUADOR

Kristin Roos[1], Julia Adams[1], Erwin Beck[1]

[1]*Department of Plant Physiology, University of Bayreuth, Bayreuth, DE, julia.adams@uni-bayreuth.de*

Deforestation for gaining pastures and croplands is still advancing in the tropical Andes while vast agricultural areas are at the same time disused due to degradation. In the research area in the south-eastern Andes of Ecuador about 40% of the potential pastureland has been abandoned because of infestation by bracken (*Pteridium* spp.). This rhizomatous plant is one of the most aggressive weeds worldwide. Infestation by bracken fern and shrubs is a consequence of the traditional use of fire for clearing of the natural forest and pasture management. Growth of both, bracken and woody weeds, is even fostered by recurrent burning. In a 2-phase experiment on a heavily bracken-infested slope at about 2000 m asl, substantial control of the weed and subsequent pasture rehabilitation could be achieved. Following our protocol, repasturisation requires about 2.5 years until the pastures can be used. Applying a balanced management of fertilization and grazing lead into a sustainable reutilization of the abandoned areas. This transfer project aims to demonstrate the management protocol to the local farmers, in order to revitalize the degraded land and thus to alleviate the pressure on the natural forests.

Merian Award Applicant

SIZE CATEGORIES OF LEOPOLDINIA PIASSABA W. (ARECACEAE) FOR SUSTAINABLE MANAGEMENT IN NORTH-WEST AMAZON

Julián David Castro-Gómez[1], Sonia Camila Pardo-Gutiérrez[1], Yessica Villarraga Cárdenas[2]

[1]Georg-August-Universität-Göttingen, Göttingen, DE, j.castrogomez@stud.uni-goettingen.de
[2]Secretaria Distrital de Ambiente, Bogota, CO

Leopoldinia piassaba W. locally known as chiqui-chiqui is an endemic palm of North-West Amazon in Brazil, Colombia and Venezuela covering more than 700.000 Ha. This palm plays a crucial role in the ecology of the forest that inhabits and also in the economy of the local and indigenous communities, mainly as a source of Non-Timber forest products (e.g. Roofing, handcrafts, food and spiritual beliefs) hence can be exposed to overharvesting. However, there is a lack of detailed information regarding ecology and structure of their populations highly important to promote sustainable usage. Therefore, we have measured populations in forests of the administrative department of Guainía, Colombia; subsequently, we have made a categorization of chiqui-chiqui palm individuals following the natural history and morphologic criteria (number of leaves, pinnae, folds, veins and height) founding a total of 7 categories: 2 Seedlings, 2 Juveniles and 3 Adults. We have implemented this categorization in forests under high and low human interventions in order to measure the frequency of individuals in each category. This approach allow us to find the higher susceptible categories under harvest practices. Moreover, this classification helps future studies to assess how has been and how will be the behaviour of the population, utilization effects on communities and ecosystems and also to enhance sustainable usage and management of this palm in the region.

WILD ETHIOPIAN COFFEE: CHALLENGES AND OPPORTUNITIES

Matthias De Beenhouwer[1]

[1] *KULeuven, Arenbergpark, Heverlee, NL, matthias.debeenhouwer@bio.kuleuven.be*

Coffea arabica grows as a natural understory shrub in the evergreen montane forests of Southwest Ethiopia (Anthony *et al*., 2002). In some remote areas here, coffee is still harvested once a year by local people in natural forests (Pers. Obs). In neighboring areas, local coffee cultivars are planted and managed under a diverse canopy layer. Only 5-10% of Ethiopian coffee is produced in intensively managed shade plantations, with a very limited set of shade trees (Schmitt, 2006). However, rising world coffee consumption and higher coffee prices have resulted in a major intensification and expansion of Ethiopian coffee forests, at the expense of natural forest (Aerts *et al*., 2011; Hylander *et al*.,2013). It is therefore expected that the percentage of naturally grown coffee in a forest context will gradually decrease.

Research on the impact of forest degradation has long been limited to coffee agroforestry in Latin America (De Beenhouwer *et al.*,2013). The last decade, however, coffee agroforestry research has greatly increased, also in its region of origin. This has indicated that coffee management intensification causes rapid plant biodiversity loss (Aerts *et al*., 2011; Hundera *et al.*, 2013), sharp declines in forest cover (Hylander *et al.*, 2013), decreased pollen dispersal, pollinator diversity and carbon sequestration (Berecha *et al.*, 2014a; Berecha *et al.*,2014b; Tadesse *et al.*, 2014) and genetic erosion of wild coffee genes (Aerts *et al.*, 2012).

As such, the importance of wild coffee plants in natural forest has become more prominent. Indeed, the economic importance of crop wild relatives cannot be underestimated (Heywood *et al.*, 2007). Recently, wild Arabica coffee has been safeguarded with the erection of three biosphere reserves, all of them in Southwest Ethiopia (UNESCO, 2010 and 2012). However, none of these biosphere reserves are fully gazetted and government support is generally negligible. External control is lacking and anthropogenic disturbance for coffee management is increasing, even in these biosphere reserves. Local and international organizations are now trying to sustainably establish these reserves, in agreement and with support of the local people, who have been using these forests for centuries.

Accordingly, instead of expanding coffee forestry, focus should be on sustainable intensification of the present coffee forests (Phalan *et al.*, 2011). Research that can increase sustainability of Ethiopian coffee forests, while still providing increased livelihood for the local people is urgently needed. In that aspect, mycorrhizae can play an important role. Arbuscular mycorrhizae (AMF; Glomeromycota) are known to be crucial in terrestrial soil ecosystem processes in general and sustainable agriculture in specific (van der Heijden et al., 2008; Verbruggen et al., 2010). Moreover, it is already known for more than hundred years that AMF colonize coffee roots (Janse 1897). Recently, it was shown that natural forest coffee is associated with a much higher diversity of AMF in comparison with cultivated coffee (De Beenhouwer *et al.*, 2014). It is expected that a higher

AMF diversity also positively influences plant productivity (Maherali and Klironomos, 2007). Moreover, phosphorus availability has been shown as the main driver of AMF diversity in coffee (De Beenhouwer *et al.*, 2015). This has important implications for Africa in general and Ethiopia in specific, where plant available phosphorus in soils is generally low and access to chemical fertilizers limited (Sanchez *et al.*, 1997; Crawford *et al.*, 2003). Still, how coffee yield and coffee quality are affected by these changes in AMF composition is not yet known. Further research is therefore necessary before AMF can be used deliberately in coffee agroforestry.

Active participation in future research of the people who are working in coffee agroforests is required as they can bridge the gap between theory and the practical perspective that is needed to fully understand sustainable agriculture (Johnson *et al.*, 2013). In general, Ethiopian small holder coffee farmers are very open to learn from research results (Pers. Obs). It is therefore of great importance that results, published in journals with limited access and scientific audience, are also accessible and understandable for people working in the field.

SOIL STRUCTURE UNDER A LONG-TERM SYSTEM TRIAL COMPARING ORGANIC AND CONVENTIONAL MANAGEMENT IN INDIA

Steffen A. Schweizer[1,2,3], Nisar A. Bhat[3,4,5], Bhupendra S. Sisodia[4], Sabine Zikeli[1], Georg Cadisch[2], Markus Graf[6], Gurbir S. Bhullar[3]

[1]University of Hohenheim, Institute of Crop Science, Co-ordination for Organic Farming and Consumer Protection, Stuttgart, DE, schweizer.steffen@gmx.de
[2]University of Hohenheim, Institute of Plant Production and Agroecology in the Tropics and Subtropics, Chair of Plant Production in the Tropics and Subtropics, Stuttgart, DE, schweizer.steffen@gmx.de
[3]Research Institute of Organic Agriculture (FiBL), Department of International Cooperation, Frick, CH, schweizer.steffen@gmx.de
[4]bioRe Association, Kasrawad, IN
[5]Government Holkar Science College, Department of Botany, Indore, IN
[6]Albert Ludwigs University of Freiburg, Institute of Forest Sciences, Chair of Soil Ecology, Freiburg, DE

The depletion of soil fertility threatens food security in rural areas in India. Especially soils under highly intensified agro-ecosystems are at risk to produce as much crop as possible and, at the same time, prevent degradation, destabilization, and subsequent erosion. Increasing the input of biomass, resulting in higher soil organic carbon (SOC), and an amendment of soil structure can sustain these intensified systems. This study therefore analyzed whether organic farming leads to (i) higher SOC, (ii) lower bulk density, (iii) higher surface area of cracks, and (iv) smaller aggregate sizes compared to conventional farming.
To determine these structural properties a 7-year-old long-term trial with four farming systems (biodynamic, organic, conventional, and conventional farming with Bt cotton) was analyzed. The long-term trial cultivates cotton-soybean/wheat in a two-year crop rotation. The biodynamic and organic systems are fertilized with composted organic manure, whereas the conventional systems receive an integrated fertilization of mineral fertilizer with a smaller amount of compost. SOC was analyzed by combustion, bulk density by core method, crack volume by photogrammetry, and aggregate size by dynamic image analysis.
There were no significant differences of SOC between systems in both top- and subsoil. Differences between the bulk densities of the topsoil were also not found to be significant. However, the subsoil showed a 2 % higher bulk density than the conventional systems. In the organic systems 1.3 times more surface cracks were observable than in the conventional systems. The topsoil aggregates of the organic systems were smaller in various size fractions from 20 to 350 µm. The aggregates of the conventional systems were in return bigger and rounder.
This study demonstrates early structural differences between organic and conventional systems in mesoaggregates under tropical and vertic conditions. The interactions of structural soil properties and their contribution towards sustaining soil fertility will be discussed.

Merian Award Applicant

NEW EVIDENCE OF ANTHROPOGENIC FORESTS IN AMAZONIA

Carolina Levis[1,2], Bernardo M. Flores[2], Priscila Ambrósio Moreira[1], Bruno Garcia Luize[3], Juliana Lins[1], Rubana Palhares Alves[1], Charles R Clement[1]

[1]*Instituto Nacional de Pesquisas da Amazônia, Manaus, BR, carollevis@gmail.com*
[2]*Wageningen University, Wageningen, NL, carollevis@gmail.com*
[3]*Instituto Piagaçu, Manaus, BR*

Amazonian forests contain thousands of tree species, yet forests are dominated by relatively few species, many of which are used by traditional peoples. Forest management and promotion by pre-Colombian and modern peoples may have contributed to this pattern. Anthropogenic forest groves are recognized by the aggregation of useful, often domesticated species, and they are often associated with archaeological site with *Terra Preta de Índio* (TPI). One 30 year old estimate suggests that 11.8% of Amazonian forests are anthropogenic. However, given the size of some pre-Columbian societies and their extensive knowledge of plant cultivation and forest management, the extension of anthropogenic forests is certainly underestimated. Because anthropogenic forests have been used by *ribeirinhos* and they inherited indigenous knowledge, their traditional knowledge can provide clues about the distribution and management practices of forest resources left by native peoples.

We visited 28 villages with TPI sites in four major river basins of Amazonia. Using participatory mapping and semi-structured interviews, we described the location, distribution and composition of groves of useful plants, and their cultural history. Thirty useful species occur in groves around the 28 TPI sites. Some were common to all river basins and some were endemic to a basin. Many of these species contain domesticated populations as a consequence of a long-term management and we also identified the management practices used by local people in their domestic areas. Local residents mentioned that many groves of useful species were probably managed by Native Amazonians and recent residents (e.g., *Poraqueiba sericea*), some were favored by fire (e.g., *Astrocaryum aculeatum*), but others (e.g., *Mauritia flexuosa*) were of unknown origin with no relations with people. In general, these groves are diverse, dominated by more than one useful species. Some groves are spread over large areas and others are restricted to secondary forests or are associated with wetlands. This new evidence suggests that numerous types of anthropogenic forest groves exist across Amazonia and this cultural legacy should be considered for conserving biocultural diversity.

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FACING MARKET ECONOMY AND BIODIVERSITY CONSERVATION: THE SHUAR OF THE ALTO NANGARITZA, ECUADOR

Andrés Gerique[1], Viviana Buitrón[1], María López Sandoval[2]

[1]Institute of Geography, University of Erlangen-Nürnberg, Erlangen, DE, andres.gerique-zipfel@fau.de
[2]FLACSO, Quito, EC

The tropical rainforests of the lower sub-Andean ranges of southeastern Ecuador constitute one of the most important hotspots of plant diversity worldwide. This species richness and the concern about habitat loss were recognized in the creation of the Podocarpus National Park and protective forest areas (*bosques protectores*) as buffer zones around it. Subsequently, the region was included in the Biosphere Reserve Podocarpus-El Cóndor.

Our study area is the Protective Forest Alto Nangaritza. It is situated between the eastern side of the Podocarpus National Park and the Cordillera del Cóndor, which corresponds to the Peruvian border. This region is traditionally inhabited by the Shuar, who are indigenous forest dwellers, and by indigenous Saraguro and Mestizo settlers from the highlands.

As with other Amazonian indigenous groups, at lower population levels the subsistence agricultural patterns of the Shuar have conservation benefits and create high biodiverse landscape mosaics, while the lack of infrastructure and of access to market places has protected their traditional plant lore and management. However, the increasing interface with the market economy and with other cultures has modified their traditional land use and has intensified resource exploitation. Also, the Shuar have been confronted with measures for biodiversity conservation that are being used as an instrument to exert influence on territorial policies and regional development.

This poster describes the productive and social processes of change among the Shuar of the Nangaritza valley during the last decades. One the one hand, it shows their adaptation to market economy and demonstrates, in accordance to other studies, that Shuar land use deforests less than that practiced by other ethnic groups. On the other hand, it reveals how they have promoted biodiversity conservation as a strategy to conserve control over land.

FALLOW LANDS IN A TROPICAL MOUNTAIN RAINFOREST AREA OF SOUTHERN ECUADOR (LOS GUABOS): DISTRIBUTION, CAUSES OF ABANDONMENT AND FUTURE LAND USE OPTIONS

Julia Kieslinger[1], Dr. Andrés Gerique[1], Prof. Dr. Perdita Pohle[1]

[1]*Institut für Geographie , Friedrich-Alexander Universität, Erlangen-Nürnberg, DE*

The megadiverse tropical mountain rainforests of the Eastern Andean Cordillera of Southern Ecuador are an important source for the livelihood of the local rural population. According to preceding findings of the former DFG Research Units 816 and 402, in the upper Zamora Valley there has been a landscape transformation process with an increasing fragmentation of the natural rainforest as a result of historical colonization processes and changing political conditions regarding the legalization of land titles. At the same time and especially on a local scale, this transformation process was and is still influenced considerably by livelihood strategies and the decision making of rural households concerning land use, food production and plant use. With regard to the land use change and forest transformation, two main processes had been identified: a) forest loss with an expansion of pastures, b) emerging and spreading of fallow land and secondary forest. The present study tied in with these findings.

The aim of this study was to advance our understanding of the rationale behind the decision making processes of the local households of Los Guabos, located at 1,870 m a.s.l. within this megadiverse ecosystem, their land use practices and changes as well as the resulting consequences for the ecosystem. Beside the socio-demographic conditions and changes, the following issues were investigated: deforestation for agricultural purposes, waste land within the selected research plots, abandonment of agricultural land, its reasons and possibilities of future utilization.

The research findings showed that deforestation in Los Guabos and the direct surroundings is currently declining because of limited forest resources on marginal non arable land; in more remote and additionally acquired parcels the possible clearing of forest was mentioned. Only half of the investigated plots can be considered as fallow land and one third of them were really abandoned. Another very important cause for the appearance of secondary vegetation was uncontrolled fires. The reasons for land abandonment were missing inheritors and the migration to Loja city. Reforestation with native tree species on burnt areas and agroforestry systems on abandoned lands are the most promising alternatives for future utilization.

Merian Award Applicant

BIOCULTURAL CONSERVATION PRIORITIES IN COLOMBIA

Rodrigo Cámara-Leret[1], Alejandro Ordoñez[1], Henrik Balslev[1], Jens-Christian Svenning[1], Manue J. Macía[2]

[1]Aarhus University, Aarhus, DK, rcamaraleret@gmail.com
[2]Universidad Autónoma de Madrid, Madrid, ES

The Convention on Biological Diversity (CBD) recognizes the dependency of indigenous and local communities on biological diversity and their unique role in conserving life on Earth. By 2020, all Parties to the CBD must safeguard their cultural heritage to meet the Aichi Biodiversity Targets. Accordingly, Parties must identify which ethnic groups face greatest risk to maximize the effectiveness of subsequent biocultural conservation actions. We present a novel multidimensional decision-making framework for Parties to rapidly identify those ethnic groups in greater need of biocultural conservation support. We exemplify this framework in Colombia because Colombia harbors both an outstanding cultural diversity (102 indigenous groups) and a mega-diverse yet highly endangered flora of global concern (>40,000 species). For each of Colombia's 102 ethnic groups, we summarize the combined effect of six critical biological and cultural risk factors, namely biological diversity loss, land use change, cultural homogenization, language endangerment, socio-environmental pressures, and scenarios of climate change velocity. This is to our knowledge the first interdisciplinary study to address the main aims of *The Akwé Kon Guidelines* adopted by Parties to the CBD in 2000, which includedeveloping indicators for the retention of traditional knowledge, methods and measures to address the underlying causes of the loss of such knowledge, and research on the impact of climate change into highly vulnerable indigenous communities.

DNA BARCODING OF VASCULAR PLANTS IN JAMBI, INDONESIA

Fitri Yola Amandita[1], Katja Rembold[1], Sri Rahayu[2], Barbara Vornam[1], Iskandar Siregar[3], Holger Kreft[1], Reiner Finkeldey[1]

[1]Georg-August University, Goettingen, DE, fitriyola.amandita@stud.uni-goettingen.de
[2]Lembaga Ilmu Pengetahuan Indonesia (LIPI), Bogor, ID
[3]Institut Pertanian Bogor (IPB), Bogor, ID

DNA barcoding aims at providing a fast, accurate, and easily accessible species identification system. The use of DNA barcoding is of particular relevance for the identification of plants in highly diverse but endangered tropical systems such as in the forests of Indonesia which are facing great threats. This research is taking place in Jambi Province (Sumatra, Indonesia), where most of the original forest cover has been converted into oil palm and rubber plantations. We aim to sequence the DNA barcodes of vascular plant species in logged-over old growth forest and three different transformation systems (jungle rubber, rubber and oil palm plantations) and then combine it with classic morphological species identification to establish a barcoding system for vascular plants in the region and to make the data available for the scientific community via DNA barcoding databases. Together with specimen data and high quality photographs of fresh and dried plant material this information should speed up plant research in tropical transformation systems.

Keywords: DNA barcoding, vascular plants, Jambi, barcoding database, transformation system

GENETIC DIVERSITY ASSESSMENT ON THE REGENERATION OF AN ENDANGERED TROPICAL TREE, SHOREA LEPROSULA IN SABAH BIODIVERSITY EXPERIMENT (SBE)

Cheng Choon Ang[1], Michael O' Brien, Kevin Kit Siong Ng, Ping Chin Lee, Andrew Hector, Bernhard Schmid, Kentaro K. Shimizu

[1]*Ang Cheng Choon, Zurich, CH, chengchoon.ang@ieu.uzh.ch*

Sabah biodiversity experiment (SBE), an area of 500 ha of heavily logged over forest (Malua forest reserve) was established in 2000 as a field center for forest ecology and restoration research. It implemented enrichment planting strategy by forming a gradient of species richness among dipterocarps to understand the effect of tree biodiversity on ecosystem services. However, during the early establishment of the SBE, less attention was paid to the source of genetic variability in the dipterocarp seedlings and no record of the level of genetic variability is available. Therefore, we used *Shorea leprosula* (Dipterocarpaceae), as model species (draft genome of ~450 MB available) to quantify the genetic diversity of the species after logging. Genotype data of 32 individuals of *S. leprosula* suggested that a moderate level of genetic diversity was maintained in the species planted in SBE with the mean number of alleles per locus (A) = 8, number of mean observed heterozygosity, *Ho* = 0.623. The genetic diversity is reduced as compared to those in natural populations in Peninsular Malaysia (A = 10.2 to 11.8, *Ho* = 0.732 to 0.782). Structure analysis also suggested that the seedlings might be originated from two different populations. More sampling of the species will be carried out from logged and unlogged forests near to SBE. We would like to know the level of loss and recovery of genetic diversity in the regeneration of the species after nearly three decades of logging. This information could be crucial in forming policy for future forest regeneration.

INTERACTIONS AMONG FRUGIVORES AND PLANTS: COMPARING REAL-WORLD NETWORKS TO ARTIFICIAL FRUIT NETWORKS

Marta Quitián[1,2], Vinicio Santillán[1,3], Carlos Iván Espinosa[2], Matthias Schleuning[1], Katrin Böhning-Gaese[1], Eike Lena Neuschulz[1]

[1]*Biodiversity and Climate Research Centre (BiK-F) Frankfurt, Frankfurt am Main, DE, Marta.Quitian@senckenberg.de*
[2]*Universidad Técnica Particular de Loja (UTPL), Loja, EC, Marta.Quitian@senckenberg.de*
[3]*Universidad del Azuay (UDA) Cuenca, Cuenca, EC*

Human-induced global change has impacts on biodiversity and ecosystem functions. Various monitoring programs have been developed to assess the effects of human impacts on different taxonomic groups. These structural indicators of biodiversity, however, are not sufficient to also assess the functioning of ecosystems. In this project,we proposethe development and validation of a cost efficient functional indicator to assess avian seed dispersal. We studied fruit-frugivore interactions in a tropical montane forest in Southern Ecuador across an elevational and human disturbance gradient. In two different seasons (wet and dry season) we recorded natural plant-frugivore networks and fruit availability at three elevations (1000, 2000 & 3000 m a. s. l.) and in two disturbance types (natural and disturbed forest). At the same study sites we recorded artificial fruit networks using the peck marks of birds on artificial modelling clay fruits. We recorded a total number of 2445 plant-frugivore interactions in 900 h of observations in both the wet and dry season. In general, we found a high number and complexity of plant-frugivore interactions at low elevations and disturbed forests. This might be explained by the high availability of fruit resources at low elevations and disturbed forests. The same pattern was reflected in the pecking rates of artificial fruits that were higher in disturbed forests than in natural forests.We recorded more natural interactions in the dry season than in the wet season. However, pecking rates were lower in the dry season compared to the wet season. These first results suggest that artificial fruits are a valuable functional indicator to monitor avian seed dispersal across elevational gradients. However, seasonal differences in plant-frugivore interactions were not captured by this functional indicator. We seek to understand this mismatch in future research.

Merian Award Applicant

LONG-TERM CONSISTENCY IN SPATIAL PATTERNS OF PRIMATE SEED DISPERSAL

Eckhard W. Heymann[1], Christoph Knogge[1], Laurence Culot[2,3], Emérita R. Tirado Herrera[4], Dietmar Zinner[5]

[1]*Verhaltensökologie & Soziobiologie, Deutsches Primatenzentrum, Göttingen, DE, eheyman@gwdg.de*
[2]*Departamento de Zoologia, Universidade Estadual Paulista, Rio Claro, SP, BR*
[3]*Research Group, Behavioral Biology Unit, University of Liège, Liège, BE*
[4]*Facultad de Ciencias Biológicas, Universidad Nacional de la Amazonía Peruana, Iquitos, PE*
[5]*Kognitive Ethologie, Deutsches Primatenzentrum, Göttingen, DE*

For zoochorously dispersed seeds, the behavior of the vectors influences the spatial patterns of seed dispersal. In turn, this provides the template for subsequent processes and thus can ultimately influence the structure and regeneration dynamics of plant populations. Finally, the consistency of dispersal patterns over ecological time periods will affect the strength of this influence. However, long-term data on spatial patterns of seed dispersal are scarce. Here we present long-term data on dispersal distances created by two Neotropical primate species, *Saguinus mystax* and *Saguinus nigrifrons*, from two independent studies at the Estación Biológica Quebrada Blanco (EBQB) in Peruvian Amazonia, separated by approximately 10 years (1994-95, 2004-08). In each study period, a mixed-species troop of *S. mystax* and *S. nigrifrons* was observed. Dispersal distances were determined as the linear distance between mapped (1994-95) or georeferenced (2004-08) primate feeding trees/lianas and defecation sites where seeds are released. We found that
1) mean dispersal do not vary between study periods (and primate species);
2) distributions of dispersal distances do not vary between study periods (and primate species);
3) cumulative dispersal curves are almost identical between study periods and show that most seeds were deposited within 300 m from the source.

In conclusion, our analyses reveal that spatial patterns of seed dispersal created by the two Neotropical primate species are highly consistent over time. In plant species where these primates are the main or exclusive disperser, this is likely to result in a strong spatial structure which remains to be tested in additional studies.

17 YEARS OF STABILITY IN A WEST AMAZONIAN PALM COMMUNITY

Ingrid Olivares[1,2], Jens-Christian Svenning[2], Peter M. van Bodegom[3], Renato Valencia[4], Henrik Balslev[2]

[1]*Institute of Systematic Botany, University of Zurich, Zurich, CH, ingrid.olivares@systbot.uzh.ch*
[2]*Section for Ecoinformatics and Biodiversity, Department of Bioscience, Aarhus University, Aarhus, DK, ingrid.olivares@systbot.uzh.ch*
[3]*Department of Ecological Science, Section of Systems Ecology, Vrije University Amsterdam, Amsterdam, NL*
[4]*Laboratorio de Ecología de Plantas, Escuela de Ciencias Biológicas, Pontificia Universidad Católica del Ecuador, Quito, EC*

Is the hyperdiverse rainforest of the western Amazon basin stable or is it undergoing changes linked to global and local drivers such as climate change, atmospheric CO_2 levels, defaunation, or successional dynamics? Comparing two censuses (1995, 2012) of a palm community in Yasuní National Park, we tested for changes in community structure and composition and assessed potential drivers of those changes (i.e. the number of canopy gaps and soil moisture). Between 1995 and 2012 the structure and composition of this palm community remained stable. Climatic records in Yasuní showed that no significant changes in precipitation, temperature or river level occurred during the last decade. Drought and canopy openness were significantly higher in 2012 compared to 1995, but these changes may result from inter-annual fluctuations and not fromecosystem disturbance. Thus, we have no evidence of recent directional shifts in the palm community of Yasuní driven by environmental change, a result of very limited deforestation and climatic stability. Our findings contrast with evidence from the eastern Amazon basin, where environmental change on the same time-scale as studied here, is driving significant changes in ecosystem structure and dynamics.

EFFECT OF DROUGHT ON GROWTH AND BIOMASS ALLOCATION OF TREE SPECIES FROM THE PACIFIC DRY FOREST OF NORTH PERU

Viviana Horna[1], Pedro Vasquez[2], Manfred Küppers[3], Reiner Zimmermann[1]

[1]*Forest Ecology and Remote Sensing Group, Institute of Botany, University of Hohenheim, Stuttgart, DE*
[2]*Centro de Datos para la Conservacion, Universidad Nacional Agraria La Molina, Lima, PE*
[3]*Institute of Botany, University of Hohenheim, Stuttgart, DE*

We tested the impact of soil water content and air humidity on the growth and biomass allocation of five drought-tolerant tree species from the Pacific dry forest (bosque seco) of North Peru. Seedlings of the deciduous species *Caesalpinia paipai* "Charan", *Loxopterigium huasango* "Hualtaco", *Erythrina smithiana* "Porotillo", and the evergreen species *Geoffroea striata* "Almendro" and *Albizia multiflora* "Angolo" were grown in climate chambers with three different watering frequencies combined with three different air humidity levels. Relative terminal growth rates were high in wet soils combined with high vapor pressure deficit (VPD), whereas the lowest growth rates were observed under low VPD. *E. smithiana*, the only obligatory deciduous species studied, showed good terminal growth even under humid or foggy climate conditions. It was also responding to every watering with immediate new leaf development. Stem diameter growth in all species was best under moderate VPD conditions and decreased under low VPD conditions. Even after seven months of treatment, *G. striata* seedlings showed no changes in biomass allocation to leaves, stem, and roots. From the other species, only *A. multiflora* showed a significant reduction in leaf biomass and an increase in root biomass with drought. Biomass allocation in *C. paipai*, *E. smithiana*, and *L. huasango* showed significant differences among some treatments but no clear trend with increasing drought stress. These results indicate that the species studied follow different strategies in growth and biomass allocation even under the extreme conditions of the Pacific dry forest.

LIANAS AND TREES SHOW DIFFERENT RESPONSES TO SEASONAL DROUGHT.

Leonor Alvarez-Cansino[1,2,3], Geertje Van der Heijden[2,3], Louis Santiago[3,4], Stefan Schnitzer[2,3]

[1]*University of Bayreuth, Bayreuth, DE, lalvarezcansino@gmail.com*
[2]*University of Wisconsin-Milwaukee, Milwaukee, US, lalvarezcansino@gmail.com*
[3]*Smithsonian Tropical Research Institute, Panama, PA, lalvarezcansino@gmail.com*
[4]*Universit of California-Riverside, Riverside, US*

Determining the factors that control large-scale patterns of species distributions is a key goal in ecology, yet the mechanisms responsible for the number of lianas and trees through the tropics with annual rainfall have received little attention. Lianas are key components of most tropical forest and they peak in abundance in seasonally dry tropical forests. The dry season growth advantage hypothesis propose that lianas are more abundant in seasonally dry forest because they may avoid physiological stress by remaining active and growing during dry periods. We tested the dry season growth advantage hypothesis for liana and trees along a steep rainfall gradient across the Isthmus of Panama. We monitored liana and tree growth and sap flow, and measured seasonal physiological responses and leaf traits (N and C content, $\delta^{15}N$, $\delta^{13}C$, LMA, gas exchange, and water potential) in co-occurring lianas and trees in a dry, moist, and wet forest. Lianas had stronger stomatal control and higher water use efficiency than trees in the drier forest, but not the wet forest. Greater leaf-level seasonal resource use strategies and growth during the dry season supports the dry season growth advantage hypothesis and may explain why lianas peak in abundance in seasonally dry tropical forests

NONSTRUCTURAL CARBOHYDRATE USE AND ALLOCATION DURING DROUGHT IN TROPICAL TREE SEEDLINGS

Annabelle Valtat[1]

[1] *University of Zurich, Zurich, CH, annabelle.valtat@gmail.com*

Nonstructural carbohydrates (NSCs) as a mediator of the physiological response of tree mortality have received an increasing interest over the last decades with the rise in the frequency and severity of global drought events. NSCs are known to play a substantial role in drought resistence of trees by maintaining hydraulic conductance and osmoregulation. Recent studies have shown the importance of NSC concentrations across ten Dipterocarpaceae species being positively correlated with the number of days until death under experimental drought conditions. However, the mechanisms causing plants to die during a water deficit are still misunderstood and need more experimental investigation of smaller temporal resolution. In this study, I will use 13C stable isotope to trace the fates of NSCs during a drought. The aim of the experiment is to quantify the allocation of NSCs from source to sink organs in seedlings of two tropical tree species. Seedlings were harvested before and during drought, and leaves, stem and roots were ground to extract starch and soluble sugars and estimate their concentration in each organ. Although starch concentrations did not significantly change with decreasing soil water, soluble sugars increased in woody tissues while leafy tissues showed a decrease. Other functional traits were measured such as relative growth rate that did not change between the treatments though stomatal conductance decreased after 20 days of drought. The isotopic ratios will be analysed and a comparison of 13C dilution in each organ between control and drought treatments will allow an estimate of the effect of drought on NSCs fluxes. These results will help disentangle fundamental questions on mortality mechanisms and could be integrated in dynamic global vegetation models for predicting die-back under increasing drought events scenarios.

WHY DOES AN UNEXPECTED SAVANNA BELT OCCUR IN COASTAL AREA OF NORTHERN SOUTH AMERICA?

Kamaleddin Alizadeh[1], Marcelo Cohen[2], Hermann Behling[1]

[1]*Department of Palynology and Climate Dynamics, Albrecht-von-Haller-Institute for Plant Sciences, University of Göttingen, Göttingen, DE, kamal.alizadeh@biologie.uni-goettingen.de*
[2]*Oceanography Faculty, Federal University of Pará, Belém, BR*

Despite an annual rainfall which is adequate for rain forest formation, a 2,000 km-long savanna belt occurs in the coastal area from British Guiana to Amapá and Pará States in northern Brazil. To discover when and under which condition(s) this unexpected savanna was formed, we carried out pollen and charcoal analysis on a 750 cm-long, 11,500 years old sediment core taken from Amapá State in the coastal savanna belt. Our results reveal that beside specific arboreal vegetation, savanna was present in the area at least since 11,500 cal yr BP which later (11,200 cal yr BP) expanded markedly due to a drier climatic conditions. The early Holocene rise of Atlantic sea level facilitated the formation of mangrove, swamp forest and later *Mauritia* swamps in the study area. During the mid-Holocene (8,500-5,500 cal yr BP), gallery forest expanded into the savanna area reflecting higher precipitation rates. During the late Holocene (after 5,500 cal yr BP), frequent oscillation between arboreal/non-arboreal vegetation occurred. We suggest that the dry early Holocene is attributed to northern most position of Inter Tropical Convergence Zone (ITCZ) which during the Holocene gradually moved southward and merged with South Atlantic convergence zone (SACZ) and caused moister condition during the mid-Holocene. Unstable late Holocene is ascribed to the intensified El Nino which prevents SACZ to reach the Northern South America. In summary, because of the specific geomorphology, the area was occupied by forest/gallery forest only during the mid-Holocene when probably annual rainfall was higher than today. In addition to climatic factors, which play the major role, high charcoal concentration throughout the studied sediment core together with long history of human settlements in Amazonia, strengthen the suggestion that natural/anthropogenic fire plays also an important role to stabilize the savanna.

RECONSTRUCTION OF LAND USE CHANGES RELATED TO HUMAN IMPACT DURING THE LATE HOLOCENE IN SW KALIMANTAN NE JAVA BASED ON POLLEN AND DINOFLAGELLATE CYSTS

Anastasia Poliakova[1]

[1]*Georg-August-University, Albrecht-von-Haller-Institute for Plant Sciences, Department of Palynology and Climate Dynamics, Göttingen, DE, anastasia.poliakova@biologie.uni-goettingen.de*

The pollen, spore and organic walled dinoflagelletas cyst associations of two marine sediment cores from the Java Sea off the mouths of Jelai River (SW Kalimantan) and Solo River (NE Java) reflect environment and vegetation changes during the last ca 3500 years in the region. A decline in primary forest taxa (e.g. *Agathis, Allophylus, Dacrycarpus, Dacrydium, Dipterocarpaceae, Phyllocladus, and Podocarpus*) suggest that the major change in vegetation is caused by the forest canopy opening that can be related to human activity. The successively increase in pollen of pioneer canopy and herb taxa (e.g. *Acalypha, Ficus, Macaranga/Mallotus, Trema, Pandanus*) indicate the development of a secondary vegetation. In Java, these changes started much earlier (at ca 2950 cal yr BP) then in Kalimantan (at ca 910 cal yr BP) and seem to be more severe. Changes in the marine realm reflected by the dinoflagellate cyst association correspond to changes in vegetation on land. They reflect a gradual change from relatively well ventilated to more hypoxic bottom water conditions in a more eutrophic environment. Near the coast of Java, the shift of the water trophic status took place between ca 820 and 500 cal yrs BP, while near the coast of Kalimantan it occurred as late as at the beginning of the 20th century. We observed an increasing amount of the cyst of *Polykrikos schwartzii*, cyst of *P. kofoidii*, *Lingulodinium machaerophorum*, *Nematosphaeropsis labyrinthus* and *Selenopemphix nephroides* at times of secondary vegetation development on land, suggesting that these species react strongly on human induced changes in the marine environment, probably related to increased pollution and eutrophication.

Merian Award Applicant

ABOVE- AND BELOW-GROUND CARBON STORAGE ESTIMATES FOR THE LARGEST PEATLAND COMPLEX IN AMAZONIA

Frederick Draper[2], Katherine Roucoux[1], Ian Lawson[1], Edward Mitchard[3], Euridice Honorio Coronado[4], Outi Lahteenoja[5], Elvis Valderrama Sandoval[6], Luis Torres Montenegro[6], Ricardo Zarate[4], Timothy Baker[2]

[1]*University of St Andrews, St Andrews, UK, khr@st-andrews.ac.uk*
[2]*University of Leeds, Leeds, UK*
[3]*University of Edinburgh, Edinburgh, UK*
[4]*Instituto de Investigaciones de la Amazonía Peruana, Iquitos, PE*
[5]*University of Turku, Turku, FI*
[6]*Universidad Nacional de la Amazonía Peruana, Iquitos, PE*

Large areas of peatland in Peruvian Amazonia have recently been described and they are known to store large quantities of carbon. However, current estimates of their spatial extent and of the amount of carbon they store are subject to large uncertainties. Our study aimed to reduce these uncertainties for the largest peatland complex in Amazonia, the Pastaza-Marañon foreland basin in northern Peru. Our approach combines optical and radar remote sensing with field data, including plot-based estimates of above-ground carbon and peat thickness and carbon density measurements to estimate below-ground carbon. We mapped the distribution of peatland vegetation types and calculate the above- and below-ground carbon stock of the area. We found that peatland ecosystems in the Pastaza-Marañon foreland basin cover an area of 35 600 ± 2133 km^2 and contain 3.14 (between 0.44 and 8.15) Pg C. One of the vegetation types, peatland pole forest, emerges as the most carbon-dense ecosystem yet identified in Amazonia (containing 1391 ± 710 Mg C ha^{-1}) when below-ground stocks are included. The most important sources of uncertainty in our estimates are variation in peat thickness and peat bulk density. Combined with their contribution to habitat diversity, the large amounts of carbon stored in these relatively intact peatlands mean that they should be made a research and conservation priority, before the rapidly developing regional infrastructure leads to acceleration in their exploitation and degradation.

WHY DOES THE BIOTA OF THE MADAGASCAR REGION HAVE SUCH A STRONG ASIATIC FLAVOUR?

Ben Warren[1,2], Dominique Strasberg[2], Henrich Bruggemann[3], Robert Prys-Jones[4], Christophe Thebaud[5]

[1]*University of Zurich, Institute of Systematic Botany, Zurich, CH, ben.warren@systbot.uzh.ch*
[2]*Universite de La Reunion—CIRAD, Saint Pierre, RE, ben.warren@systbot.uzh.ch*
[3]*Universite de La Reunion, Saint Denis, RE*
[4]*Bird Group, The Natural History Museum, Tring, UK*
[5]*Universite Paul Sabatier, Toulouse, FR*

A corollary of island biogeographical theory is that islands are largely colonized from their nearest mainland source. Despite Madagascar's extreme isolation from India and proximity to Africa, a high proportion of the biota of the Madagascar region (Madagascar and surrounding archipelagos of the Seychelles, Mascarenes and Comoros) has Asian affinities. This pattern has rarely been viewed as surprising, as it is consistent with Gondwanan vicariance. Molecular phylogenetic data provide strong support for such Asian affinities, but often not for their vicariant origin; most divergences between lineages in Asia and the Madagascar region post-date the separation of India and Madagascar considerably (up to 87 Myr), implying a high frequency of dispersal that mirrors colonization of the Hawaiian archipelago in distance. Indian Ocean bathymetry and the magnitude of recent sea-level lowstands support the repeated existence of sizeable islands across the western Indian Ocean, greatly reducing the isolation of Madagascar from Asia. We put forward predictions to test the role of this historical factor in the assembly of the regional biota.

INDONESIAN PEAT SWAMP HISTORY: ENVIRONMENTAL DYNAMICS AND HUMAN IMPACTS INFERRED FROM THE SUNGAI BULUH IN CENTRAL SUMATRA

Kartika Anggi Hapsari[1], Siria Biagioni[1], Peter Meyer[2], Yudhi Achnopha[3], Asmadi Saad[3], Supiandi Sabiham[4], Tim C. Jennerjahn[5], Hermann Behling[1]

[1]Department of Palynology and Climate Dynamics – Albrecht-von-Haller Institute, Georg-August-University of Goettingen, Göttingen, DE, kartika.hapsari@biologie.uni-goettingen.de
[2]Department of Biological Science, Goshen College, Goshen, Indiana, US
[3]Department of Soil Science, University of Jambi, Jambi, ID
[4]Department of Soil Science and Land Resource, Bogor Agriculture University (IPB), Bogor, ID
[5]Department of Biogeochemistry and Geology, Leibniz Center for Tropical Marine Ecology (ZMT), Bremen, DE

Tropical peat swamp forests are important for their high biodiversity and carbon storage. Nowadays, disturbances related to the increased with the growth of human population threaten this fragile ecosystem. Many of the peat swamp forests are converted into settlement, rice field and different plantations. In the Jambi Province in central Sumatra, the conversion rate of peat swamps into oil palm plantations is very high. Land protection and recovery programs have been done were less effective due to lack of information regarding natural processes. Further study for a better understanding of ecological processes in order to improve future decision making processes becomes necessary. Therefore our research aim is to provide longterm data, which consists of vegetation history, fire activities and biogeochemical record.

A 250 cm-long core was taken from a secondary peat swamp forest in Sungai Buluh in eastern Jambi, Sumatra, Indonesia. Twentyfive samples of 10 cm-resolution of pollen and charcoal analyses were carried out from this core. Standard acetolysis procedure has been applied for pollen extraction. Further analyses included radiocarbon dating and biogeochemical analyses on carbon and nitrogen content and stable carbon and nitrogen isotope composition.

The results indicate marked changes of vegetation and environmental conditions in the studied peat swamp forest during Late Glacial and Holocene periods. The results were also used to recognize the anthropogenic signal and its impact, as well as to understand the response from vegetation and environment. The results display the history of peat swamp degradation and provide information on the underlying processes. Conclusion from this study are expected to give answer of how Jambi peat swamp forest has degraded), how its dynamics and responses during environmental and anthropogenic events.

EXPLORING THE COMPLEX NETWORK OF THE AMAZON'S WATER PUMP AND FLYING RIVERS

Delphine Zemp[1], Carl–Friedrich Schleussner[1,2], Henrique Barbosa[3], Ruud van der Ent[5], Jonathan Donges[1,4], Anja Rammig[1]

[1]Potsdam-Institut für Klimafolgenforschung, Potsdam, DE, delphine.zemp@pik-potsdam.de
[2]Climate analytics, Berlin, DE
[3]Universidade de São Paulo, Sao Paulo, BR
[4]Stockholm Resilience Centre, Stockholm, SE
[5]Delft University of Technology, Delft, NL

In South America, the exchange of moisture between the land and the atmosphere plays a crucial role. The tropical trees from the Amazonian forests pump a large amount of water from the ground and release it to the atmosphere. This atmospheric moisture contributes to rainfall over the Amazon basin, but is also transported by winds east of the Andes up to the subtropical La Plata basin. In this study, we use an atmospheric moisture tracking model to diagnose the amount and direction of moisture traveling for its origin (evaporation and transpiration by trees) to its destination (precipitation) in South America. We build a moisture recycling network and we explore its architecture using analysis methods developed in complex network theory. We show that atmospheric moisture runs through re-evaporation cycles (re-evaporation of precipitating water) on the way from the Amazon basin to the La Plata basin. We reveal the south-eastern part of the Amazon Basin as a key intermediary region for cascading moisture recycling pathways. Our results suggest that this region should be protected from land-use change to avoid downwind rainfall reduction that might be stronger than previously thought.

Merian Award Applicant

DETECTION OF CLIMATE CHANGE IN LAKE GAHAR REGION IN LORESTAN PROVINCE OF IRAN AS A SUBTROPICAL REGION

Tayebeh Akbari Azirani[1], Fariba Karami[1]

[1]*Shahid Beheshti University, Tehran, IR, tayebakbari@gmail.com*

Lake Gahar which is located in the slopes of the Oshtorankuh Mountains in Zagros-Anti-Taurus, is the permanent fresh-water lake. A variety of flora and fauna can be observed here, making the surrounding area of the lake into a wonderful park. However unfortunately it is evident that it has threatened by significant climatic and anthropogenic risks including the drought, over grazing, and degradation of the vegetation.

Climate change being the main driving factor in the growth and expansion of the dominant oak species in the Zagros–Anti-Taurus Mountains which is the major biome of the Near East and play a significant role in biodiversity. Despite the importance of the ecosystem to modern and future environmental change and biodiversity, relatively little is known about its future. This study can be used for detecting the climate change in Lake Gahar region in Lorestan province (Iran) as a subtropical region.Climate change and climatic factors including temperature and precipitation and also its effects during future environmental dynamics in Near East will be investigated using Global Circulation Model (GCM).

In present study, three climate changes scenarios of Special Report on Emission Scenarios (SRES) (A1,A1B and B2) and the outputs from HadCM3 ,a GCM are used .For detecting the climate change ,three time windows (2011–2040, 2041–2070, 2071–2100) by LARS WG5 Modelas a tool for the assessment of climate changewere used. Furthermore, the outputs provided by GCMs are too coarse, as they require information at finer scales. Downscaling of GCM outputs is usually employed to provide fine-resolution or point-scale information required for detection of climate change. In this paper, minimum temperature, maximum temperature, rain and radiation data and the data of three stations: Azna, Aligoudarz and Doroud in the basin of Gahar Lake are used. The model was run for 30 years of baseline climate. Results showed that in the mentioned periods, in this basin, temperature has increased and rain has decreased.

AQUATIC INSECT COMMUNITIES IN BROMELIADS ALONG ELEVATION GRADIENTS

Marcia Andrea Adler Yanez[1], Annika Busse[2], Jana S. Petermenn[2]

[1]Georg-August-Universität Göttingen, Göttingen, DE, marcia_adler@hotmail.com
[2]Freie Universität Berlin, Berlin, DE

Elevational gradients have shown to have a large impact on species richness and community composition in many species. It is important to study these changes in animal community structure as well as the changes in environmental factors related to altitude to elucidate the relationship between them. These responses to changing environmental factors along elevational gradients may then serve as analogues for effects on climate warming.

Aquatic communities that live in the water accumulated between leaves of bromeliad plants (an example of phytotelmata or "plant-held waters") are composed mostly of insect larvae and other small invertebrates. These communities are good model systems since - given they are relatively small size - they are easy to study. Furthermore, they can be censused in their entirety, i.e. it is possible to get an exact count of the inhabiting individuals and species. With this study, we aim to get a better understanding of the factors that structure communities in tropical ecosystems and specifically, how elevation affects community patterns.

We conducted a survey in Costa Rica during the wet season 2014 (May-August) to study aquatic insect community composition in bromeliads along elevational gradients. We measured abiotic variables of the phytotelmata water such as pH, dissolved oxygen and temperature as well as other environmental factors such as bromeliad size, dry weight of dead organic matter accumulating in the phytotelmata, air temperature and light availability. Then, we extracted the inhabiting communities and identified and counted all insect larvae. Furthermore, a colonization experiment in which artificial bromeliads were placed in different altitudes along three mountains and collected at different points in time was conducted to investigate colonization dynamics.

Preliminary data show that there is no significant change in the number of insects individuals along the elevational gradient. However, some species just occur in lower elevations while others are only found in higher elevations. Temperature seems to be the only factor that significantly changes with elevation, although smaller changes in many factors may also play a role. Understanding the relationship between these factors and their influence on the communities along elevational gradients will also help to predict how communities may respond to climate change.

ABIOTIC FACTORS AFFECTING PROTIST COMMUNITY COMPOSITION IN COSTA RICAN BROMELIADS

Annika Busse[1], Marcia Andrea Adler Yanez[1,2], Prof. Dr. Jana S. Petermann[1]

[1]*Freie Universität Berlin, Berlin, DE, abusse@zedat.fu-berlin.de*
[2]*Georg-August-Universität Göttingen, Göttingen, DE*

Climate warming, habitat fragmentation, environmental pollution and other anthropogenic stressors have been observed to affect ecosystems and their functions. Therefore, the ability to predict these changes will be of great importance for future conservation attempts.
Naturally changing gradients of environmental variables are a popular approach to study this topic in the field. One of the best known opportunities is provided by elevational gradients. They are prevalently used in studies to assess changes in community compositions induced by, for example, changes in temperature.
We conducted a field survey along three different mountainsides in Costa Rica to assess the community composition of protists (inter alia flagellates, ciliates, amoeba) living in the water-filled tanks of epiphytic bromeliads. Our aim was to investigate if a change in community composition occurred along the elevational gradient and to identify the relevant environmental variables that can cause such a shift in community composition.
Within the scope of our field survey, water samples of bromeliads belonging to the genera Werauhia and Guzmania were taken during the wet season 2014 (May-August) along three different transects on inactive volcanoes in the Área de Conservación Guanacaste, Costa Rica. Altitudinal gradients ranged between 683 - 1906 m above sea level. Parameters measured included water temperature, dissolved oxygen concentration, pH, dry weight of detritus and light availability. Protists were preserved with Lugol solution and identified and counted under the microscope after the end of the field period.
Furthermore, we conducted three daily measurements (duration 13h each) to assess the short-time variability in the following abiotic factors: water temperature, air temperature, ph, dissolved oxygen concentration and light availability.
We found that temperature is the only environmental variables that significantly changes along the elevational gradient. However, preliminary results show that there is no change in protist community composition along the three studied transects. Moreover, the daily variability of the abiotic variables measured revealed that some factors like pH are rather constant throughout the day, while other factors such as temperature and dissolved oxygen concentration can vary more or less strongly depending on differences in weather conditions, location of the bromeliad (open field or shaded) or sampled leaf compartment.
This indicates that the composition of protist communities is probably regulated by other (biotic) factors such as predation pressure through insect larvae. Within the scope of our field work another study on aquatic insect community composition in bromeliads along an elevational gradient was carried out. Results from this other study will be used to gain further insight into the factors driving protist community structure.

DECADAL CHANGES IN ABOVEGROUND BIOMASS ACCUMULATION AND BIODIVERSITY ACROSS TROPICAL SECONDARY FORESTS, WESTERN AMAZON

Joshua Jones[1], Richard Lucas[3], Joao Carreiras[2]

[1]Aberystwyth University, Aberystwyth, UK, jsj8@aber.ac.uk
[2]University of Sheffield, Sheffield, UK
[3]University of New South Wales, Sydney, AU

Changes in aboveground biomass and tree species diversitywere evaluated in Amazonian secondary forest communities that had experienced different land-use histories.

This study aimed at quantifying the long terms trends of aboveground biomass (AGB) accumulation and biodiversity dynamics in forest succession in central Amazonia using field inventory data from 1994 and 2014. As a case study 23 forest plots were installed in secondary forest representative of different clearance histories, a combination of clearance frequency and period of active land use prior to abandonment, on which extensive deforestation has occurred. Land use history for these areas was obtained from Landsat images time-series (1970's - present) analysis (Carreiras *et al.*, 2014).

Sites which had experienced low frequency of clearing (<2 times) with only short subsequent use (<2 years) were dominated by the pioneer genus Cecropia after up to 20 years after abandonment and demonstrated changes through succession over the time series. Sites used for pasture (>2 years subsequent use) after clearing were dominated by the pioneer genus Vismia. They showed a higher stem density which did not show a decline over time. There were the same 4 plant families in both stands whilst 42 species were identified in the Cecropia stands whilst 38 species were identified in Vismia stands after 27 years of regrowth. The Cecropia stands also consistently showed a greater diversity of other species as indicated in Simpsons Index and Shannon Weaver Index scores and through greater evenness as demonstrated by lower Pielou Index scores.

A significant positive relationship ($p<0.001$) between AGB accumulation and regrowth age was observed. A significant ($p<0.01$) and decreasing AGB accumulation with increased frequency of clearance was also observed. On the other hand, no significant relationship was observed between AGB accumulation and the period of active land use.

This study suggests that for the central Amazon, secondary succession involves a more rapid return of primary forest species if deforestation is not followed by use as pasture before abandonment.

ECOLOGICAL AND PHYLOGENETIC CONTROLS OVER FOLIAR NITROGEN AND PHOSPHORUS IN FORESTS OF BORNEO: AN ISLAND-WIDE ANALYSIS

Francis Brearley[1], Stavros Veresoglou[2]

[1]*Manchester Metropolitan University, Manchester, UK, f.q.brearley@mmu.ac.uk*
[2]*Freie Universität Berlin, Berlin, DE*

Nitrogen (N) and phosphorus (P), along with water, represent the commonest limiting resources for terrestrial plant growth. Understanding the way their abundance in plant tissues varies within ecological communities is of major interest as this may improve estimates ofplant photosynthesis, NPP, defence strategies and biomass of foliar-feeding animals. The existing literature has typically focused on single study sites or across wide biogeographical areas often exceeding the distribution ranges of the studied plant species. Here, we aimed to determine the relative contributions of ecology, biogeography and phylogeny in explaining species variability in N and P concentrations and N:P ratios across the island of Borneo.

We analyzed data (a combination of primary and secondary data) from 900+ samples from 500+ species of woody plant species, from twenty sites across Borneo comprising lowland evergreen rain forests (LERF), heath forests (HF), peat swamp forests (PSF), forests over ultramafic soils, montane forests (>1600 m asl) and mangroves.

Nitrogen concentrations were highest in LERF, lower in HF and PSF and lowest in mangroves; P concentrations were, again, highest in LERF, lower in HF and mangroves and lowest in PSF. N:P ratios declined in the order PSF>LERF>HF>mangroves indicating putative P-limitation of PSF and through to putative N-limitation of mangroves. The variation in N:P ratios in HF was smaller than that in LERF indicating limited stoichiometric flexibility under stressful edaphic conditions. It was difficult to determine the differences between montane and ultramafic forests as these two forest types were often coincident (and limited in sample size).

Precipitation explained less than 10 % of the variation in foliar nutrients and, surprisingly, altitude was also a poor predictor of N and P but was a better, although not strong, predictor of N:P. After correcting for across-site ecological and biogeographical variability, N concentrations were not phylogenetically conserved while phylogeny explained a considerable proportion of variability with regard to N:P ratios.

This study represents one of the most comprehensive attempts to explore niche partitioning of limiting resources, through analysis of foliar nutrients, by plants in high-diversity tropical forest ecosystems in South-east Asia.

GUT PASSAGE DURATION AND SEED DISPERSAL BY EAST AFRICAN FRUIT BATS

Anna Valeska Vogeler[1], Ulrike Schweiger[1], Marco Tschapka[1,2]

[1]*University of Ulm, Ulm, DE, avvogeler@aol.de*
[2]*Smithsonian Tropical Research Institute, Balboa, PA*

Frugivorous bats are important seed dispersers in both the Palaeo– and Neotropics. However, since the average transit time of seeds through the gut of a frugivorous bat is rather rapid (generally < 30 minutes), most seeds are dispersed over a radius of a few kilometers. Nevertheless, maximum retention time may be much longer. For this study we used a controlled setting, where fruit bats were kept in a small experimental cage, fed and filmed as well as directly observed and defecation times noted. The retention time of viable fig seeds (*Ficus*, Moraceae) in the gut of the Old World fruit bat *Epomophorus wahlbergi* was examined and faeces were analyzed for additional seeds of not experimentally fed fruit to see how long a seed could stay in a bat's gut (if longer than a 12 hour cycle). The observation time was 36 hours. As highly mobile species, Old World fruit are capable of covering considerable distances during foraging and migration. Our preliminary results suggest that Old World fruit bats have the potential to disperse small seeds over hundreds of kilometers and to fulfill crucial roles in reforestation and seed dispersal.

Merian Award Applicant

TOLERANCE TOWARDS WILD ELEPHANTS IS ASSOCIATED WITH SOCIO-ECONOMIC FACTORS IN THE NILGIRI BIOSPHERE RESERVE, INDIA

Pratheesh Mammen[1], Jean-Philippe Puyravaud[2], Priya Davidar[1]

[1]*Pondicherry University, Pondicherry, IN, pratheeshmammen@gmail.com*
[2]*Sigur Nature Trust, Mavinhalla, IN*

Attitude of local communities towards wildlife is an important factor in mitigating conflicts and increasing efficiency of conservation efforts. The Nilgiri Biosphere Reserve (NBR) has the largest wild population of the Asian elephant (*Elephas maximus* L.). This study assesses the perceptions of local human communities towards the Asian elephant using a questionnaire survey. The null hypothesis tested is that tolerance to elephants is independent of levels of elephant incursions into their property, damage caused, socio-economic profile of respondents and levels of dependence on forest resources. The results indicate that attitude towards elephants was not associated with frequency of incursions, nor with levels of damage. Socio-economic factors like annual income, type of employment, land use and the community to which they belonged were strongly associated with attitudes: respondents with negative attitudes were significantly from higher socio-economic strata, had attained higher educational levels, owned land and practiced agriculture. Whereas the majority of tribals and lower caste people with subsistence lifestyle were tolerant of elephants and preferred co-existence. This suggests that the type of economic activity practiced locally is strongly associated with attitudes, and inappropriate economic activities near protected areas such as growing crops attractive to elephants creates negative attitudes.

PHEROMONE INDUCED HELPING BEHAVIOUR IN THE TERMITE HUNTING ANT MEGAPONERA ANALIS

Erik Frank[1], Jonas Stiegler[1], Thomas Schmitt[1], K. Eduard Linsenmair[1]

[1]*University of Würzburg, Würzburg, DE, erik.frank@uni-wuerzburg.de*

In social insects foraging workers are particularly at risk to be injured or get killed. Thus, strategies might have evolved to avoid loss of foraging individuals. The termite hunting ant species *Megaponera analis* is well known for its organised column like formation moving to and from termite feeding sites. During raids, which according to our observations in the Comoé National Park (Northern Ivory Coast) normally take place 2-4 times a day, the majors break open the protective soil layer over the termite-feeding sites so that the minors can enter to kill and carry out the prey. During these raids we observed a distinct helping behaviour focused on injured nestmates. These injuries occur rather frequently since termites evolved very effective defence mechanisms against predators. After a raid, healthy ants inspect injured ants at the hunting ground and carry them back to the nest, where they may recover in peace without the threat of predators. The aim of this study was to investigate the mechanisms causing this behaviour. We were able to show that mandibular glands initiated helping behaviour when experimentally coated on life or dead ants, while other glands like the Dufour or poison gland did not induce it. Stridulation did not play a role in initiating helping behaviour. Conducting experiments with artificially injured ants we were also able to show that this behaviour is clearly context specific. Ants injured before hunting were ignored. In contrast injured ants were recognized and carried back after the raid. *Megaponera analis* also clearly differentiated between nestmates and ants from other colonies, only offering help to ants of their own colony while showing aggressive behaviour towards injured non-nestmates.

Merian Award Applicant

COMOÉ RESEARCH STATION

Susanne Ziels[1], K. Eduard Linsenmair[1]

[1]*University of Wuerzburg, Wuerzburg, DE, erik@the-franks.de*

The Comoé Nationalpark, located in North-eastern Côte d'Ivoire, is a UNESCO World heritage site and biosphere reserve. With its 11.500 km^2 it is one of the most diverse and biggest National parks in West Africa offering numerous research possibilities to be conducted in the field and in the lab.

The Comoé Research station was founded by Professor K. E. Linsenmair in 1989/90, at first as a provisory research camp. It wasn't until the year 2000, with financing from the Fritz Thyssen Foundation and the University of Würzburg that construction for the actual research station began. Unfortunately construction came to a halt during the socio-political crisis that occurred in Côte d'Ivoire from 2002 until 2011. With the remaining funds available Prof. Linsenmair was able though to re-establish the research station from 2012 onward and in 2014 the constructions were complete making it the most modern research station in West Africa. With a total of 14 houses, a large refectory, a garage with space for various landcruisers and a large climatised laboratory the research station allows ideal working conditions for up to 20 researchers in long term projects or 30 for short term research. The whole research station has permanent electricity supply delivered by a large solar station and, in case of a disturbance, a back up generator is present. A satellite dish also allows for Internet communication in the laboratory and the water supply is guaranteed by a large water reservoir tower connected to a water pump, which provides best quality groundwater from 80m depth. The possibility to conduct state of the art research both in the field and in the lab allow for unique research opportunities directly in the national park and attract an international research community.

AGRICULTURAL LAND USE CONSTRAINTS AND ATLANTIC FOREST RESILIENCE: CHALLENGES FOR RURAL ACTIVITIES AND OPPORTUNITIES FOR ECOSYSTEM RECOVERY

Ramon Felipe Bicudo da Silva[1], Mateus Batistella[2], Emilio Moran[3]

[1]*University of Campinas, Campinas, BR, ramonbicudo@gmail.com*
[2]*Embrapa Satellite Monitoring, Campinas, BR*
[3]*Michigan State University, East Lansing, US*

Understanding resilience of tropical ecosystems raises knowledge about how the environment reacts after disturbances. In the case of the Brazilian Atlantic Forest, centuries of pressure over its original domain and forest remnants raises doubts about its resilience capacity, considering that only few patches of the original biome remained in landscapes (about 8% in 1990s). Over the last decades many restoration projects aiming to recovery the Atlantic Forest and its related ecosystems were launched; however natural regeneration processes have driven the main trajectory of ecosystem recovery. These dynamic processes have occurred since the 1960s and are related to agricultural constraints such as land use policies, environmental legislations, rural socioeconomic changes and biophysical aspects of the landscape. This set of driving factors of forest regeneration is analyzed for the Paraíba Valley region, in São Paulo State, Brazil. The Valley is characterized by a relief dominated by hills, two mountain ranges and flat areas covered by urban areas. During the 18th and 19th centuries, the farms on the Valley were responsible for the providing the largest portion of the State wealthy. Despite of that, nowadays the, Valley contributes to about 6% to the State´s GDP, the contribution of rural activities is inexpressive. Between 1962 and 2011, the forest cover area increased from ~ 225 to 446 thousand hectares (+98%), in the Paraíba Valley. Map analysis, field observation and a set of ninety interviews point out that land abandonment followed by forest regeneration represents the main trend for recovery. We conclude that the diminishing of land use pressure in the Paraíba Valley is releasing disturbed and deforested areas for ecosystem recovery and revealing resilience capacity of the Brazilian Atlantic Forest.

RELATIONSHIPS BETWEEN BIOSPHERE RESERVE CONSTRAINTS AND NATURAL RESOURCES DEPENDENT HOUSEHOLDS' LIVELIHOODS?

Doriane Desclee[2,3]

[2]ERAIFT, Kinshasa, CD, ddesclee@fastmail.fm
[3]UCL, Louvain-la-Neuve, BE, ddesclee@fastmail.fm

Poverty issues have to be addressed in a holistic way. It imposes adopting a systemic approach for ensuring a multidimensional analysis. This research seeks to address poverty through the concepts of livelihoods and the capitals theory. Livelihoods available to households are a set of space-time varying assets allocated between capitals: financial capital, physical capital, human capital, social capital and natural capital. Depending on assets and behaviours, households make choices to create a stock and achieve a sustainable life balance. The livelihoods approach provides an analytical framework for measuring capitals in order to monitor a long lasting development process.

In the context of protected forest areas, as the Biosphere Reserve of Luki in the DRC, human activities evolve to use natural resources as a source of income.The Luki Reserve is unfortunately in the process of a long-term collapse from a species rich heaven into a landscape of degraded secondary forest and subsistence agriculture. We have investigated the impact of the Luki Reserve on the livelihood of people depending on its resources. To this end, a household survey has been conducted to collect targeted field data on the five capitals. Data have been integrated in a relational database, and linked to geographical elements. After exploration, certain key variables are shown on maps of the study area in order to compare the effects of these elements on the location in and around the Reserve. It allows having intuitions about the impact of variables on livelihood strategies.

Given the mixed types and the dimensionality of the dataset, a pipeline of processing algorithms haven been applied on each capital to investigate the original intuition and potentially confirm them using automated classification tools. The purpose is to define deferent types of livelihoods' strategies. If such groups of livelihoods' strategies can be determinate, effects on variables through decisions can be anticipated and some decision support can take place in the overall strategies against poverty and protecting the environment, as well as lifestyle choices at the household level.

CLIMATIC FLUCTUATIONS AS MOTOR FOR SPECIATION PROCESSES IN FLIGHTLESS GRASSHOPPERS (INSECTA: ORTHOPTERA): STUDY ON THE AFRICAN GENUS PAREPISTAURUS

Claudia Hemp[1], Siegfried Kehl[2], Johann Wolfgang Wägele[3], Oliver Schultz[3], Andreas Hemp[2]

[1]University of Würzburg, Würzburg, DE, claudia.hemp@uni-wuerzburg.de
[2]University of Bayreuth, Bayreuth, DE
[3]Museum Koenig, Bonn, DE

Abstract. East Africa is known for its high degree of endemism, especially in the old basaltic rock mountains like the Eastern Arcs. Many genera of Orthoptera have radiated in montane areas, especially from the families with flightless members like Lentulidae, Eumastacidae, Acrididae and Tettigoniidae. In every nowadays isolated montane area different species are present. Their narrow ecological demands do not allow dispersion under the present climatic conditions. Modes and times of spread and speciation are exemplary shown for the flightless grasshopper genus *Parepistaurus*. Distribution patterns makes a reconstruction of the former climate (and thus the vegetation cover) possible when a spreading of common ancestors occurred and also corridors get apparent through which these ancestors originated.

Methods. Mechanisms of speciation in mountainous and coastal East Africa are inferred considering (a) phylogenies estimated with a combination of molecular markers (16S rRNA locus, COI and Histone 3), (b) ecological data and (c) the geographic distribution of *Parepistaurus* species.

Results. The study suggests that coastal taxa of *Parepistaurus* were the source of the high diversity of species found in the Eastern Arc Mountains of Tanzania and Kenya. Network analyses and a molecular clock approach, calibrated with the geological age of the volcanoes showed that speciation was boosted by climatic fluctuations affecting large areas of East Africa. With the aridification beginning 2.8 Ma b.p., forest taxa were isolated in East Africa due to forest fragmentation and population separation by extended grasslands. However, a humid period between 2.7-2.5 Ma triggered a spread of coastal taxa along the Eastern Arc Mountains. Forests expanded again and riparian vegetation along rivers draining into the Indian Ocean served as corridors for the spread of coastal taxa to the hinterland. The inland volcanoes such as Mount Kilimanjaro hereby are good time markers since their geological age is known, limiting the available time for speciation processes of *Parepistaurus* in the area to a maximum of about 1-2 million years. A third humid but cold period between 1.1 and 0.9 Ma probably boosted further the spread of several flightless and montane adapted Orthoptera taxa.

DOES DROUGHT MAKE A DIFFERENCE? - VEGETATION, CLIMATE AND FIRE RECONSTRUCTIONS AT MT. KILIMANJARO'S DRIER NORTHERN SLOPES

Caroline Greiser[1], Lisa Schüler[2], Hermann Behling[1]

[1]*Department of Palynology and Climate Dynamics, University of Göttingen, Göttingen, DE, cgreise@gwdg.de*
[2]*Department of Plant Systematics, University of Bayreuth, Bayreuth, DE*

In our project, we study environmental archives from different key areas at Kilimanjaro´s wetter southern and drier northern slopes by pollen, spore and charcoal analysis to reconstruct former and to predict future landscape dynamics.

We want to understand local and regional ecosystems, climate and fire dynamics in a larger context. Of special interest are the dynamics of mountain ecosystems, their reaction on environmental changes, connections and disjunctions of different ecosystems and their role for the development of the biodiversity hot spots in East Africa.

In a previous study pollen archives from the southern slopes were analyzed and now we are adding pollen data from the northern slopes, which experience considerably less precipitation and show a deviating vegetation zonation and species composition.

The results allow comparison of palaeo-environmental changes and patterns between the southern and northern slopes and with other archives from mountain areas in East Africa.

BIOMASS AND GROWTH DYNAMICS OF ENTANDROPHRAGMA EXCELSUM (MELIACEAE), THE TALLEST FOREST TREE SPECIES AT MT. KILIMANJARO

Sabine Remmele[2], Berd Jörg Berauer[2], Reiner Zimmermann[2], Küppers Manfred[2], Marion Renner[3], Andreas Hemp[1]

[1]*University of Bayreuth, Bayreuth, DE, andreas.hemp@uni-bayreuth.de*
[2]*University of Hohenheim, Hohenheim, DE*
[3]*University of Bern, Bern, CH*

The seasonal growth dynamics and the aboveground biomass accumulation of *Entandrophragma excelsum* (*Meliaceae*), the tallest forest tree species found in the montane forests at Mt. Kilimanjaro, was studied in the Mrusunga valley which is located at the south slope of Mt. Kilimanjaro. *E. excelsum* is naturally occurring in humid, lower montane forests from 1300 to 2150m a.s.l. in Tanzania and Uganda. It is on the red list of the IUCN. Since it is a valuable timber, illegal logging is threatening this rare species.

The tallest individual reached 74m in height. Terminal growth ceases when the diameter at breast height reaches approx. 1m. About 4.6 to 5.7% of the stem volume is bark volume. The stem biomass of the largest specimens was estimated to exceed 25tons of dry weight. Wood density varied from 0.42 to 0.5g cm^{-3}. An interesting anomaly was found in the outer phloem-cambium-xylem of the stem and in the large stem buttresses where specific weight was significantly higher with 0.56g cm^{-3}. Comparing popular pan tropical models published by BROWN, CHAVE, Overman and ZIANIS with actual measurements of *E. excelsum* individuals, all models strongly underestimated tree biomass, pointing to the need to determine allometric relationships for tall trees in tropical forests.

Seasonal growth dynamics were studied for two years using high resolution dendrometers. Results were anatomically verified with regular sampling of tree micro cores. Tree growth was continuous and pronounced during the rainy season from March until June, while August until September was a phase of dormancy. Absolute ring width increment during the growing phase was 1 to 3mm. However, tree growth was not closely correlated for all individuals observed, indicating that others than ambient climatic triggers modify cambial growth activity. Estimating absolute tree age from observed growth rates let's assume that tall individuals may reach at least 300 to 400 years of age.

SPECIES RICHNESS AND DISTRIBUTION OF FERNS AND LYCOPHYTES ALONG AN ELEVATIONAL GRADIENT AT COFRE DE PEROTE, CENTRAL VERACRUZ, MEXICO

Cesar Carvajal-Hernández[1], Thorsten Krömer[1], Juan Carlos López-Acosta[1], Michael Kessler[2]

[1]*Centro de Investigaciones Tropicales. Universidad Veracruzana, Xalapa, Veracruz, MX, cesar.carvajalh@gmail.com*
[2]*Institute of Systematic Botany, University of Zurich, Zürich, CH*

We studied species richness and distribution of ferns and lycophytes along an elevational gradient (20-3,500 m) at the Cofre de Perote, Veracruz, including contrasting environments with different degrees of forest disturbance as well as azonal vegetation. We established 15-25 plots of 20 x 20 m each at eight elevational steps separated by 500 m in elevation. In each plot we recorded all terrestrial and epiphytic understory species (up to a height of 8 m).In the 135 plots, we found 140 species and four varieties of ferns (22 families, 58 genera) and 11 species of lycophytes (two families, three genera).The number of species is contrasting at different elevational steps of the gradient and mid-elevations with humid montane forest between 1,500 and 2,500 m showed maximum richness values. At the upper and lower ends of the gradient, characterized by coniferous forest and deciduous forest, respectively, the number of species decreased. The richness of the humid montane forest and its loss of species caused by anthropogenic disturbance are noteworthy. Furthermore, the azonal vegetation at ravines and riversides represents an important reservoir for the pteridophyte flora, which highlights its conservation value. The species of ferns and lycophytes present in the middle and lower zones along the transect (1500-20 m) are more vulnerable to anthropogenic disturbance, as demonstrated with high values of beta diversity when there are changes in the ecosystem. These results highlight: i) the importance of azonal vegetation as a reservoir of diversity of ferns and lycophytes, which therefore should be considered as priority areas for conservation; ii) the great fragility of the humid montane forests and tropical lowland ecosystems, compared with coniferous forests in the highlands. However, as these ecosystems are drastically reduced and fragmented in the study area, the ongoing changes in land use are causing a significant loss of species richness.

PRELIMINARY ANALYSIS OF AQUATIC MACROINVERTEBRATES OF ENVIRONMENTAL PROTECTION AREA - APA PEDRA BRANCA - POÇOS DE CALDAS' PLATEAU - BRAZIL

MIREILE REIS DOS SANTOS[1,2,3], DANIELA DE FIGUEIREDO[1,1], PAULO AUGUSTO ZAITUNE PAMPLIN[2,3]

[1]IFSULDEMINAS - CÂMPUS POÇOS DE CALDAS, POÇOS DE CALDAS, BR
[2]UNIVERSIDADE FEDERAL DE SÃO CARLOS, SÃO CARLOS, BR,
mireile.santos@ifsuldeminas.edu.br
[3]UNIVERSIDADE FEDERAL DE ALFENAS, POÇOS DE CALDAS, BR

In Brazil, there are areas of great environmental importance, which are protected by law. The Environmental Protection Area of Ecological Sanctuary of Pedra Branca is located within the limits of the city of Caldas, southwest region of the state of Minas Gerais. It belongs to the Atlantic Forest biome with the presence of vegetation types of rock fields of altitude and gallery forests with species composition and presence of endemic species. It has an area of 119Km^2 and altitudes ranging between 1000 and 1760 meters (MONTEIRO AND ROSE, 2012). The region in which it operates, the plateau of Pocos de Caldas, was formed for approximately 75m.a. for characteristical geological processes culminating in the relevant uplift and the formation of a volcano caldera approximate diameter of 30 Km with the corrugated center flatter and steeper edges. With this feature geomorphology and few studies on the fauna and flora the area in question becomes very important biological, ecological and evolutionary point of view (ALBERTI, 2008). Thus, started the diagnostic study on the diversity of aquatic invertebrates in streams of this area. So far, we sampled five streams. Samples was collected out using a D-shaped net (1minute/point) and Surber net (triplicate/point). The specimens were fixed in the field with 10% formalin. At the momnet, 1557 specimens were counted and been distributed in 31 taxa, belonging to the phylum Arthropoda (majority), Annelida, Mollusca, and Nematoda Platyhelmintes. Among the arthropods is dominant chironomid (1264), but there is also record of some groups of organisms considered environmental indicators preserved as Coleoptera (58), Ephemeroptera (15), Trichoptera (04) and Odonata (28). Diversity (Shannon) and Equitability (Pielou) indices were calculated, being resuts in 1.57 and 0.46, respectively. The altitude of the sampling sites ranged from 1243 to 1369metros. The medium was analyzed in local pH 5.83 (± 1.06), the average dissolved oxygen concentration was 7.71 mg L-1 (± 2.86) and the water temperature was 15.51 ° C (± 0.41). The general in collection areas have good vegetation cover in the environment, sedimentary bed with diverse habitats, but some degree of human impacts as trampling by cattle and certain assoreameto in some locations.

SPECIES RICHNESS AND COMPLEMENTARITY OF HERBACEOUS ANGIOSPERMS ALONG AN ELEVATIONAL GRADIENT IN CENTRAL VERACRUZ, MEXICO

Jorge Antonio Gomez Diaz[1], Thorsten Krömer[2], Gerhard Gerold[1], Felix Heitkamp[1]

[1]*Georg-August-Universität Göttingen, Göttingen, DE, mo_long_ti@yahoo.com.mx*
[2]*Universidad Veracruzana, Xalapa, MX*

Veracruz hosts a high plant diversity of herbaceous angiosperms that is threatened by land use changes and shows a lack of research. For these reasons, we studied this plant group in central Veracruz, Mexico, along an elevational gradient at the slopes of the volcano *Cofre de Perote* between 40 and 3,520 m. The aim was to compare species richness and similarity between elevational belts and vegetation types. In total, 136 plots of 20 x 20 m (total area: 5.4 ha), distributed in natural, azonal, disturbed and or secondary vegetation in the localities of: *La Mancha* (40 m), *Palmarejo* (500 m), *Chavarrillo* (1000 m), *Los Capulines* (1500 m), *El Zapotal* (2000 m), *El Encinal* (2500 m), *Los Pescados* (3000 m) and *El Conejo* (3500 m) were investigated. We found 252 herbaceous angiosperm species in 142 genera and 52 families. This richness represents 3.7% of taxa of the Veracruz´ angiosperm flora. We found 28 endemic species to Mexico, one to Veracruz and three threatened. The most important families are Poaceae (36), Asteraceae (29) and Orchidaceae (23) and the most important genera are *Peperomia* (10), *Salvia*, *Begonia* and *Cyperus* (8 each). To compare the elevational belts, we used the values with and without azonal vegetation. In the first case, the belts with the highest species richness are 2,500 m (67), 1,500 m (53) and 3,000 m (50); in the second case, the highest number of species were found in 2,500 (58), 3,000 m (50) and 500 m (43). Disturbed and secondary forests of the 2,500 m belt and secondary forests of the 3,000 m belt have the highest species richness of the elevational gradient. We found a not very pronounced hump-shaped pattern in the species distribution, which is a typical pattern found in various plant groups in the tropics. Poaceae and Orchidaceae increase in disturbed sites and Asteraceae increase in secondary sites, which demonstrates that the disturbance can affect species richness in different ways. This high richness and turnover of species highlights the importance for plant conservation of the study area that is highly threatened by anthropogenic influence. It is necessary to protect, not only one vegetation type, but the complete mosaic of environments and climate zones, connecting all landscape units with small protected areas.

ANNUAL TREE GROWTH DYNAMICS AND WATER USE OF ELFIN FOREST SPECIES AT THE ISOLATED WEST AMAZON MOUNTAIN RANGE "EL SIRA" IN PERU

Armin Niessner[1], Sabine Remmele[1,3], Reiner Zimmermann[1,3], Manfred Küppers[1], Luis Valenzuela[2]

[1]*University of Hohenheim, Inst. of Botany 210a, Stuttgart, DE*
[2]*Missouri Botanical Gardens, St. Louis, US*
[3]*University of Bayreuth, ÖBG, Bayreuth, DE*

Annual tree growth dynamics and water use of dominant elfin forest species from the West Amazon Mountain Range El Sira in Peru was studied, representing the upper vegetation zone within a series of observation sites along an altitudinal transect reaching from 275m up to 2230m a.s.l. A completely pristine, dense elfin forest, locally called "bosque achapparado", covers above 2000m a.s.l. the upper reaches of the cordillera El Sira, a completely isolated and unpopulated mountain range emerging from the surrounding Amazon lowland forests. The canopy of this heath forest reaches between 2 to 4 m in height. The dominant species are *Schefflera patula*, *Clethrea castaneifolia*, *Miconia elongata*, *Ladenbergia macrocarpa* and *Weinmannia cochensis*. The site is exposed to an extremely humid tropical climate. Precipitation measurements on the eastern upper slopes resulted in more than 7000mm of rain per year with year round daily average temperatures of 15 deg Celsius (amplitude ranging from 12 up to 25 degrees). Annual radial stem growth rates of all species observed with point dendrometers were in average very low at 10 micrometer, but ranged from 0.03mm (*Clethrea*) to 1.6mm (*Schefflera*). It was surprising, that growth rates within a species were quite different under similar climatic conditions. This points to growth limitations by edaphic factors or root competition. The growth of basically all woody species constituting the canopy of the elfin forest is continuous throughout the year. Measurements of xylem flux density were compared with daily variation in stem diameter. Brief periods (several days) of stem shrinkage are coinciding with days of no precipitation, indicating a high sensitivity of the wood hydration to water supply shortages from the roots and soil while transpiration is maintained. We assume that the occurrence of prolonged periods of drought as expected by future climatic changes in the Amazon Basin will result in severe drought damage to the montane tropical elfin forests.

THE RELATIONSHIP BETWEEN LEAF TOUGHNESS, VEIN DENSITY AND CHEMISTRY

Norma Salinas[1,2], Sandra Diaz[1], Lisa Patrick[1], Alexander Shenkin[1], Eric Cosio[2], Percy Chambi[3], Valeria Salinas[2], Tatiana Boza[3], Gloria Rayme[3], Yovana Illanes[3], Yadvinder Malhi[1]

[1]*University Oxford, Oxford, UK, norma.salinas@ouce.ox.ac.uk*
[2]*Pontificia Universidad Catolica del Peru, Lima, PE, norma.salinas@ouce.ox.ac.uk*
[3]*Universidad Nacional de San Antonio Abad del Cusco, Cusco, PE*

The physiognomy of the vegetation is a response to the influence of the environment on which tree species develop. The different climatic conditions produce differences in the structure and characteristics of the forest. The elevation gradients are useful for the analysis of these differences in response to different climatic variables which originate several changes in the morphology and structure of plants

The leaves are plants main interface with the environment and affect a wide range of ecological processes. The morphological and physiological variation of leaves is important in the adaptation of a climate plant factor because its size, thickness and shape affect the heat exchange, perspiration, photosynthesis and nutrient supply. The relationship climate and leaf characteristics strongly reflect micro climatic conditions of the habitat showing morphological variations in anatomical structure; also carbon and nutrients investment is associated with these aspects.

Set these variations is important to understand the global changes in ecosystems and how these trees have the ability to adjust their leaf characteristics in response to these changes. To know these strategies we perform the study of leaf toughness and its relation with venation along an elevational gradient from the Andes to the Amazon in southeastern Peru, finding that these characteristics vary in relation to elevation and climatic variables. Leaf toughness traits vary along the altitudinal gradient and were correlated with vein density and some chemical traits. Results imply that material toughness enhances resistance to natural enemies, which increases survival and offsets the biomass allocation cost of producing tough leaves along the gradient and also our results suggest that these traits are correlated with species taxonomy.

VEGETATION AND POLLEN REPRESENTATION ALONG A 200 KM ELEVATIONAL GRADIENT IN KHYBER PAKHTUNKHWA PROVINCE, NORTH-WESTERN PAKISTAN

Farooq Jan[1]

[1]*Georg-August- University of Göttingen, Göttingen, DE, farooqjanbio79@yahoo.com*

This paper presents the first study on the relationship between vegetation and modern pollen rain along a 200 km elevational gradient (275-2600 m a.s.l.), in the Khyber Pakhtunkhwa Province of North-Western Pakistan. A vegetation survey of 24 plots (6 plots of 10x10 m from four elevational zones) was carried out following the Braun-Blanquet´smethod.Percent cover of all taxa was documented and species were assigned to their respective families.24 surface samples each taken from the same plots were processed according to standard methods for retrieving pollen grains. Based on a count of 300 pollen grains per sample, the percent abundance of taxa in the pollen assemblages was compared to the corresponding percentage of cover abundance in the vegetation at family level.Results of the constrained incremental sum of squares (CONISS) from the pollen data reveal that the natural vegetation zonation is well reflected in pollen assemblages despite alteration of the vegetation by human activities. The identification of key taxa for the different vegetation zones improvesour confidence to draw vegetation boundaries and distinguish the elevational zones along the gradient. The Spearman's rank correlation coefficient at $P < 0.05$ indicates a significant correlation between vegetation cover and pollen rain in Poaceae, Asteraceae, Cyperaceae, Verbenaceae, Acanthaceae and Euphorbiaceae whereas weak correlations are observed in Boraginaceae, Saxifragaceae, Apiaceae, Balsaminaceae and Rubiaceae families. Results based on the comparison of vegetation with pollen spectra at family level and their transfer factors (TF) reveal that large sized Poaceae cereal pollen grains > 45 µm, Myrtaceae, Polygonaceae, Brassicaceae, Asteraceae,Chenopodiaceae/Amaranthaceae and Cannabaceae families reflect the proximity of cultivated land and human habitation in the lower three vegetation zones of Peshawar valley, lower montane Malakand hills and Swat valley (275-1450 m a.s.l). Alternatively the representation of species belonging to Pinaceae and spore producing Pteridaceae and Dryopteridaceae families reflect natural vegetation in the upper montane Malam Jabba zone (1550-2600 m a.s.l).

BIODIVERSITY AND LAND-USE IMPACTS ON TROPICAL ECOSYSTEM FUNCTION (BALI): QUANTIFYING BIOGEOCHEMISTRY ACROSS FOREST DISTURBANCE GRADIENTS IN SABAH

Ming Nie[1], Yit Arn Teh[1]

[1]*University of Aberdeen, Aberdeen, UK*

Anthropogenic disturbance and land-use change in the tropics have caused significant effects on biodiversity and ecosystem processes. Yet despite studies of land-use change impacts on the biodiversity and biogeochemistry of tropical forests, the links between these impacts have received less attention: we still have a poor understanding of how human-driven changes in biodiversity feedback to alter biogeochemical processes. These uncertainties substantially restrict our ability to model and predict the response of tropical ecosystems to current and future environmental change. Since 2014, the BALI consortium (www.bali.hmft.info) are addressing these knowledge gaps by launching a large-scale, replicated, and fully integrated study that brings together a multi-disciplinary team with the skills and expertise to study multiple taxonomic and trophic groups, different biogeochemical processes, and the complex interactions amongst them. The overarching goal is to quantify rates of biogeochemical cycling and biosphere-atmosphere exchange across a land-use gradient (old growth forest – logged forest – oil palm). Specifically, we will investigate: 1) net primary productivity and plant-soil fluxes of carbon and nutrients; 2) decomposition of plant tissues and soil organic matter; 3) soil fluxes of carbon, nitrogen and phosphorous; 4) canopy gas exchange and atmospheric composition; 5) soil microbial diversity and activity.

DISTRIBUTION OF INVASIVE PLANT SPECIES AND RECOMMENDATION FOR MANAGEMENT ACTIONS AT BUKIT DUABELAS, JAMBI, SUMATRA, INDONESIA

Sri Sudarmiyati Tjitrosoedirdjo[1]

[1]*Sri S. Tjitrosoedirdjo, Bogor, ID, sudarmiyati@biotrop.org*
[2]*Indah Wahyuni, Bogor, ID*
[3]*Setiabudi, Bogor, ID*
[4]*Sulistijorini, Bogor, ID*

Studies on the distribution of invasive plant species and recommendation for their management were conducted at Bukit Duabelas, Jambi, Sumatra, Indonesia. The aims of this study are (1) To gather a list of invasive plant species in Bukit Duabelas, Jambi, Sumatra, and their vicinity; (2) To determine their distribution in each ecosystem types (natural forest, jungle rubber, rubber and oil palm plantation); and (3) Risk analysis of the important invasive plant species. The data collection on the distribution and coverage of invasive plant species was conducted at the CRC 990 permanent plots (50×50 m^2). Spatial distribution pattern was conducted bycreating vegetation profile diagram horizontally on the permanent plots. Scoring system of risk analysis was also conducted based on the protocol of risk management of invasive plant species. There are 76 species of invasive plant species belonging to 30 families at Bukit Duabelas and their vicinity. The number of invasive plant species varied on each location. High risk of invasive plant species infestations found at the disturbed and open areas. Residential area has the highest number of species, followed by oil palm plantation, rubber plantation, and jungle rubber. However, invasive plant species were not found inside of the natural forest plots. It indicated that the natural forest is still in good condition from invasive plant species infestations. Mapping on the vegetation profile diagram was also prepared. Jungle rubber has the lowest number of invasive species compared oil palm and rubber plantation. Scoring system of some important species was evaluated on their invasive plant risk factor and their feasibility. The result will be use for giving the recommendation on the management of invasive plant species.

PATTERNS OF REPTILE DIVERSITY LOSS IN RESPONSE TO DEGRADATION IN THE SPINY FOREST OF SOUTHERN MADAGASCAR

Ole Theisinger[1], Marcel Christian Ratianarivo[2]

[1]*University of Hamburg, Hamburg, DE, olthei@gmail.com*
[2]*University of Toamasina, Tamatave, MG*

Southern Madagascar, with its semi-arid climate, contains a high number of endemic species. However, the spiny forest is under severe human pressure with a high rate of habitat loss. To understand how reptiles are affected by degradation, we surveyed sites with different levels of habitat degradation in the recently established Ifotaka North Protected Area in the Mandrare Valley. We used species richness, abundance, and microhabitat use of reptiles to examine which species and/or groups of species are most prone to disappear with progressive anthropogenic disturbance. Microhabitat requirements can differ even within closely related species and general patterns for different taxonomic groups (families) were not present. However, combining species with similar microhabitat-use (fossorial, terrestrial, and arboreal), we found patterns in response to degradation. Fossorial species disappeared first, followed by arboreal species. The least sensitive group was the terrestrial lizards, which contains many synanthropic generalists. Anthropogenic effects were generally negative but not in a continuous way. Diversity loss was present even after slight habitat modification as long as some factors (e.g., trees, leaf litter) were unchanged. Even highly degraded areas represented valuable habitats for most species. Although these areas are not inherently suitable as permanent habitats, these areas can be useful as corridors or as stepping stones between fully protected zones.

ARE BIODIVERSITY, PEST INCIDENCE, AND ENVIRONMENTAL CONDITIONS RELATED TO THE PRODUCT QUALITY OF CACAO? A CASE STUDY FROM PERUVIAN AMAZONIA

Katharina Zug[1], Julia Susanne Kieck[1], Roberto Gomez Aliaga[2], Arne Cierjacks[1]

[1]University of Hamburg, Biocenter Klein Flottbek, Hamburg, DE, julia.susanne.kieck@uni-hamburg.de
[2]United Nations Office on Drugs and Crime, Lima, PE

Quality traits of cocoa beans may be a clue to the sustainable use of lowland rainforests as high product quality may compensate for potentially lower yield in diverse agroforestry schemes. However, little is known about the interplay of biodiversity, pest incidence, and soil characteristics with regard to quality parameters of raw cocoa. In this study, we surveyed 48 cacao trees (24 local varieties and 24 of the high-performance clone CCN-51) on 14 farms in Peruvian Amazonia and analyzed cacao seed biochemistry. These results were related to biodiversity, infestation rate with fungal pathogens and soil parameters. Our analyses revealed significant correlations of Shannon evenness, disease incidence in cacao trees, and soil conditions with the content of secondary plant compounds in seeds. Lower levels of Shannon evenness in understory vegetation led to significantly higher polyphenol contents within the seeds. Infestation by the fungus *Moniliophtora perniciosa* (Witches' Broom) along with lower soil pH-level also caused significantly higher polyphenol contents. Moreover, soil pH was significantly negatively correlated with the caffeine level within the seeds. Our results give novel insights into the plasticity of quality traits of raw cocoa and the underlying mechanisms. A low evenness points to pronounced dominance of a few weed species which may be expected to increase competition and reduce pest control. In accordance, reduced evenness along with fungal diseases and nutrient deficiency on acidic soils foster the production of secondary metabolites in the seeds, independently from the cacao variety studied. The data provide evidence that adapted farm management (liming, pest control, weed management) may be a relevant option for increased quality of cocoa products and hence a more sustainable use of forest resources.

PROCESSES ENTANGLING PLANT-HUMMINGBIRD NETWORKS ACROSS SPACE: IMPORTANCE OF FORBIDDEN LINKS IN DETRIMENT OF ABUNDANCES

Jeferson Vizentin-Bugoni[1,3], Pietro K Maruyama[1,3], Ana M Rui[2], Bo Dalsgaard[3], Marlies Sazima[1]

[1]*University of Campinas, Campinas, BR, jbugoni@yahoo.com.br*
[2]*Universidade Federal de Pelotas, Pelotas, BR*
[3]*Center for Macroecology, Evolution and Climate, University of Copenhagen, Copenhagen, DK, jbugoni@yahoo.com.br*

Despite the increasing consensus on the importance of species abundance defining interactions in communities, recent studies on plant-hummingbird networks have pointed to higher importance of forbidden links in detriment of species abundances. However, how general these finding are across plant-hummingbird networks remains elusive. Here we used null models, associated to likelihood analysis and models selection to investigate the relative importance of forbidden links *vs.* abundances on the structure of six plant-hummingbird networks from three biomes in Brazil: Atlantic Rainforest, Cerrado and Pampas. The frequencies of interactions were better predicted by forbidden links than by abundances in all networks, except Pampas. The discrepancy found for Pampas could be explained by the high similarity of traits, both for hummingbirds and plant species (which results in low specialization), as well as by the high dominance of a single hummingbird. Ours findings show that, more than abundances, ecological and evolutionary processes acting on species traits produces spatio-temporal and morphological mismatches, which creates several forbidden links and defining network structure across plant-hummingbird networks.

SHREDDER CHIRONOMIDAE (DIPTERA) LARVAE IN A TROPICAL STREAM: HOW THE LEAF LITTER NUTRIENTS INFLUENCES THE COLONIZATION?

Luciene Leite-Rossi[1], Susana Trivinho-Strixino[1], Marcela Bianchessi Cunha-Santino[1]

[1] *Universidade Federal de São Carlos, São Carlos, BR*

The nutritional quality of plants can influence the action of shredders chironomid larvae on leaf litter decomposition in aquatic systems. In tropical regions, studies that have evaluated the association of these larvae to the nutrients and decomposition of detritus are rare. This family of aquatic insects is abundant in streams, with high density and richness in leaf litter. The invasion of exotic plants in the riparian zone may alter the nutritional quality of allochthonous material and influences the decomposition. This study analyzed the nutritional quality of leaves of two invasive plants (*Hedychium coronarium* and *Pteridium arachnoideum*) and a native plant (*Magnolia ovata*) during the decomposition and investigated its relation to shredder chironomid larvae. Colonization containers with dried leaves of these plant species were immersed in a stream. Samples were taken at 1, 3, 7, 22, 36, 55 and 85 days. The detritus were washed on sieve, dried, weighed and the screened fauna identified to genus level. Chemical analysis of nutritional quality of leaf litter remaining was performed. The results showed that the weight loss and the nutritional quality of the plant detritus were different. The levels of nitrogen, lignin, phenols and fine particulate organic matter together attached sediment influenced the taxonomic structure of the fauna. Larvae densities were different among different detritus, both taxonomically and functionally. The colonization by shredders was similar in the detritus of *M. ovata* and *H. coronarium*, although by different taxa: *Endotribelos* pointed out in *M. ovata* and *Stenochironomus* in *H. coronarium*. The *P. arachnoideum* detritus was colonized by few shredders due to its high lignin and phenols content. The shredders density was related mainly to nitrogen, carbohydrates, lignin and phenols levels in detritus.

DATA ON THE ECOLOGY AND BEHAVIOUR OF THE FIRST HABITUATED GROUP OF WILD MACACA NEMESTRINA IN WEST-MALAYSIA

Anna Gisbrecht[3], Antje Engelhardt[2], Nadine Ruppert[1]

[1]*Universiti Sains Malaysia, Penang, MY*
[2]*German Primate Center, Göttingen, DE*
[3]*Humboldt University Berlin, Berlin, DE, gisb_anna@gmx.net*

The southern pig-tailed macaque (*Macaca nemestrina*) is a common primate species of Malaysian forests but hardly studied in the wild. Here, data of a first habituated wild group of *Macaca nemestrina* is presented. To date the group consists of 18 adult females, 6 adult males and around 15 juveniles and infants, and has been followed in the Segari Melintang Forest Reserve, Perak, Malaysia, since October 2012. From May 2013 to May 2013, we systematically recorded GPS and scan data on a regular basis. The group was tracked for an average of 4.9 hours per day. Every 30 minutes scan data as recorded on 3 adult males, 3 adult females and 3 juveniles (total contact time 1254 hours, 2324 scans). Our analysis shows that the group ranged within an area of 1.3 km^2 (Kernel Density Area) with the core area comprising 0.84 km^2. 11% of the home range lied within oil palm plantations on the forest edge, where they spent an average of 2 hours daily. Oil palm fruits made up 29% of their diet. The group's daily walking distance ranged between 1.5 and 3.5 km (mean 1880 m) with an average travel speed of 420 m h^{-1}.The animals spent most of the time (55.5% of all scans) in locomotion, resting (23.4%) and feeding (8.5%) occurred more frequent than foraging (7.5%), grooming (3.6%), cheek pouch feeding (0.5%) and agonistic behaviours (0.5%). Males were more terrestrial than females, and juveniles stayed above adults throughout the day (ground scan males 71.9%; females 57.2%; juveniles 32.1%; total 54.1%). The observed frequent usage of oil palm plantation as alternative foraging ground poses new questions about the ability of this species to adapt to land use changes that should be studied in the future. We have recently started focal animal data collection on this group in order to learn more about the species' social structure and behaviour; and a second group is soon to be habituated.

MACROBETHONS ASSEMBLAGES IN CAMEROONIAN MANGROVE FORESTS. FIRST EVIDENCE FROM THE WOURI ESTUARY, DOUALA.

Marco Fusi[1], Daniele Daffonchio[1], Angela Sacchi[3], Ngongo Din[5], Joseph Bayi[5], Farid Dhadouh-Guebas[4], Stefano Cannicci[1]

[1]KAUST King Abdullah University of Science and Technology, Thuwal, SA, marco.fusi@kaust.edu.sa
[2]Department of Biology, University of Florence, Florence, IT
[3]Università Cattolica del Sacro Cuore, Piacenza, IT
[4]Département de Biologie des Organismes, Université Libre de Bruxelles – ULB, Bruxelles, BE
[5]Department of Botany , Faculty of Sciences, University of Douala, Douala, CM

West African mangroves macrobenthos is understudied compared to other mangrove systems. Few studies address a comprehensive and inclusive monitoring of macrobenthos assemblages of these systems. Here, we aim to fill this gap focusing on the cameroonian mangroves surrounding Douala City in Woury estuary. This forest is one of the largest systems along the west African coast and is also one of the most impacted given the vicinity to the fast developing Doula City often clearing mangrove trees for land use. We estimated macrobenthos through a survey carried out at two sites near Douala city: Wouri brudge (WB) and Bois de Singes (BS). We used visual census focused on two of the main components of macrobenthos: crabs and molluscs. We identified three main vegetation belts dominated respectively by *Avicennia* sp. *Pandanus* sp. and *Rhizophora* sp. in WB forest, and only *Rhizophora* sp. for BS forest. Observation plots were made along these vegetation belts in order to characterize them at macrobenthos level. Several sesarmid species among crabs occurred in these belts, *Perisesarma*, *Chiromantes*, *Metograpus*, *Armases* and *Sesarma* spp and two species of gastropods as *Pachymelania fusca* and *Tympanotonus radula*. No ocipodids were found like usually occurring along the East African system. We also detected a crab species not yet described. Differences in macrobenthos assemblages were recorded between vegetation belts and sites, the latter probably due to difference position and age of forest. For the *Pandanus* sp. belt the we recorded the higher presence of a crab, *Chiromantes buettikoferi*, possibly eligibile to a phytothelmic species since they seem dwell on leaf axis on *Pandanus* sp. This work represent one the first descriptions of macrobenthos assemblages for Cameroonian mangrove forest.

FUNCTIONAL STRUCTURE OF MACROBENTHIC COMMUNITIES IN A DEGRADED MANGROVE FOREST IN JAVA, INDONESIA

Inga Nordhaus[1]

[1]*Leibniz Center for Tropical Marine Ecology, Bremen, DE, inga.nordhaus@zmt-bremen.de*

Essential functions of mangrove forests may depend on particular macrobenthic species. For instance, crabs and gastropods enhance carbon storage and nutrient cycling through feeding and burrowing. Forest degradation can cause changes in community structure and a decline in species numbers which can lead to a loss in functional diversity. Since data on the functional structure and diversity of benthic communities and their response to environmental change are scarce, consequences for the ecosystem are largely unknown.This study investigates the response of macrobenthic communities to mangrove deforestation in the Segara Anakan Lagoon, a mangrove-fringed estuarine system in Java. The study combines a taxonomic diversity analysis with a biological traits analysis. Behavioural, life history and morphological characteristics were used to define functional groups. Species-specific trait data were gained through field investigations and laboratory experiments. A high species richness but a low biomass of benthic invertebrates were recorded compared to other Indo-West Pacific forests. In Java, species richness of invertebrates and trees were not correlated at different spatial scales. Instead, a response to mangrove degradation was recorded for some functional groups. Diversity and distribution of leaf-eating crabs were related to tree diversity and density of seedlings and undergrowth plants. The benthic communities were dominated by burrowing, opportunistic species with a short life span whereas long-lived and large species were rare. Some functional groups were only represented by one or two species. The dominant crabs have a highly opportunistic feeding behaviour, indicating a low vulnerability to vegetation changes. Their burrows are very shallow compared to other forests, which is directly related to the small average crab size. This is likely to affect nutrient cycling and the oxygenation and desalting of the sediment.

THE ROLE OF GRAPSID CRABS IN MANGROVE NUTRIENT CYCLING

Anne van Zon[1], Harry Olde Venterink[1], Stefano Cannicci[2], Nico Koedam[1]

[1]Vrije Universiteit Brussel, Brussels, BE, anne.van.zon@vub.ac.be
[2]Department of Biology Università degli Studi di Firenze, Firenze, IT

Mangrove ecosystems are productive systems but their soils are often nutrient deficient. In particular nitrogen (N) and phosphorus (P) can limit tree growth. Availabilities of these nutrients are affected by activities of grapsid crabs. However, their quantitative role in N and P turnover rates, and differences in contribution among crab species and life stages remain to be clarified. Grapsid crabs are abundant in mangroves and species distribution follows environmental zonation, similar to the tidal positioning of tree species. Grapsid crabs feed largely on litter of leaves and propagules whereby litter remains within the system. Hence their role must be viewed in mangrove nutrient cycling as both herbivores and decomposers, as well as through preprocessing of organic material.

Our aim is to study variation in diet composition (tree species and C:N:P composition of the feed) among crab species, and to evaluate how this relates to C:N:P composition of the faeces from different crab species. Also, N and P release rates of crab faeces are investigated, and this in comparison with release rates from litter decomposition.

Leaf and propagule C:N:P stoichiometry is expected to vary widely among mangrove species, and to affect the diet composition of grapsid crabs and their faecal C:N:P. Furthermore, we hypothesize that N and P release rates of crab faeces will strongly be controlled by its C:N:P composition, similar as for dung of mammalian herbivores.

Mangroves in Kenya and Hong Kong are targeted to determine variation in C:N:P from leaves, propagules, litter and crab faeces. Additionally, via mesocosm experiments crab feeding behaviour, decomposition and N and P release rates of faeces and litter are studied. Subsequently, we investigate experimentally whether supply of crab faeces stimulates the growth of mangrove seedlings.

The outcome of this study will improve our understanding of the role of grapsid crabs in mangrove nutrient cycling and tree productivity, and how this varies among crab species and their feed intake.

keywords: nutrient availabilities, nutrient cycling, grapsid crabs, faeces, C:N:P stoichiometry

THE EFFECT OF MACROFAUNAL BIOTURBATION ON THE MANGROVE SEDIMENT MICROBIOME

Jenny Booth[1], Marco Fusi[1], Daniele Daffonchio[1]

[1]*KAUST King Abdullah University of Science and Technology, Thuwal, SA, jenny.booth@kaust.edu.sa*

Mangrove sediment biogeochemistry is strongly mediated by microbial processes that cycle nutrients and maintain overall ecosystem functioning. The activity of the mangrove sediment microbiome is deeply impacted by bioturbation, which creates steep biogeochemical gradients, introducing oxygen into typically anoxic sediment and promoting oxidation reactions, causing partitioning of respiration pathways. Here we focus on how the action of the main macrofauna responsible for bioturbation in mangroves, Ocypodidae and Sesarmidae crabs,can affect sediment biogeochemistry and the associated microbiome, with implications for nutrient fluxes and cycling in mangrove sediment.Studies of the effect of bioturbation by mangrove macrofauna on the mangrove sediment microbiome are scarce. Furthermore, coupled analysis of inextricably linked sediment biogeochemical processes and microbiome composition and functionality are lacking. Development of advanced molecular techniques, such as metagenomic and metatranscriptomic analyses, has boosted knowledge of the mangrove microbiome. However, these techniques are yet to be used in studies of the effect of macrofaunal bioturbation, thus current knowledge is restricted to a few early studies and short geographic range inferring microbial abundance and metabolic pathways from sediment biogeochemistry. Indeed, ocypodid crabs have been shown to enhance the activity of functional groups of microorganisms and the partitioning of iron and sulphur respiration pathways in mangrove sediment. Yet, no studies have examined the effect of burrowing sesarmid crabs, which construct larger deeper burrows that trap organic carbon.We highlight here the lack of understanding of the effect of macrofaunal bioturbation. We propose a framework study for a large latitudinal scale on the community structure and function of the mangrove sediment microbiome, which is of great importance since this ecosystem faces many threats and the sediment microbiome is fundamental for ecosystem functioning and resilience to stress.

THE IMPROVED FISH SMOKING AND MANGROVE RESTORATION IN ACTION PROJECT - SNV GHANA

Emmanuel Aziebor[1]

[1] *SNV Netherlands Development Organisation, Accra, GH, eaziebor@snvworld.org*

From 2005 to 2010, Ghana lost on average 2.19% of its forests annually, the highest globally after Togo and Nigeria. The mangrove forest cover reduced from 12,400 ha in 2005 to 9,500 ha in 2010; a staggering annual loss of 5.8%, more than double the national average deforestation rate. At this rate there will be no mangrove forests in Ghana by 2025.

The identified causes of mangrove deforestation are urbanisation and fuel wood harvesting. In Ghana, mangroves are mainly used as fuel wood for fish smoking, which is a dominant economic activity in Ghana. Ghana produces an estimated 560,000 tonnes of smoked fish per year (Bank of Ghana, 2008). This is done on an estimated 120,000 fish smoking stoves, consuming 7.4 million tonnes of fuel wood per year; most of which, is mangrove wood.

Reversing this trend calls for integrated solutions targeting both demand and supply side factors. Demand side solutions include the introduction of efficient fish smoking stoves that reduce fuel wood consumption by at least 40%. Supply side interventions, involves sustainable mangrove and alternative woodlot cultivation, conservation and rehabilitation.

SNV Ghana, under its Renewable Energy Program, is implementing the 'Mangrove Restoration in Action' Project under which a 5 hectare community-led mangrove and 3 hectare alternative woodlot plantation have been developed and 100 improved fish smoking stoves have been installed thus far. The project aims to create an enabling environment to scale up both demand and supply options to make a measurable impact and restore the mangrove forests in Ghana.

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Graphics:
Wendy Martin and Roman Tschirf

Conference Management:
Heike Kulmann
KCS Kuhlmann Convention Service
Rue des Chênes 12
CH-2800 Delémont
Phone: 0041-32-4234384
Fax: 0041-32-4234385
Email: info@kcs-convention.com

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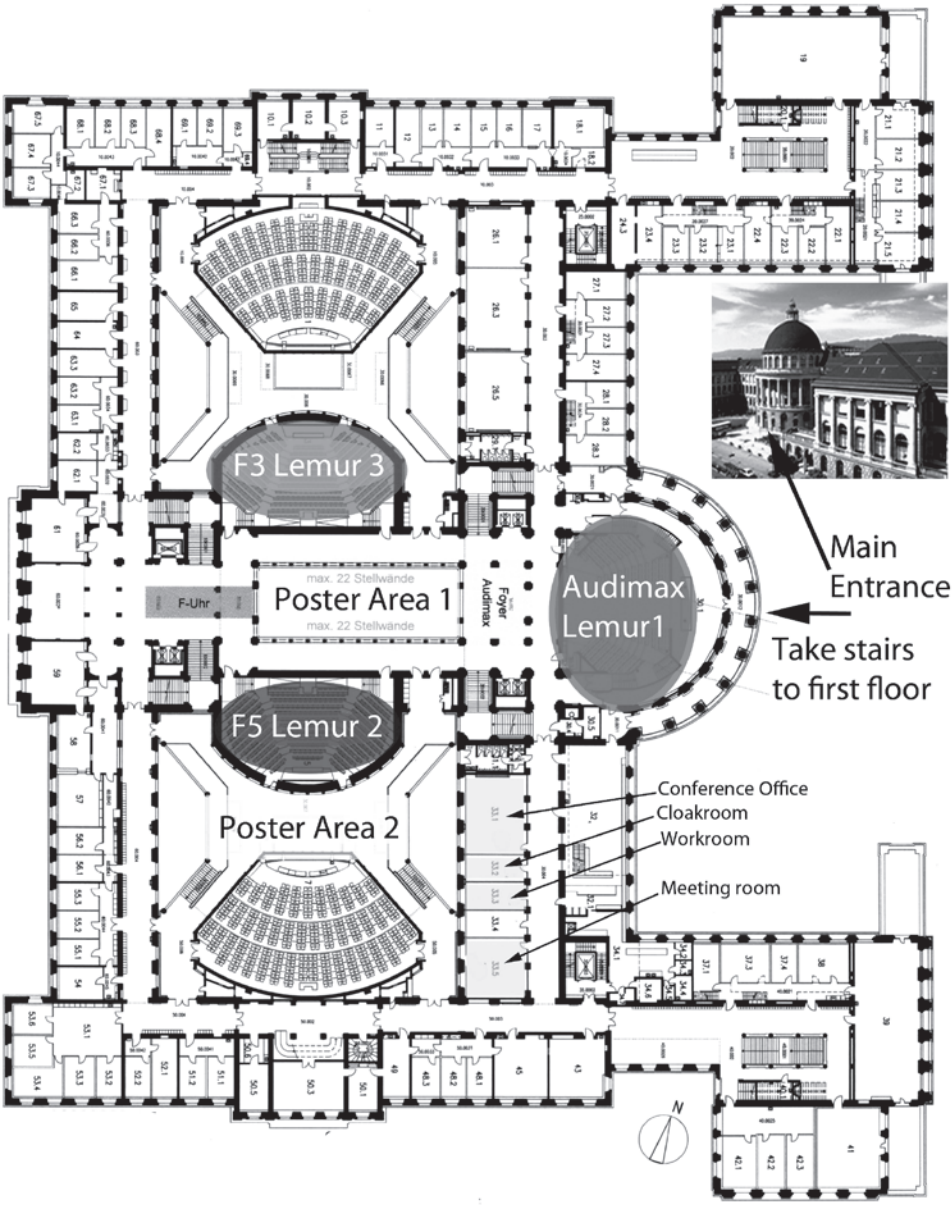
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Within the ETH you have a choice of different cafeterias and 3 Mensa's
see the map for different locations as well as the University of Zurich's mensa (UZH).
http://www.gastro.ethz.ch/locations/eth_zentrum/index_EN

Within the main building "Hauptgebäude" you find
The main mensa **"Polyterrasse"** (Student cafeteria) (Index No 3)
http://www.gastro.ethz.ch/locations/eth_zentrum/mensa/index_EN
Lots of choices, vegetarian dishes and salad bar.
Opening hours 11:15 to 13:30

and **"Polysnack"**
http://www.gastro.ethz.ch/locations/eth_zentrum/snack/index_EN
Opening hours 07:30 to 17:00

Just across the road at Tannenstrasse the **"Tannenbar"** which is a coffee shop style outlet with small snacks, sandwiches, salads etc.
http://www.gastro.ethz.ch/locations/eth_zentrum/tannenbar/index_EN
Opening hours 07:00 to 17:00

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"Einstein & Zweistein" is a cafeteria located within the main building serving snacks.
Opening hours 06:45 to 19:45

"bQm MM" is a student cafe and bar located right under the Polyterrasse with wide choice of beers, hot and cold drinks.
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"Dozentenfoyer HG" is a restaurant for professors and employees from ETH and UZH.
Opening hours 09:00 to 16:00, lunchtime 11:00 to 14:00.

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PUBLIC TRANSPORT

HOW TO GET TO THE CONFERENCE VENUE…

From the Main train Station (Hauptbahnhof):

From the "Bahnhofstrasse/HB" stop:
Tram no. 6 (towards the Zoo) as far as the "ETH/Universitätsspital" stop.
Journey time: approx. 6 minutes

From the "Bahnhofplatz/HB" stop:
Tram no. 10 (towards the Airport or Oerlikon station) as far as the "ETH/Universitätsspital" stop or Tram Nr. 3 (towards Klusplatz) as far as the "Central" stop (1 stop), from "Central" by Polybahn (departs every three minutes) to the Polyterrasse.
Journey time: approx. 8 minutes. You will require a ticket that is valid for zone 110 (city of Zurich).

From the airport:

By tram, From the "Zurich Airport" tram stop:
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The tram runs every 7 to 15 minutes between 6 o'clock in the morning and 11 o'clock at night.
Please note: from the airport you must include an additional zone to the basic city day pass, or buy a separate ticket.
Journey time: 30 minutes

By rail:
If you wish to travel from the airport to the city centre (Central Station), you are recommended to use the S-Bahn or mainline services. The trains depart from the "Zurich Airport" station.
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If you are spending the whole day in Zurich, it is worth buying a day pass (valid for 24 hours).

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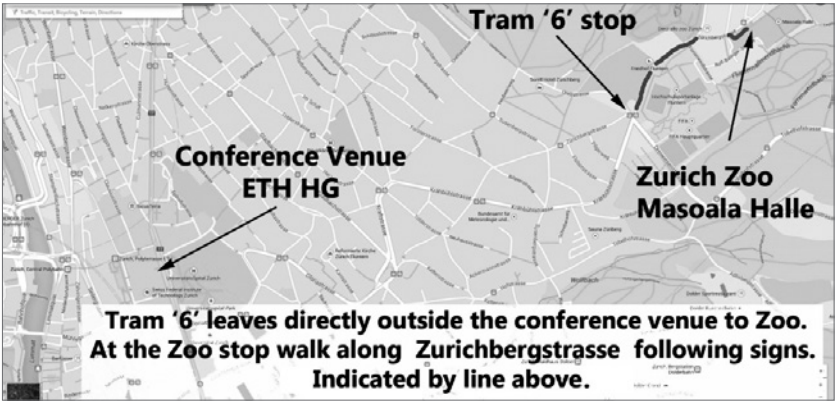
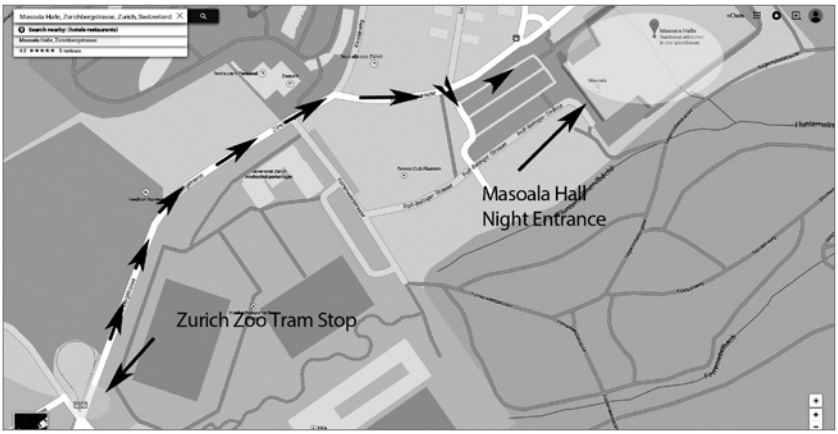
From the "Bahnhofstrasse/HB" stop:
Tram no. 6 (towards the Zoo) as far as the "Zurich Zoo" stop.
Journey time: approx. 20 minutes

From the conference venue:

From the "ETH/Universitätsspital" stop:
Tram no. 6 (towards the Zoo) as far as the "Zurich Zoo" stop.
Journey time: approx. 15 minutes
Get off at the terminal station from here it's an approximate 5 minutes walk to the Night Entrance of Masoala. Last tram departs at 00:41 from the "Zurich Zoo" stop.





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