# CRC 990 - EFForTS

# NEWSLETTER

HIGHLIGHTS
PHASE 1
2012–2015

Issue 4 / May 2016

Cover:
Left: Village scene, Jambi, Indonesia
(Photo: Stefan Scheu).
Right: Village scene, Jernih, Jambi, Indonesia
(Photo: Barbara Beckert).

# Content

## DFG field visit in Indonesia and on-site evaluation

On-site evaluation of the Collaborative Research Center EFForTS in Indonesia was carried out between 14 and 17 September 2015 by a team of internationally recognized scientific experts under the guidance of the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG, see photo). Dense haze from fire induced agricultural activities was a particular challenge for the team during the field visit. Its occurrence, on the other side, demonstrated the significance of the research project in this particular area. Jambi belongs to the regions most affected by global demand triggered land-use change. During the last 15 to 20 years, the forest in Jambi Province has been transformed largely to intensively cultivated monoculture systems.

On the first day, the team visited the campus of the University of Jambi (UNJA) and the EFForTS facilities there, including the office rooms and laboratories. After a general introduction of the project, its technical facilities and organisational structure, the Indonesian counterparts presented highlights of their research activities within the frame of EFForTS (see Chapter 3). In the afternoon, the group visited the state oil plantation PTPN VI which hosts the climate tower (see Chapter 1, A03) and the planned management experiment. The first day ended with a visit of a rubber factory in Jambi City where the structure and conduct of the rubber value chain was presented (see Chapter 1, C01, C04, C07).

On the second day, the core village Singkawang of EFForTS near Jambi was visited. The village history, its population development, land tenure regulation and current land use and land-use conflicts were presented. Two farmers with different background who benefitted differently from agricultural intensification were interviewed (see Chapter 1, C02, C03, C06, C07, C08). Thereafter, the group continued to Sungkai village where both rubber and oil palm plots of the project are located. The core plot design including the new riparian zones of Phase 2 were introduced. All enjoyed a local outdoor lunch at this field site. In the afternoon, the team travelled to the forest reference plots hosted by our partner institution PT REKI (Harapan Rainforest), who manages 100.000 ha of an Ecosystem Restoration Concession in the south of Jambi Province. This is one of the few places in Jambi Province where old growth tropical lowland rainforest of considerable size is present.

On the last morning of the field visit, the team went to the forest core plots in Harapan Rainforest where key results of groups A and B were discussed: forest in relation to the three other land-use systems regarding climate and soil as well as vegetation structure and diversity of the different plant and animal groups (see Chapter 1, groups A and B). Thereafter, the group continued to the Biodiversity enrichment experiment at the oil palm plantation PT Humusindo (see Chapter 2, B11, C08 and foci 1 to 4). Tree islands of different size and varying tree species diversity and composition were established in 2013 to study gap enrichment plantings as suitable measure for biodiversity enrichment. Results from socio-economic and ecological trade-off analyses were presented and discussed.

The on-site evaluation ended in the evening at Jambi city. Part 2 of the review of the project was conducted at the University of Göttingen on September 23 and 24, 2015.

*By EFForTS coordination team*

**Photo 1:**
Sitting in front from left to right:
Ms. Brit Redöhl (Programme Director Research Centers, DFG Bonn), Dr. Ir. Rosyani (Speaker of group C at UNJA, counterpart of C02 & C03).

First row from left to right:
Prof. Zulkifli Alamsyah (Member of the Management Board Indonesia, counterpart of C01 & C07), Wolfram Lorenz (Coordination Head Office Indonesia), Dr. Aiyen Tjoa (Member of the Management Board Indonesia, counterpart of A05), Prof. Damayanti Buchori (Member of the Management Board Indonesia, counterpart of B09 & Z02), Dr. Leti Sundawati (Speaker group B at IPB, counterpart of B11), Dr. Upik Yelianti (Speaker group B at UNJA, counterpart of B07), Dr. Surya Tarigan (Speaker group A at IPB, counterpart of B10), Prof. Anas Fauzi (Speaker of the Indonesian Consortium – EFForTS), Prof. Stefan Scheu (Speaker of the CRC – EFForTS), Mr. Mohammad Zuhdi (Counterpart of B05), Prof. Edzo Veldkamp (Speaker group A at UGoe, PI A05)

Second row from left to right:
Prof. Matin Qaim (Member of the Management Board Göttingen, PI C07), Prof. Jörg Bendix (Philipps-Universität Marburg), Prof. Timo Goeschl (Ruprecht-Karls-Universität Heidelberg), Prof. Alexander Knohl (Member of the Management Board Göttingen, PI A03 & Z02), Dr. Christoph Limbach (Programme Director Life Sciences DFG Bonn), Prof. Teja Tscharntke (Speaker group B at UGoe, PI B09), Prof. Iskandar Siregar (Member of the Management Board Indonesia, counterpart of B03), Prof. Sven Bacher (University of Fribourg), Dr. Bambang Irawan (Representative of the CRC at UNJA, counterpart of B03, B07, B11), Prof. Rüdiger Korff (Universität Passau), Dr. Asmadi Saad (Counterpart of A01), Prof. Bernhard Brümmer (PI C01), Prof. Holger Kreft (Member of the Management Board Göttingen, PI B06 & B11), Dr. Jochen Drescher (Postdoctoral researcher Z02), Dr. Vijesh Krishna (Postdoctoral researcher C07), Prof. Heiko Faust (Member of the Management Board Göttingen, PI C02), Prof. Meike Wollni (Speaker group C at UGoe, PI C08), Dr. Katja Rembold (Postdoctoral researcher B06).

## Z01 – Central tasks

### Management

EFForTS successfully established managerial structures that allow a smooth project implementation at international level. Various boards have been set up to guide the project. The Joint Management Board (JMB) consists of the members of the German and the Indonesian Management Boards, and directs the long-term research and development planning. Furthermore, a Convention on Biological Diversity (CBD) Board has been established. Elected scientists from all participating universities monitor the implementation of the CBD guidelines at project level. Other important boards are the Data Management Board and the Publication Board.

### Agreements

The CRC has achieved a number of important milestones in Phase 1:

- The Memorandum of Agreement (MoA) between the University of Göttingen and the Indonesian University Consortium (2012).
- The counterpart agreements (2012), i.e. agreements between German PIs and their Indonesian counterparts.
- The agreements with plot owners for the establishment of research plots (2012).
- The MoA with PTPN VI in 2013; PTPN VI is a state-owned oil palm estate where our meteorological tower (see Chapter 1, A03) is installed. It will likely host the new oil palm management experiment planned for Phase 2.
- The Material Transfer Agreements (MTA, 2013).
- The Data Exchange Agreement (2013).
- The Technical Agreement with PT Humusindo (2014); PT Humusindo is a private oil palm company where the enrichment planting experiment has been established (see Chapter 2).
- The Agreement on the Publication Policy (2014).
- The Establishment of the mirror data server at LIPI (2014; see Chapter 1, INF).
- The established agreements result in a transparent, open and trustful collaboration, taken by authorities in Indonesia as a best practice example for international collaboration in science.

**Photo 2:** The EFForTS coordination team Mira Kartikasari (IPB, left) and Rizky Febrianty (UNJA, right).

**Photo 3:** The EFForTS coordination team at IPB (from left to right: Indri Hapsari, Megawati Syafni – UNJA, Mira Kartikasari, Arintha Traya Soegiarso).

**Photo 4:** Central research hub at the PT Humusindo oil palm estate (near Bungku village, Harapan region). The management of PT Humusindo enabled us to build a research station with a small field laboratory and accommodation funded by the DFG.

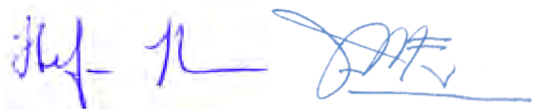
**Administration and research infrastructure in the field**

Two regional coordination offices were set up in Bogor (Bogor Agricultural University – IPB) and in Jambi (Jambi University – UNJA) to manage the multiple tasks on-site. Bogor serves as the central hub for additional cooperation partners, governmental and non-governmental stakeholders and administration institutions. Also, permits and the import-and-export of samples and equipment as well as the financial accounting of project funds was processed at IPB (Photo 2, 3).

In Jambi, UNJA is the (local) logistics centre. It connects to local authorities at district and village level. The UNJA office coordinates the operational management of the research plots and transportation to the study sites. The university has provided EFForTS with a large building with laboratory, office and storage rooms as well as two guest houses for the researchers (Photo 4, 5, 6).

In the field we established four research hubs, two at rainforest sites and two at villages providing basic infrastructure including accommodation, electricity, internet, motorcycles and two small field labs (Photo 7, 8).

Enjoy reading!



*Stefan Scheu (Speaker of the CRC 990), Anas M. Fauzi (Speaker Indonesian Universtity Consortium of the CRC 990)*

**Photo 7 and 8**: Local house of EFForTS in Batu Kucing – Bukit Duabelas region

**Photo 5:** EFForTS coordination office at UNJA.

**Photo 6:** The EFForTS coordination team at UNJA (from left to right: Yuking Linatra, Abdullah Darussalam, Rizky Febrianty, Megawati Syafni, Muhammad Fahrozi, Epriansyah).

# I. Highlights of Research Activities of Phase 1

## 1. Research activities of groups A, B, C, Z02 and INF

## Group A

FIELDS OF RESEARCH

- Environmental processes

GROUP COORDINATORS

Alexander Knohl, Edzo Veldkamp (University of Göttingen, UGoe); Suria Darma Tarigan (Bogor Agricultural University, IPB); Muhammad Damris (UNJA)

### A01

TITLE: **Prehistoric and historic rainforest transformations of the Jambi landscape**

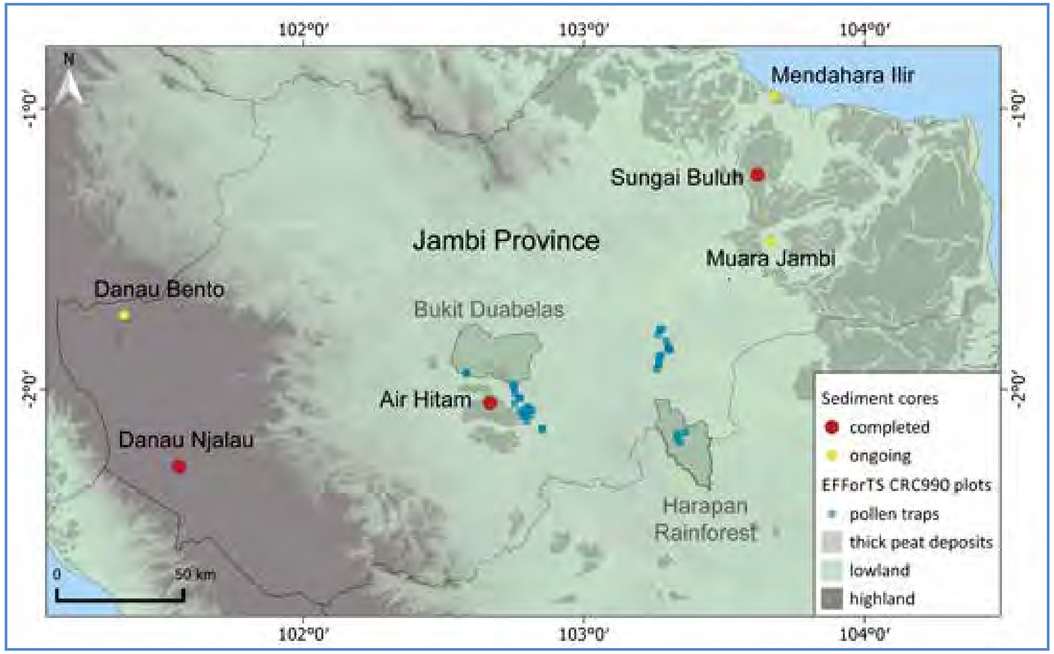
TEAM: Principle Investigators: Hermann Behling (UGoe), Supiandi Sabiham (IPB), Asmadi Saad (UNJA), Yudhi Achnopha (UNJA)
Scientific staff: Siria Biagioni (Postdoc), Christina Ani Setyaningsih, Kartika Hapsari (PhD students)

RESEARCH SUMMARY

Multi-proxy paleoecological and palaeoenvironmental analyses including pollen, testate amoebae, C and N isotopes, sedimentology and macro-charcoal were applied on sediment cores to reconstruct centennial to millennial scale vegetation, fire and climate variability in Province of Jambi (Fig. 1). Three sites are completed: Danau Njalau from the submontane ecosystems of the Kerinci National Park; Jaw SPT, from the inland peatland of Air Hitam; Sungai Buluh from a coastal peatland restoration area. Three additional sites were cored to be studied in the second phase (Fig.1). Palynological and sedimentological analyses of the Danau Njalau core indicate that volcanic deposition had a strong impact on the long-term vegetation dynamics of submontane rainforests in Kerinci. Forest succession to primary rainforest took 900 year since volcanic deposition in the soil ended Reconstructed long-term carbon accumulation rates (LORCA) from the two peatland sites of Air Hitam and Sungai Buluh revealed that LORCA was site-specific and largely dependent on vegetation cover and time. At Sungai Buluh pollen evidence of vegetation disturbance, suggests peatlands were impacted by human activities already at the time of the Malayu Empire in Jambi. Additionally, the first year (2013) set of pollen traps from the core plots was analyzed. Results indicate that land-use change affects pollen and spore rain influx and diversity which decreased from forest remnant to oil palm plots.

**Photo 9:** Looking for the right deposits to core. A01 team in Kerinci National Park, Jambi, Indonesia in 2013 (left: Siria Biagioni, postdoctoral researcher).

**Figure 1:** Location of A01 sites




## A02

**Photo 10:** (a und b): Setting up the sap flux equipment in a forest and an oil palm plot.

TITLE: **Tree and palm water use**

TEAM: Principle Investigators: Dirk Hölscher (UGoe); Herdhata Agusta, Hendrayanto (IPB); Heri Junedi (UNJA)
Scientific staff: Alexander Röll, Andrea Hanf, Niu Furong, Afik Hardanto (former PhD students)

RESEARCH SUMMARY

Rainforest transformation alters ecosystem water cycles with respect to the magnitude of fluxes, their spatial heterogeneity and their temporal variability. In the first study period, the focus was on mean stand transpiration rates in forests, jungle rubber and rubber and oil palm monocultures, which were assessed by sap flux methods. The estimated mean transpiration rate was highest for forests and lowest for rubber plantations (Fig. 2). Some oil palm plantations also reached high values.

Oil palm landscapes usually consist of a mosaic of mono-cultural, even-aged oil palm stands of different age. It was found that the water use per oil palm (Fig. 3a) and the stand-level oil palm transpiration (Fig. 3b) increased in the first five years followed by a pronounced variation among medium-aged stands. Across 15 studied oil palm stands, palm transpiration varied 12-fold. The highest value was observed in an intensively managed 12-yr-old oil palm plantation (2.5 mm day-1). Other water fluxes, e. g. from the soil, grasses or epiphytes, contributed substantially and variably to evapotranspiration, reducing the large difference between the lowest and highest transpiring stands to a less than two-fold difference in evapotranspiration (eddy covariance measurements, *A03 Knohl*).

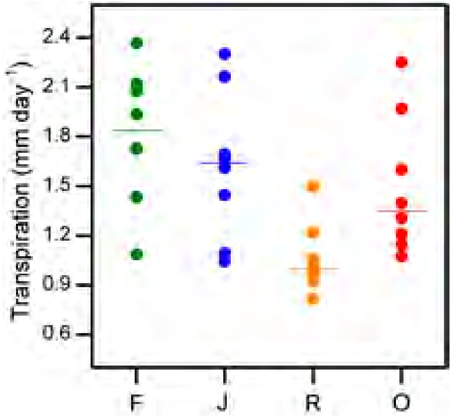
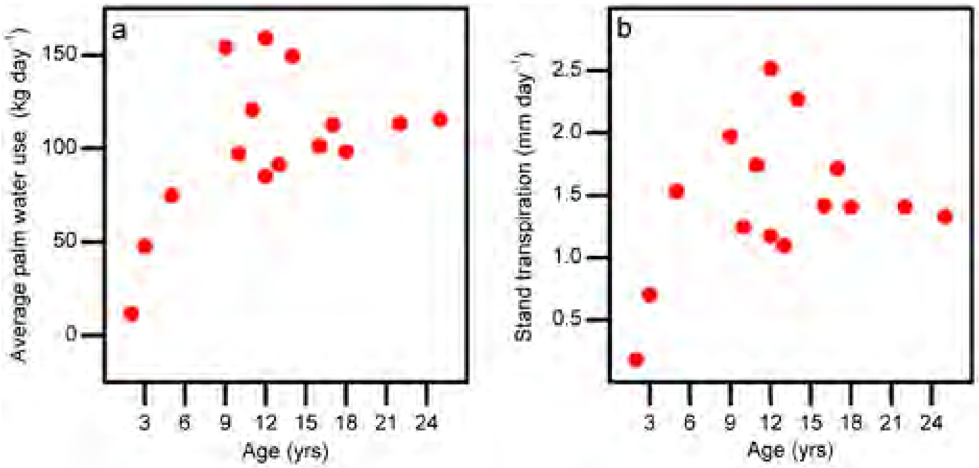



**Figure 2:** Plot-to-plot variation of transpiration rates in the four land use types forest (F), jungle rubber (J), rubber (R) and oil palm (O) on three sunny days. Data from 32 plots (8 per land-use type). Horizontal lines indicate means (Röll 2015).

**Figure 3:** Oil palm water use over age. (a) Per palm and (b) at the stand level, which is influenced by a decreasing number of stems per unit of area; three sunny days averaged (Röll *et al.* 2015).




## A03

**Photo 11:** Eddy covariance instrumentation, including a sonic anemometer and infrared gas analyzer for $H_2O$ and $CO_2$ fluxes, installed at the top of the climate tower in PTPN VI.

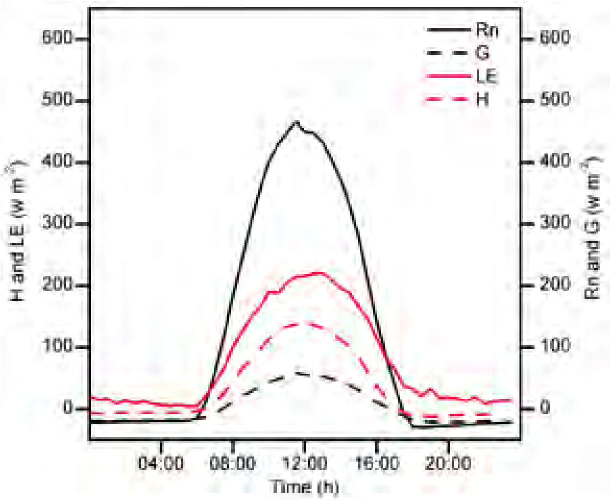
TITLE: **Influence on local and regional climate**

TEAM: Principle Investigators: Alexander Knohl (UGoe); Tania June (IPB); Heri Junedi (UNJA); Abdul Rauf (UNTAD); Dodo Gunawan (Badan Meteorologi Klimatologi, Dan Geofisika – BMKG)

Scientific staff: Ana Meijide, Andre Ringeler (Postdocs); Yuanchao Fan, Clifton Sabajo (PhD students), Edgar Tunsch, Malte Puhan (Technicians)

RESEARCH SUMMARY

We successfully installed a climate tower in oil palm plantations, with the aim of evaluating energy, water, $CO_2$ and $CH_4$ fluxes using the eddy covariance technique. In order to assess the effect of oil palm cultivation at its different stages of development, we first installed the tower in 2013 for 8 months in a



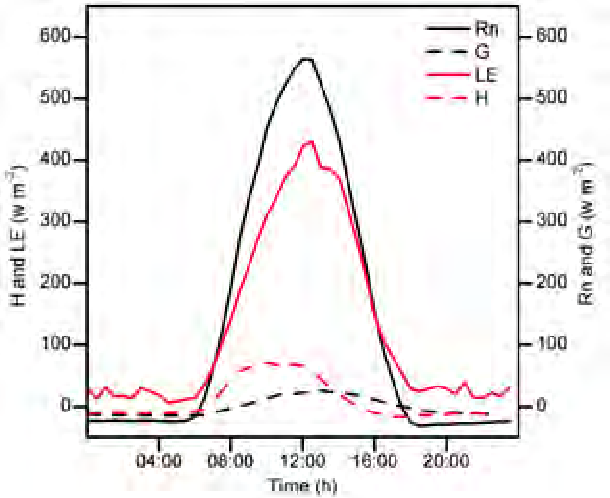
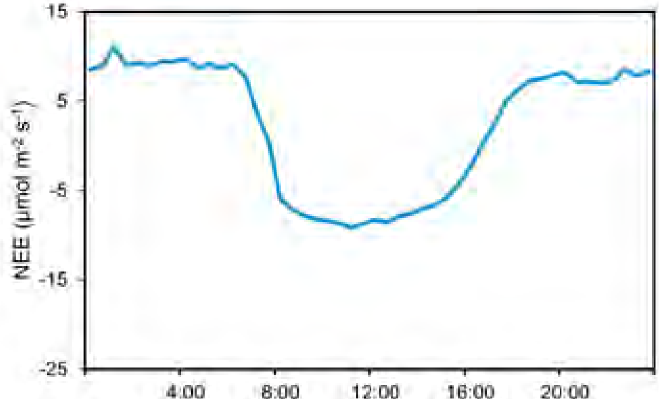




**Figure 4:** Mean diurnal cycles of sensible heat flux (H), latent heat flux (LE), net radiation (Rnet) and soil heat fluxes (G) in the (a) 2-yr old non-productive and (b) 12-yr old mature plantations.

2-yr old non-productive plantation. Since March 2014, the tower is now measuring continuously in a 12-yr old mature plantation in PTPN VI- Batang Hari unit.

Our results highlight the existence of strong differences in the studied fluxes from young to mature oil palm plantations. The 12-yr old plantation used most energy for latent heat fluxes due to high evapotranspiration rates (Fig. 4b). The 2-yr old plantation had lower evapotranspiration and thus produced relatively speaking more sensible heat (Fig. 4a). This indicates that young oil palm plantations result in stronger surface and local atmospheric heating. Similar differences were also observed in $CO_2$ fluxes, with lower uptake rates in the 2-yr old plantation (Fig. 5a) than in the in the 12-yr old (Fig. 5b). This indicates that oil palm plantations act as strong carbon sources in early stages of development and as a strong carbon sinks as mature plantations (not considering carbon export via harvest).

The environmental variables and fluxes measured in our climate towers have been used to calibrate and validate the Community Land Model (CLM) for oil palm, or to validate remote sensing products, both allowing to evaluate the broader effect of oil palm expansion on ecosystem greenhouse gas and energy fluxes.



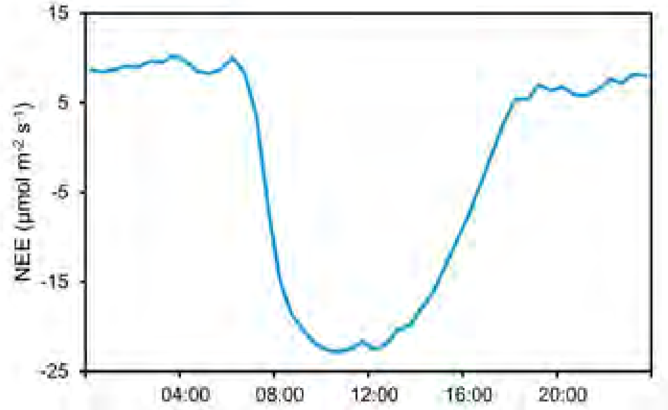




**Figure 5:** Mean diurnal cycles of $CO_2$ net ecosystem exchange (NEE) in the (a) 2-yr old non-productive and (b) 12-yr old mature plantations. Negative values indicate $CO_2$ uptake, positive values $CO_2$ release.

## A04

TITLE: **Stock, turnover and functions of carbon in heavily weathered soils under lowland rainforest transformation systems**

TEAM: Principle Investigators:
Yakov Kuzyakov (UGoe); Kukuh Murtilaksono (IPB); Muhammad Damris (UNJA)
Scientific staff: Thomas Guillaume (former PhD student)

RESEARCH SUMMARY

We investigated soil organic carbon (SOC) and its soil fertility functions in the transformation systems. Thanks to the good collaboration with other scientific projects, we were able to extended our research area from the core plots to plots that will be extensively investigate during the second phase (e. g. PTPN VI) and to the region level (e. g. plantations from household survey).

We observed a strong decrease of SOC content in the topsoil of the plantations, depending on land-use intensity; e. g. up to 70 % SOC decrease under oil palm plantations (Fig. 6). Soil erosion, estimated by the isotopic signature of SOC, was high in rubber and oil palm plantations, pointing out the negative impact of reduced ground cover in intensive plantations. SOC losses were limited to the topsoil and were small relative to the C losses from the biomass. Nevertheless, it had a strong impact on microbial activity, and thus on soil fertility. Oil palm and rubber plantations had a similar impact in term of SOC losses and erosion. However, SOC under oil palm was depleted in labile SOC pool, showed reduced SOC turnover and had a lower microbial activity than under rubber (Fig. 7). This suggested that oil palm plantations have a stronger negative impact on soil fertility than rubber because of the absence of C input from leaf litter in oil palm plantations.

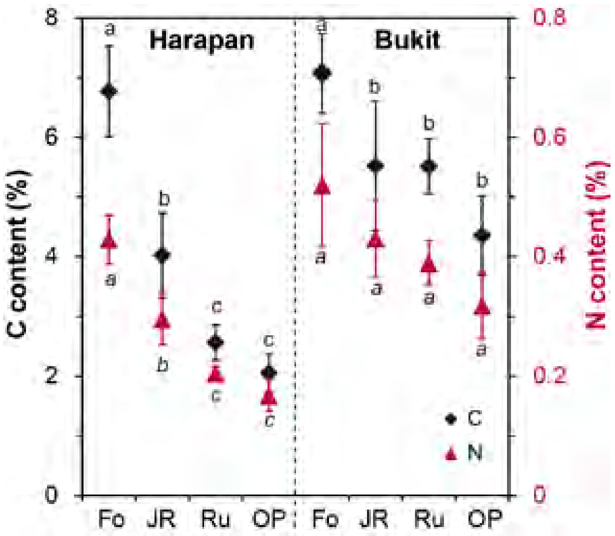



**Figure 6:** Carbon and nitrogen contents in the Ah horizons under (Fo) forest, (JR) jungle rubber, (Ru) rubber and (OP) oil palm plantations in Harapan and Bukit regions.

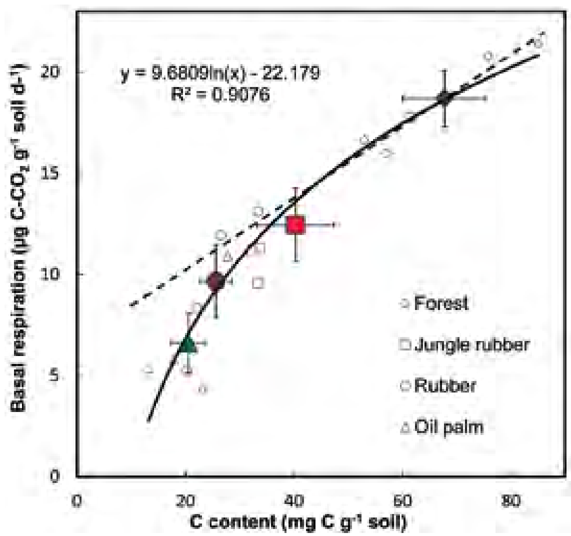



**Figure 7:** Relationship between basal respiration and C content (solid line) fitted with the 16 sites from Harapan region (empty symbols). The basal respiration, i. e. an indicator of microbial activity, is resistant at high C content but strongly decreases at low C content.

At the region level, soil under oil palm plantations had lower SOC content and high compaction in the topsoil (Fig. 8). The high frequency of oil palm plantations having highly degraded soil or established on peat soils raises concern about the sustainability of oil palm cultivation in the province.

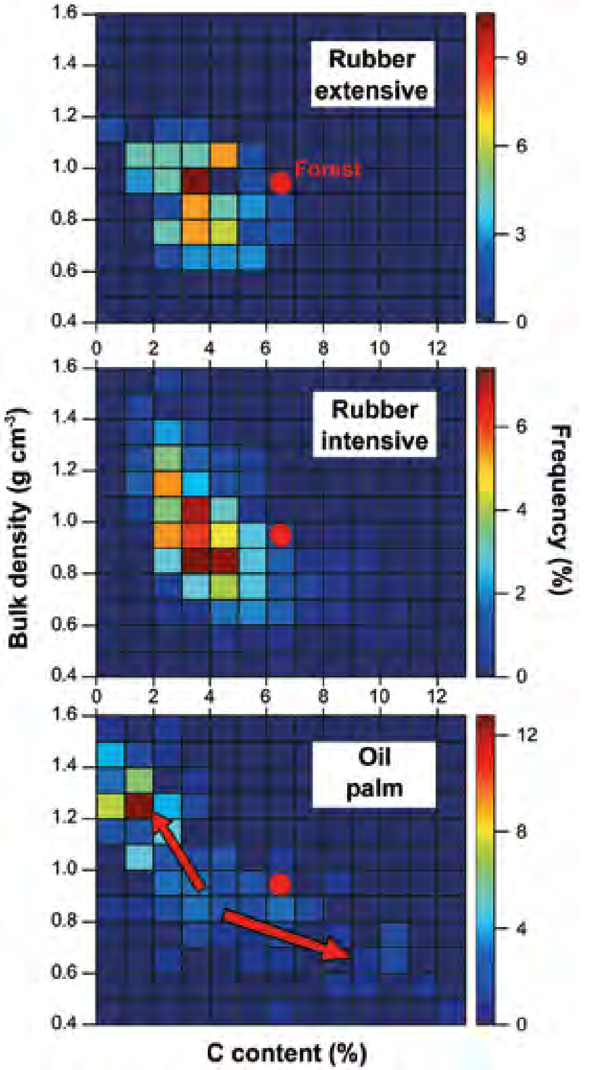



**Figure 8:** Distributions of C content and bulk density in mineral soils under three land-use types: extensive and intensive rubber, and oil palm plantations. The red dots correspond to the mean C content and bulk density in Harapan and Bukit forest sites.

A05

**Photo 12:** Soil sampling in the field (left: Kara Allen, former doctoral researcher in the scientific project A05).

TITLE: **Trace gas fluxes and soil N cycling under rainforest transformation systems**

TEAM: Principle Investigators: Marife D. Corre, Edzo Veldkamp (UGoe); Muhammad Damris (UNJA); Sri Rahayu Utami (University of Brawijaya – UB); Aiyen Tjoa (UNTAD)
Scientific staff: Kara Allen, Evelyn Preuß, Syahrul Kurniawan (former PhD students)

RESEARCH SUMMARY

Tropical deforestation for the establishment of tree cash crop plantations causes significant alterations to soil organic carbon (SOC) dynamics. Despite this recognition, the current Intergovernmental Panel on Climate Change (IPCC) tier 1 method has a SOC change factor of 1 (no SOC loss) for conversion of forests to perennial tree crops, because of scarcity of SOC data. In this pantropic study, conducted in active deforestation regions of Indonesia, Cameroon, and Peru, we quantified the impact of forest conversion to oil palm (Elaeis guineensis), rubber (Hevea brasiliensis), and cacao (Theobroma cacao) agroforestry plantations on SOC stocks within 3-m depth in deeply weathered mineral soils (i. e. Acrisols and Ferralsols). We also investigated the underlying biophysical controls regulating SOC stock changes. Using a space-for-time substitution approach, we compared SOC stocks from paired forests (n = 32) and adjacent plantations (n = 54). Our study showed that deforestation for these plantations decreased SOC stocks by up to 50 % (Fig. 9). The key variable that predicted SOC changes across plantations was the amount of SOC present in the forest before conversion – the higher the initial SOC, the higher the loss (Fig. 10). Decreases in SOC stocks were most pronounced in the topsoil, although older plantations showed considerable SOC losses below 1-m depth. Our results suggest that (i) the IPCC tier 1 method should be revised from its current SOC change factor of 1 to 0.6 ± 0.1 for oil palm and cacao agroforestry plantations and 0.8 ± 0.3 for rubber plantations in the humid tropics; and (ii) land use management policies should protect natural forests on carbon-rich mineral soils to minimize SOC losses.

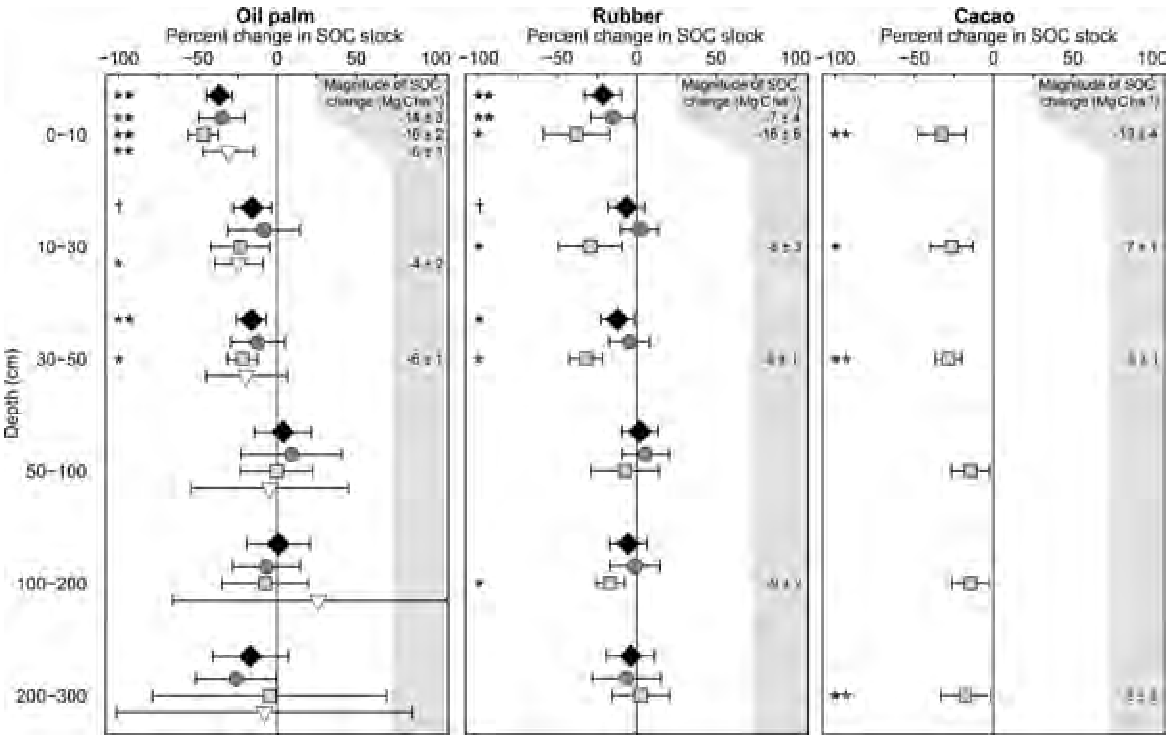



**Figure 9:** Relative change ((forest – plantation) / forest x 100) in soil organic carbon (SOC) stock in the 0-3-m depth of the three plantation types: across three regions ( ), Indonesia ( ), Cameroon ( ) and Peru ( ). Error bars indicate the 95% confidence intervals based on the Student's T distribution. Statistical significance is based on linear mixed effects models at p ≤ 0.10 (†, marginally significant), p ≤ 0.05 (*) and p ≤ 0.01 (**). Cumulative decreases in SOC stocks (considering only the depths with significant changes) for oil palm were 14±3 Mg C ha 1 (n = 11) in Indonesia, 22±1 Mg C ha 1 (n = 5) in Cameroon and 10±2 Mg C ha 1 (n = 5) in Peru. Cumulative decreases in SOC stocks for rubber were 7±4 Mg C ha 1 (n = 16) in Indonesia and 41±3 Mg C ha 1 (n = 6) in Cameroon. SOC loss for cacao agroforest was 35±2 Mg C ha 1 (n = 11) in Cameroon. The magnitude of SOC losses for the depths with significant changes are presented in the gray-shaded area.

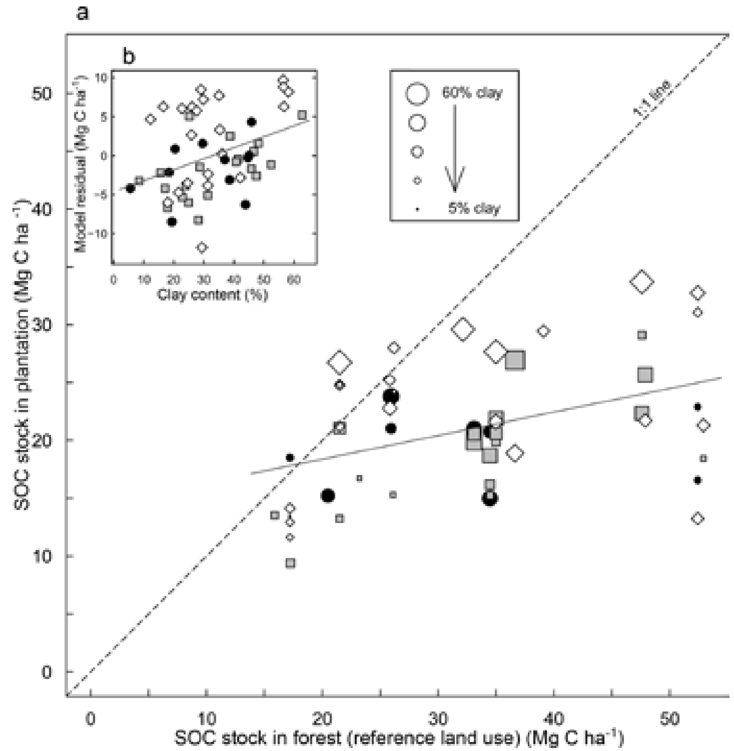



**Figure 10: (a)** The higher the initial soil organic carbon (SOC) stock, the larger the SOC losses, evident from the slope (slope = 0.21, which is significantly different from the 1, p ≤ 0.01) of the regression model (R2 = 0.18, p ≤ 0.01, n = 54) of SOC stocks within 0-10-cm depth between paired reference forests and oil palm ( ), rubber ( ) and cacao agroforestry ( ) plantations. The size of the data points is proportional to the soil clay percentage measured in the plantation plots. **(b)** The residuals of the regression model explained by clay contents of the soils (R2 = 0.14, p = 0.01, n = 54).

## Group B

FIELDS OF RESEARCH

- Biota and ecosystem services

GROUP COORDINATORS

Teja Tscharntke, Holger Kreft (UGoe); Leti Sundawati (IPB); Upik Yelianti (UNJA)

### B01

**Photo 13:** The two former doctoral researchers (Andrew Barnes, left and Malte Jochum, right) and their field assistant (Megawati – Jambi University, middle) preparing for fieldwork.

TITLE: **Structure, stability and functioning of macro-invertebrate communities in rainforest transformation systems in Sumatra (Indonesia)**

TEAM: Principle Investigators: Ulrich Brose (UGoe); Achmad Farajallah, Tri Heru Widarto, Noor Farikhah Haneda (IPB)
Scientific staff: Andrew Barnes, Malte Jochum (former PhD students)

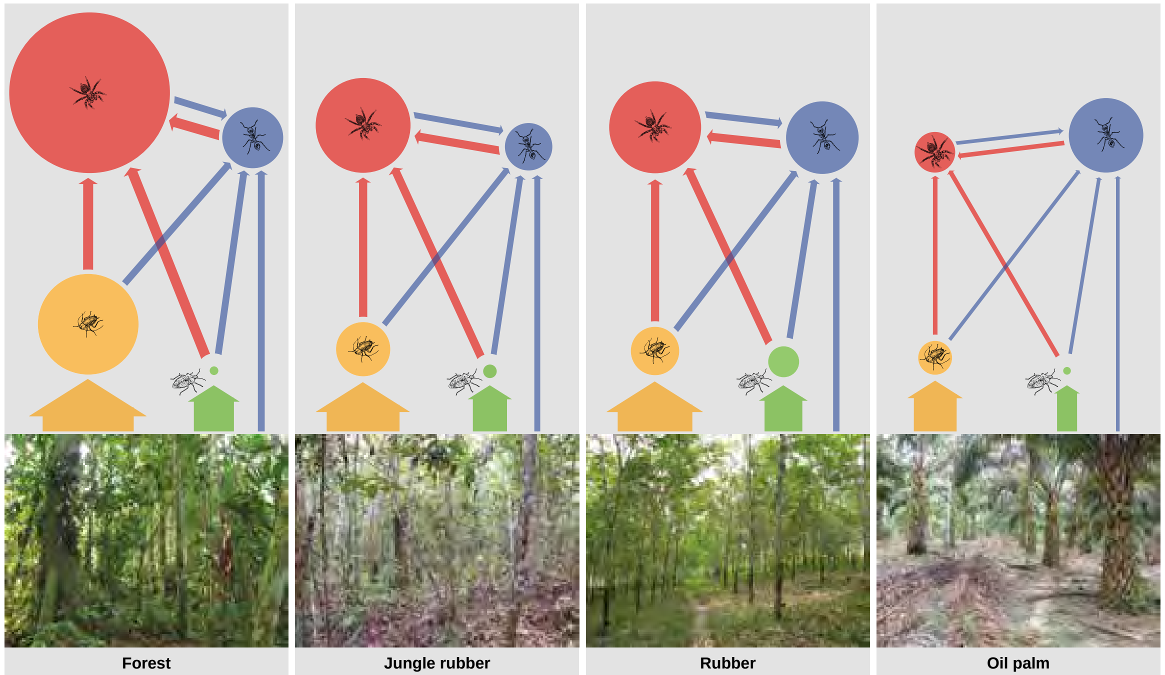



**Figure 11**: Energy networks displaying the relative annual energy flux (coloured arrow width weighted by calculated energy flux (kg ha−1 per year)) and biomass (coloured node diameter weighted by total biomass) among the functional feeding guilds: predators (red), omnivores (blue), detritivores (yellow) and herbivores (green). Each panel represents an energy network for one of the four land-use transformation systems.

ROGRESS / CURRENT STATUS

During the first phase of EFForTS, we achieved a number of important milestones. Notably, three articles have already been published in internationally renowned journals. In one of these papers, we developed a method for calculating energy flux as a measure of multi-trophic ecosystem functioning and quantified how intensified land-use results in loss of whole-community ecosystem functioning (Fig. 11; Barnes *et al.* 2014). Following this, we published a paper that indicates how functional stability of these invertebrate communities is threatened, indicated by the loss of redundant species within functional groups (Mumme *et al.* 2015). Most recently, we combined our data collected in Jambi, Indonesia with similar data from the Biodiversity Exploratories project in Germany to investigate the mechanisms that drive spatial turnover in ecosystem functioning across landscapes (Barnes *et al.* 2016). Furthermore, we are currently preparing or revising three other manuscripts for publication. These manuscripts, which have already been through at least one round of review, test questions such as how resource stoichiometry affects consumer diversity and biomass, how consumers across different trophic levels respond to changing resource quality, and how land-use intensification alters multi-taxa systems directly or indirectly via cascading effects – a project that has developed from a collaboration among at least six other subprojects within the CRC 990.

## B02

TITLE: **Impact of rainforest transformation on phylogenetic and functional diversity of soil prokaryotic communities in Sumatra (Indonesi**a)

TEAM: Principle Investigators: Rolf Daniel (UGoe); Nisa Mubarik, Iman Rusmana, Anja Meryandini (IPB)
Scientific staff: Dominik Schneider (Postdoc)

RESEARCH SUMMARY

Prokaryotes are the most abundant and diverse group of microorganisms in soil and mediate virtually all biogeochemical cycles in terrestrial ecosystems. Thereby, they influence aboveground plant productivity and diversity. In this project, the impact of rainforest conversion to intensively managed land use systems on soil prokaryotic communities was investigated. The studied managed land use system comprised rubber agroforests (jungle rubber), rubber plantation and oil plantations within two Indonesian landscapes Bukit Duabelas and Harapan. To identify changes in indigenous

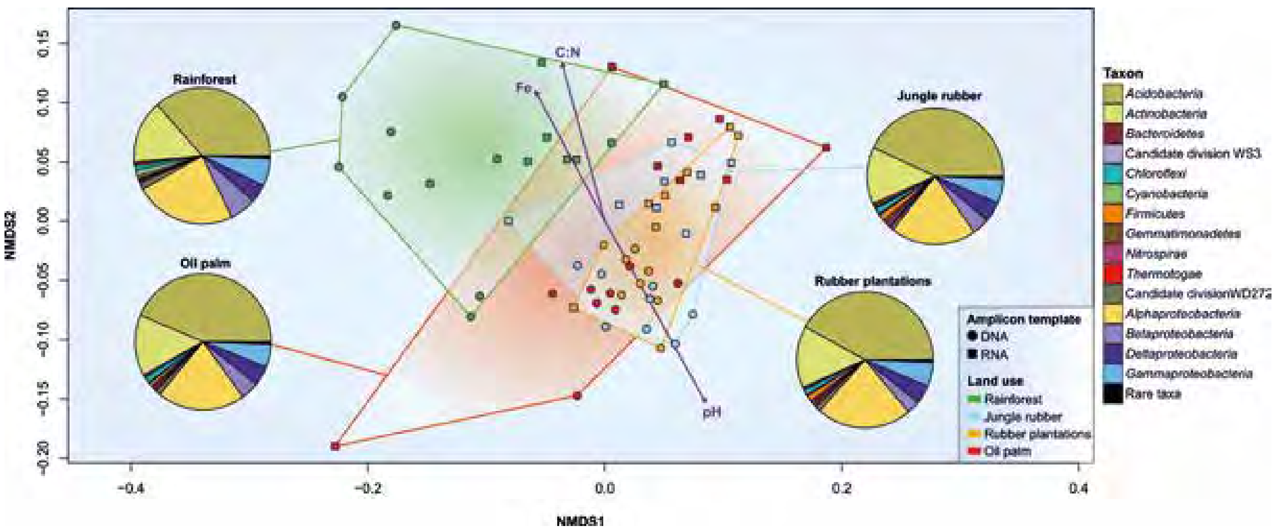



**Figure 12:** Bacterial community composition and nonmetric multidimensional scaling (NMDS) of community composition in all core plots of the land use systems rainforest, jungle rubber, rubber and oil palm based on weighted Unifracdistance matrices. Significant correlations of environmental parameters to community composition are shown by purple arrows.

gene- and taxon-specific patterns and key metabolic functions accompanying rainforest transformation, comparative phylogenetic and functional profiling of soil microbial communities were performed. So far, we compared soil prokaryotic (Bacteria and Archaea) community composition, diversity and function of the four systems by culture-independent DNA-based metagenomic (entire community level) and RNA-based metatranscriptomic (active community level) approaches at all core sites. Soil prokaryotic community composition and diversity were assessed by pyrotag sequencing of bacterial and archaeal 16S rRNA genes. Changes in indigenous taxon-specific patterns of soil prokaryotic communities accompanying lowland rainforest conversion to jungle rubber, and intensively managed rubber and oil palm plantations were encountered (Fig. 12). Distinct clustering of the rainforest soil communities indicated that these are different from the communities in the studied managed land use systems. Overall, the bacterial community shifted from proteobacterial groups in rainforest soils to Acidobacteria in managed soils. The archaeal soil communities were mainly represented by *Thaumarchaeota* and *Euryarchaeota*. Against expectations, the diversity of the soil prokaryotic communities was higher in managed land use systems than in rainforest. In the case of bacteria, this was related to soil characteristics such as pH value, exchangeable Ca and Fe content, C to N ratio, and extractable P content. Archaeal community composition and diversity were correlated to pH value, exchangeable Fe content, water content, and total N. The distribution of bacterial and archaeal taxa involved in biological N cycle indicated functional shifts of the cycle during conversion of rainforest to plantations.

## B04

**Photo 14:** (left) Excavating soil pits for root biomass estimate, (right) Martyna Kotowska: measuring canopy cover with spherical densiometer close to a litter trap.

TITLE: **Carbon sequestration, litter C input to the soil, and resource use-efficiency**

TEAM: Principle Investigators: Dietrich Hertel, Christoph Leuschner (UGoe); Cecep Kusmana, Triadiati Antono, Elias (IPB); Rahmi Dianita (UNJA)
Scientific staff: Bernhard Schuldt (Postdoc); Martyna Kotowska, Yasmin Abou Rajab (former PhD students)

RESEARCH SUMMARY

We analysed the consequences of forest conversion on carbon stocks in standing above- and belowground biomass and C sequestration in net primary production. Total tree biomass in the natural forest stands was more than two times higher than in jungle rubber stands and more than four times higher than in monoculture rubber and oil palm plantations. Similarly, NPP decreased from the natural forest with increasing land-use intensity towards the rubber plantations, but was highest in the oil palm system due to very high fruit production. Notably, leaf litter and oil palm fruits in this system are only partly returned to the soil due to harvesting and palm frond pruning management. Therefore, we conclude that conversion of natural lowland forest into different agricultural systems leads to a strong reduction not only in the biomass carbon pool (up to 166 Mg C ha$^{-1}$) but also in the C sequestration potential via long-term biomass accumulation which was highest in the natural forest (Fig. 13). Combining productivity data with sap flow measurements, we estimated that the water-use efficiency (WUE) was comparable across the natural forest and the rubber land-use systems, while the oil palm plantations had a significantly higher WUE. Vice versa, oil palm stands had markedly lower nutrient-use efficiency (on a canopy level) regarding the usage of elements N, P, K, and Ca. Moreover, under current land-use and climate change in tropical lowlands we expect further increases in seasonality of net primary production in the landscape as well as potentially increasing drought stress and decreasing nutrient cycling in these originally highly biodiverse and carbon dense regions.

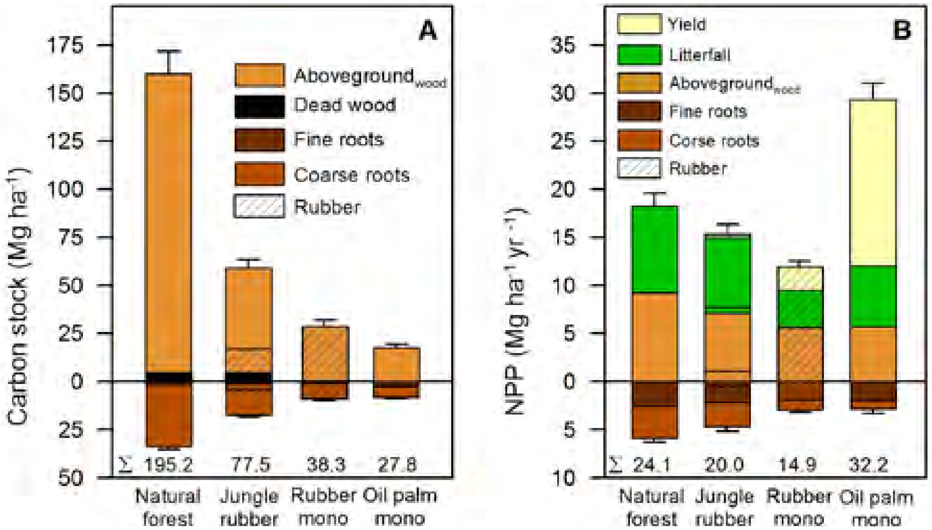



**Fig. 13: A:** Above- and belowground carbon stock (Mg ha$^{-1}$) and **B:** Net primary production (Mg ha$^{-1}$ yr$^{-1}$) of the four land-use systems in Jambi, Sumatra. Shown are means ± SE (n = 8).

## B05

**Figure 14:** Improving biomass estimates of buttressed trees: terrestrial laser scanuof *Sterculia foetida*.

TITLE: **Methodological approaches to the assessment of all tree resources in transition systems in forested tropical landscapes**

TEAM: Principle Investigators: Christoph Kleinn (UGoe); I Nengah Surati Jaya, Tatang Tiryana (IPB); Muhammad Zuhdi (UNJA)
Scientific staff: Lutz Fehrmann, César Pérez-Cruzado (Postdocs); Dian Nuraini Melati (PhD student)

RESEARCH SUMMARY

We conducted field sampling of tree resources in the four transformation systems with n = 35 forest inventory plots in secondary forests S, n = 4 in jungle rubber J, n = 9 in oil palm O, and n = 11 in rubber plantation R. The goal was to estimate the characteristics of different land use systems regarding stand structure (i. e. basal area, tree density, and species diversity). An example result is shown in Figure 16. Forest inventory was done in very close collaboration with PT REKI.

A manuscript on forest structure analysis is currently being prepared.

Furthermore, we studied the historical land use change in Jambi Province for the years 1990, 2000, 2011, and 2013. A first preliminary results was published in Melati *et al.* (2014). We found that SF is most heavily affected by the land transformation processes; a manuscript is in preparation that analyses the increasing fragmentation and decreasing area of secondary forests. The historical land use maps as shown in Figure 15 were produced in close collaboration between IPB (lead), UNJA and Göttingen (Access and Benefit Sharing / ABS project, see page 49) Resulting from a successful proposal to the RapidEye Science Archive (RESA) of German Aerospace Center (DLR), we received RapidEye images for the study area of CRC. From this imagery, the existing land use pattern for selected study areas was mapped at higher spatial resolution. These land use maps have been uploaded to EFForTS-WebGIS, which was developed by B05 for the CRC as a means to illustrate spatial data sets and share them internally and thus facilitating collaborations.

Additional studies were conducted to address relevant issues in forest monitoring: one study addressed the challenge to estimate biomass of buttressed trees (see Fig. 14 from Nölke *et al.*, 2015). A further methodological study addressed the challenge to evaluate whether an available biomass model may be suitable for application at a particular site (Pérez-Cruzado *et al.* 2015) did study on the methodology to decide model suitability for biomass estimation. An ongoing collaboration with B04 looks into an approach to the specific (individual) measurement of wood density where CRC data are put into a global context (publication pending).

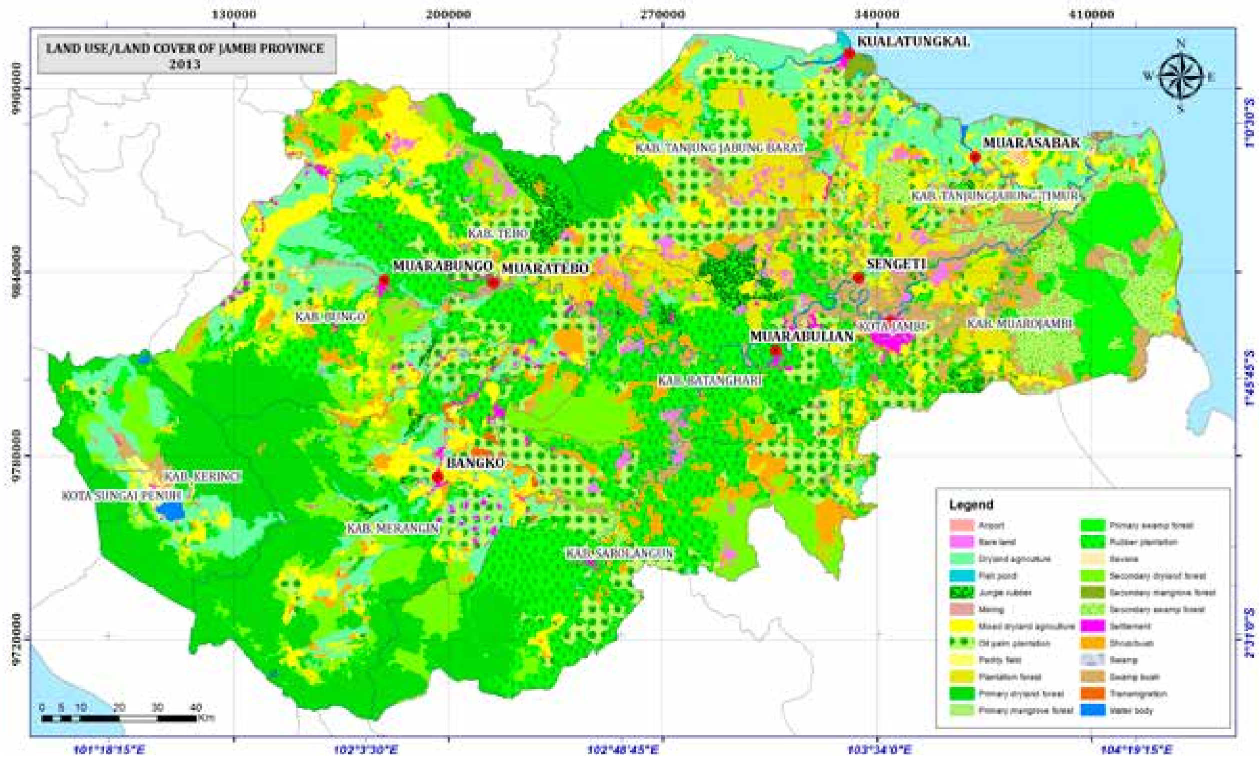


**Figure 15:** Land use map 2013 of Jambi Province (also produced for 1990, 2000, 2011), a product from the cooperation between IPB and UNJA.

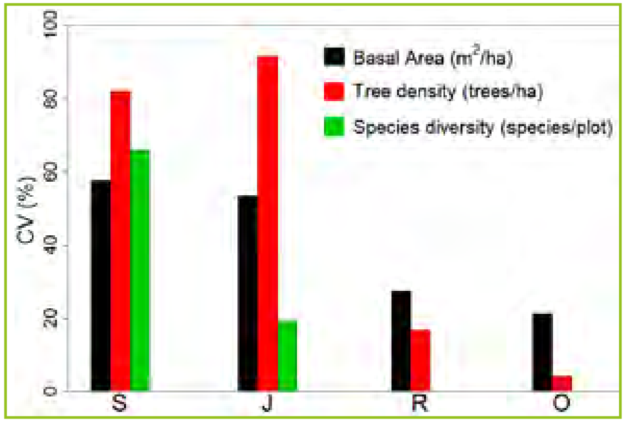


**Figure 16:** Variability (CV%) of some stand variables in the four land use systems, resulting from field sample plots (S=secondary forest; J=jungle rubber, R=rubber plantations and O=oil palm plantations).

## B06

TITLE: **Plant diversity**

TEAM: Principle Investigators: Holger Kreft (UGoe); Hardianto Mangopo (IPB/UGoe); Sri Sudarmiyati Tjitrosoedirdjo, Indah Wahyuni (IPB); Bambang Haryadi (UNJA)
Scientific staff: Katja Rembold (Postdoc)

RESEARCH SUMMARY:

We investigated different dimensions of plant diversity in the four systems. The focus of the first phase was on inventorying the diversity of vascular plants in all core plots in order to assess the effects of land-use changes on plant diversity and key structural parameters. Within the 32 core plots, 1,697 species and morphospecies of vascular plants were identified including 841 trees, 453 shrubs, 367 herbs and 36 morphospecies that were only encountered as seedlings. Forests had significantly higher species richness per plot than the other land use systems followed by jungle rubber (Fig. 18). Oil palm plantations had the highest density of understorey plants, but lowest understorey species richness and a significantly lower tree density than all other systems. Understorey plants in forest and jungle rubber occurred in lower densities but were significantly taller compared to plantations. Jungle rubber had a similar tree density as forest, but significantly lower basal area (Fig. 18). Preliminary data on native and naturalized alien plants for the Bukit Duabelas landscape showed that forest plots were by far the least invaded system and almost entirely composed by indigenous species. An important factor contributing to the lower species numbers in plantations are differences in stand structure and light: canopy openness was significantly higher in plantations than in forest and jungle rubber and correlated negative-

**Photo 15:** B06 team and topics – upper row (always from left to right): Holger Kreft, Marlene Schmitz, Judith Krobbach, Sri S. Tjitrosoedirdjo, Tim Böhnert, Miki Nomura, Indah Wahyuni, Dirga; second row: Arne Wenzel, Yayan Wahyu C. Kusuma, Christian Altenhövel, Mei L. Mardalena, Lukas Beeretz, Dima, Katja Rembold, Hardianto Mangopo; third row: colour guide „Common wayside plants of Sumatra", herbarium specimen, online Sumatra plant database.

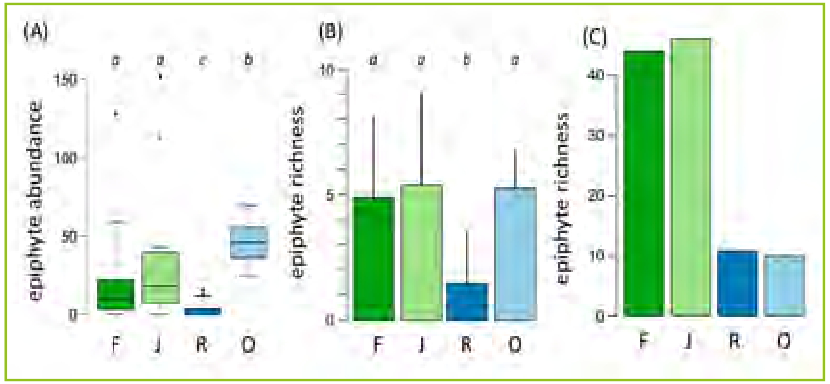



**Figure 17:** Plot-level (A) epiphyte abundance (individuals plot-1), and (B) species richness of vascular epiphytes in the four land-use systems (n=30 plots per system). Letters indicate significant differences among systems (ANOVA results / Tukey's Honest Significant Differences, $p<0.05$); (C) total number of epiphyte species recorded in each system. Abbreviations: F – forest, J – jungle rubber, R – rubber, O – oil palm.

ly with species richness (p<0.001). Rapid colour guides and a preliminary version of an online plant database were designed (beta version available at http://134.76.19.22/sumatra/home) to help EFForTS researchers and others with plant identification.
Due to their relevance for canopy biota and indicator value, vascular epiphytes, i.e. plants that grow non-parasitically on trees, represented a special model group and were intensively studied in the first phase. In 120 epiphyte plots, we recorded a total of 3,955 individuals of vascular epiphytes belonging to 81 species and 20 families. Oil palm plantations had the highest epiphyte abundance per plot (Fig. 17A), but jungle rubber had the highest total epiphyte abundance: 48 % (1,933 individuals) of all individuals were recorded in jungle rubber and 35 % (1,385 individuals) in oil palm plantations. Despite the high epiphyte density in oil palm plantations, the mean epiphyte species diversity per plot did not differ significantly from forest and jungle rubber (Fig. 17B). Contradicting the general notion, the overall richness of the epiphyte flora in oil palm plantations is surprisingly poor (10 species, 7 families) and almost entirely composed of fern generalist. Rubber plantations had the lowest abundance and richness at the plot scale, but had slightly higher total species numbers (11 species, 6 families) than oil palm plantations (Fig. 17C) (Böhnert *et al.* unpublished manuscript).

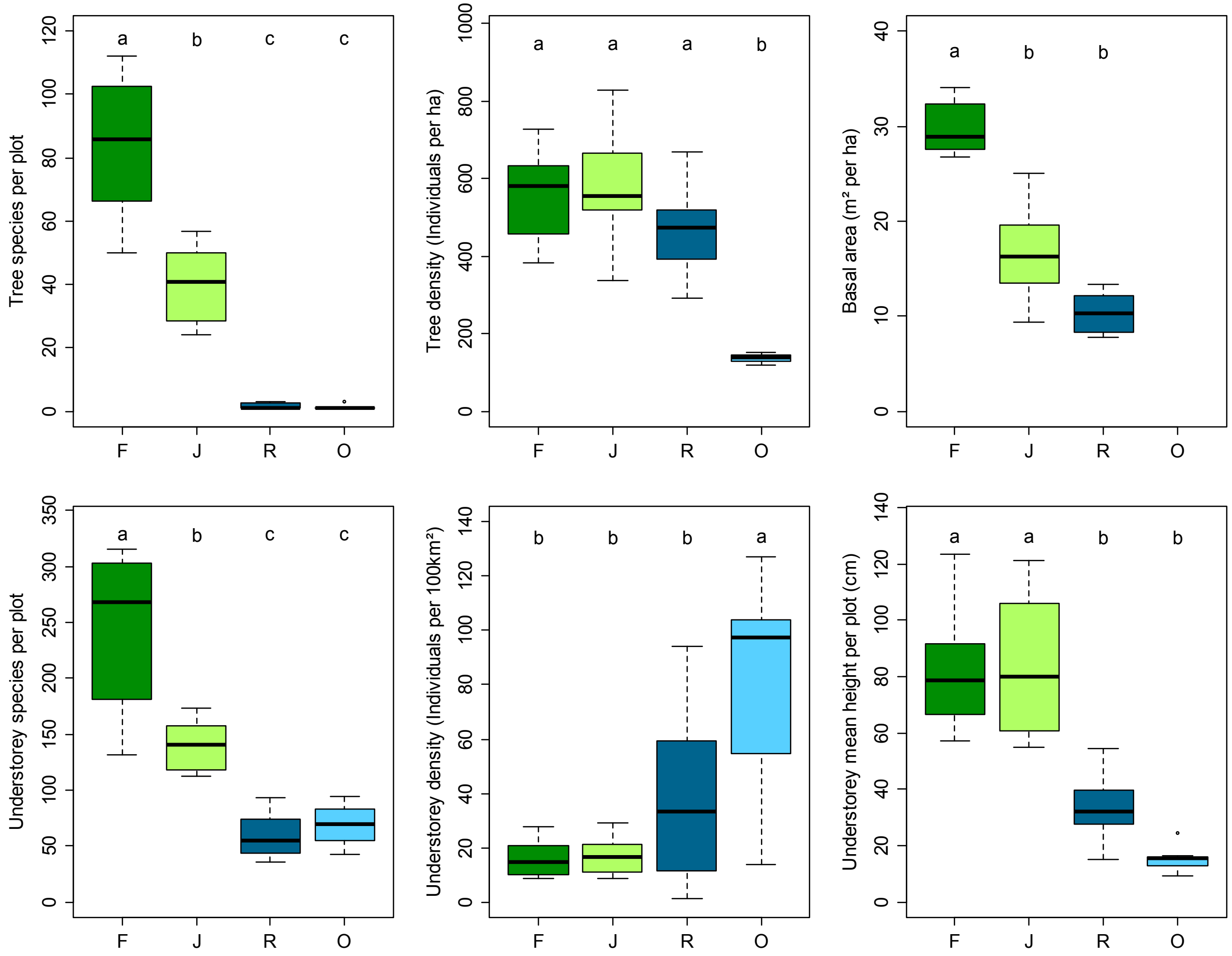



**Figure. 18:** Species richness, density, basal area and height of vascular plants within the four land-use systems. Letters indicate significant differences between systems (ANOVA results / Tukey's Honest Significant Differences, p<0.05). Note that basal area for oil palms is based on DBH incl. the attached leaf axils. Abbreviations: F – forest, J – jungle rubber, R – rubber, O – oil palm.

**B07**


**Photo 16:** Doctoral researchers of the first project phase: A) Dr. Nur Edy (second from left) in the Harapan Rainforest and B) Josephine Sahner (first from right) in the National Park Bukit Duabelas.

TITLE: **Characterization of soil and root fungal communities along a tropical land-use gradient**

TEAM: Principle Investigators: Andrea Polle (UGoe); Sri Wilarso Budi (IPB); Bambang Irawan, Upik Yelianti (UNJA); Henry Barus, Efi Toding (UNTAD)
Scientific staff: Nur Edy, Josephine Sahner (former PhD students)

## RESEARCH SUMMARY

Roots and their associated mycorrhizal fungi play a central role for nutrient uptake from and carbon transfer into the soil and thereby have a significant impact on biogeochemical cycles. However, the consequences of rain forest clearance for soil and root-associated fungi are still not fully understood. During the first project phase (2012–2015) of EFForTS we found that arbuscular mycorrhizal fungal (AMF) colonization was little affected by land-use systems. Ectomycorrhizal colonization was rare. Root health in oil palm plantations was lower than in other land use systems (Fig.19). We found a massive decrease in species richness of arbuscular mycorrhizal fungi (AMF) in cash-crop plantations compared to forests (Fig. 20), but $^{15}NH_{4+}$ uptake efficiency of roots in forests was similar to that in oil palm plantations. Soil fungal diversity was not reduced by intensive land-use in cash-crop monocultures of oil palm and rubber (Fig. 21). The community structure of fungal guilds was shifted from high abundance of ectomycorrhizal genera towards pathogenic fungi in transformation systems.

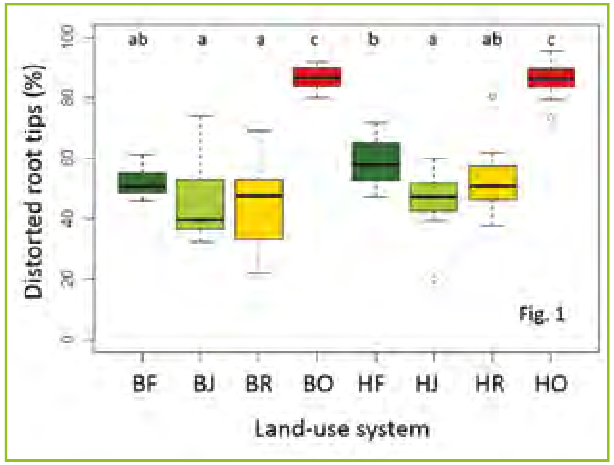



**Figure 19:** Visual assessment of root health by root tip counting in both landscapes (Bukit Duabelas, Harapan) and different land-use systems (forest, jungle rubber, rubber tree and oil palm plantation).

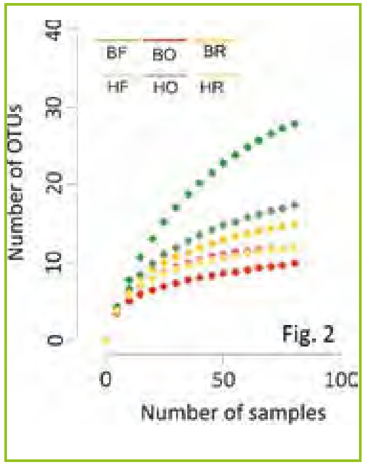



**Figure. 20:** Sampling effort for the arbuscular mycorrhizal (AM) community in single plant roots from both landscapes (Bukit Duabelas, Harapan) and different land-use systems (forest, rubber tree and oil palm plantation).

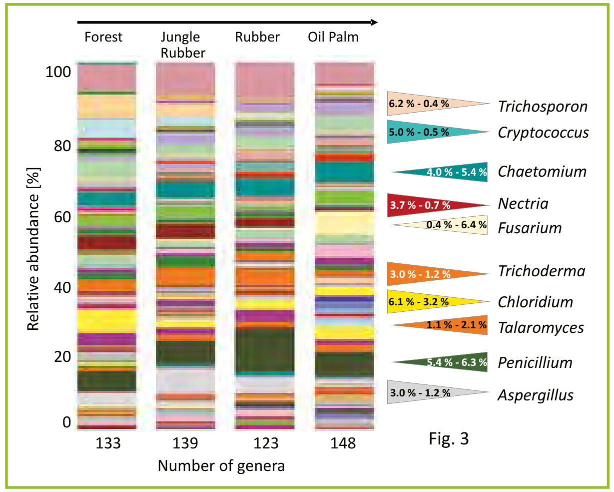



**Figure 21:** Soil fungal community composition based on relative abundances separated by land-use systems in Bukit Duabelas. Triangles indicate increase/decrease of pathogens (e. g. *Fusarium*) and beneficial fungi (e. g. *Trichoderma*) in different land use systems.

## B08

TITLE: **Structure and functioning of the decomposer system in tropical lowland rainforest transformation systems**

TEAM: Principle Investigators: Stefan Scheu, Mark Maraun (UGoe); Rahayu Widyastuti (IPB); Wilyus Wilyus (UNJA)
Scientific staff: Bernhard Klarner, Valentyna Krashevska (Postdocs)

RESEARCH SUMMARY

Conversion of tropical rainforest strongly affects testate amoeba community composition (Fig. 22 a) and associated ecological functions. The trophic composition changed from even numbers of species feeding on high and low trophic level in rainforests to a strong dominance of low trophic level species in rubber and oil palm (Fig. 22 b). Such compositional changes in one of the major microbial feeding protist group indicate fundamental changes at the base of the soil food web.

Further, lower stable isotope signatures of centipede (Chilopoda) species (Fig. 23 a, b) indicate that generalist macro-invertebrate top predators switch from decomposer prey to other, likely herbivorous prey, after conversion of forest to oil palm.

Overall, the results document that the species composition and trophic structure of the soil animal food web is strongly altered by rainforest conversion, with changes at the resource base propagating to top consumer levels. These structural changes are related to decreasing litter decomposition rates and disturbance of the soil microbial communities with land use intensification (data not shown) and thereby to a reduction of the ecosystem services provided by the decomposer system.

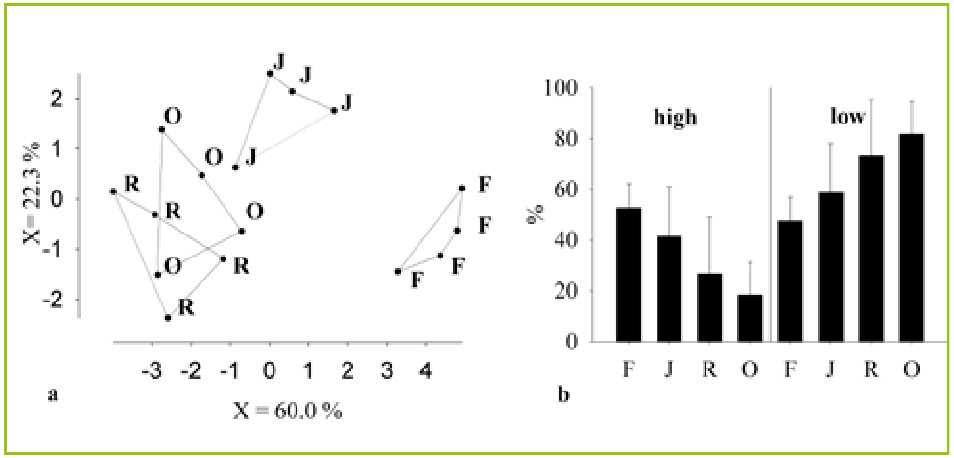



**Figure 22: (a)** Discriminant function analysis of live testate amoebae in litter; **(b)** Relative density of testate amoebae taxa of high and low trophic level in litter of four land-use systems: rainforest (R), jungle rubber (J), rubber (R) and oil palm (O); means with s. d. (n = 8).

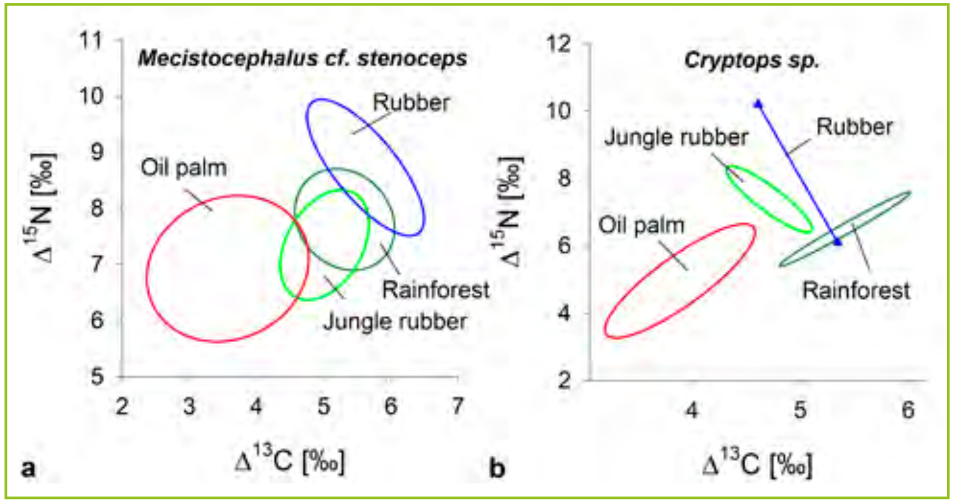



**Figure 23:** Isotopic niche of centipede species (**a** *Mecistocephalus* cf. *stenoceps* and **b** *Cryptops* sp.) in four rainforest transformation systems; coloured lines represent sample size corrected standard ellipse areas (SEAc) of dual stable isotope signatures ($\delta^{13}C$, $\delta^{15}N$) of individuals from rainforest, jungle rubber, rubber and oil palm plantations; data are normalized to the signature of plant litter of the respective sampling site.

## B09

TITLE: **Aboveground patterns of biodiversity and associated ecosystem functions across tropical rainforest transformations systems**

TEAM: Principle Investigators: Teja Tscharntke, Yann Clough (UGoe); Damayanti Buchori, Akhmad Rizale (IPB)
Scientific staff: Kevin Darras (Postdoc), Lisa Denmead, Fuad Nurdiansyah (former PhD students)

RESEARCH SUMMARY

We investigated the diversity and associated functions of aboveground animal communities, focusing on ants and birds (see photo 17). While ant species richness did not differ between land-use systems, their communities did. In contrast, point count and mist-netting results show that bird taxonomic diversity clearly declines from forests to plantations; likewise results from bat netting surveys also show a drastic decline of species richness.

We developed methods for monitoring biodiversity using autonomous sound recorders. Importantly, we show how to calibrate acoustic data by measuring sound detection spaces and demonstrate that acoustic sampling methods are overall more efficient than traditional human observation methods. A platform for managing and processing field sound recordings has been created (http://soundefforts.uni-goettingen.de/) to tackle the large amount of acoustic data.

Functional changes along the transformation gradient are also evident: ant and bird communities are less dominated by predators, and more mobile in the plantation systems. Arthropod surveys at plantations borders also revealed increased predation rates next to other land-use systems. Interestingly, our large-scale exclusion experiment showed that birds and ants do not affect ecosystem functions much in young oil palm plantations, nor did they impair agricultural productivity.

**Photo 17:** Bird, bat and ant exclusion in oil palm plantations.

**Photo 18:** B09 group photo in the field (from left to right: Yann Clough, Manuel Toledo Hernandez, Damayanti Buchori, Yeni Mulyani, Lisa Denmead, Teja Tscharntke, Kevin Darras, Fuad Nurdiansyah).

## B10

TITLE: **Landscape-level assessment of ecological and socio-economic functions of rainforest transformation systems**

TEAM: Principle Investigators: Kerstin Wiegand, Katrin Meyer, Jann Lay (UGoe); Surya Tarigan Alinda Zain, Ernan Rustiadi (IPB); Sunarti (UNJA)
Scientific staff: Claudia Dislich, Johannes Heinonen (Postdocs); Elisabeth Hettig, Fuad Nurdiansyah (PhD students)

RESEARCH SUMMARY

We have developed a dynamic, spatially-explicit model of smallholder farms for simulating smallholders' land-use decisions. The model, called EFForTS-ABM, builds on an extensive database of economic and ecological data from Jambi, Sumatra. While the economic household model focuses on farmers profit maximization, the ecological submodel includes carbon sequestration of the different land uses. We demonstrate potential economic and ecological dynamics and the influence of output prices on such dynamics. The model will be further developed in three respects, first we will include agents' heterogeneity in agricultural production, second, interaction of agents will be met by technological spill-over effect on the village level, and third more ecological functions will be implemented. Hence the model could serve as explanatory tool to define scenarios under which there are sufficient economic benefits from potential yield levels while at the same time ecological functions will be maintained. For model initialization, we have developed a landscape generator that produces artificial land-use maps and land-ownership maps (Fig. 24). The output maps produced by this landscape generator are used as input for the EFForTS-ABM. In a comprehensive review, we have reviewed all ecosystem functions in oil palm plantations.crops (work in progress).

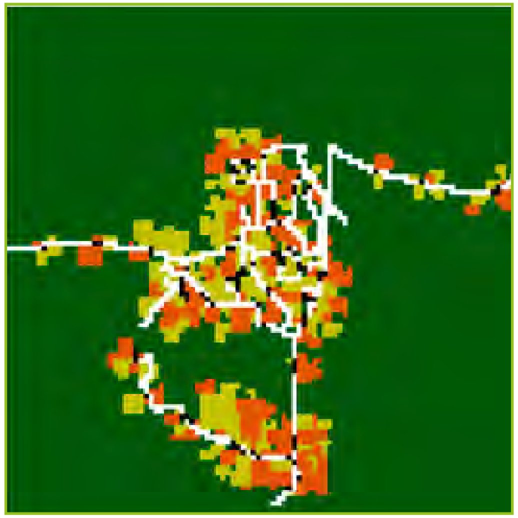


**Figure 24:** Exemplary land-use map as generated by the landscape generator. Orange: oil palm plantations, yellow: rubber plantations, green: secondary forest, white: roads, black: smallholder farmers.

## B 12

TITLE: **Reproductive strategies of flowering plants in tropical rainforest transformation systems**

TEAM: Principle Investigators: Elvira Hörandl (UGoe); Sri Sudarmiyati Tjitrosoedirdjo (IPB and South East Regional Centre for Tropical Biology – BIOTROP), Sri Rahayu (Lembaga Ilmu Pengetahuan Indonesia – LIPI)
Scientific staff: Ladislav Hodac (Postdoc); Nicole Opfermann (PhD student)

RESEARCH SUMMARY

We focused on reproductive strategies of weedy flowering plants in the transformation systems. Specifically, we wanted to test the hypothesis that apomixis, the asexual reproduction via seed, is an advantage for colonization of tropical land-use systems by invasive species. Apomixis occurs in Jambi in at least four of the ten most common naturalized alien herbs. Abundance of these species is clearly negatively correlated to naturalness of land-use systems.
Among the alien grasses, we identified *Centotheca lappacea* as the most common species in the land-use systems. Obligate outcrossing, diploid chromosome number (Ulum, 2014, unpublished Master thesis), high genetic diversity and signatures of selection (AFLP data) characterize this weed.

In the colonization process, the species is already in a phase of establishment, which may be enhanced by efficient selection acting on a highly diverse gene pool.The species is established in land-use systems but not yet a threat in natural forests (Fig. 25, Hodac *et al.* 2016).

We identified the shrub *Clidemia hirta*, native to Central America, as the by far most abundant invasive plant in all transformation systems. Pollen-exclusion and germination experiments confirmed pollen-independent apomixis. Population genetic studies showed lack of recombination and clonality in all land-use systems. Chromosome counts, flow cytometry, and microsatellite allele profiles revealed that the species is consistently triploid. Invasion success is not dependent on genetic diversity (Fig. 26).

Ecological niche shifts of invasive species were explored world-wide in international collaborations by comparing 13 pairs of invasive sexual/apomictic species in their native and invasive range, and included four of our "top ten" invasive species in Sumatra. Three of them, among them also *C. hirta*, shifted their niche optimum in the invaded areas. We confirmed the ability of invasive plants to conduct niche shifts (Dellinger *et al.* 2016).

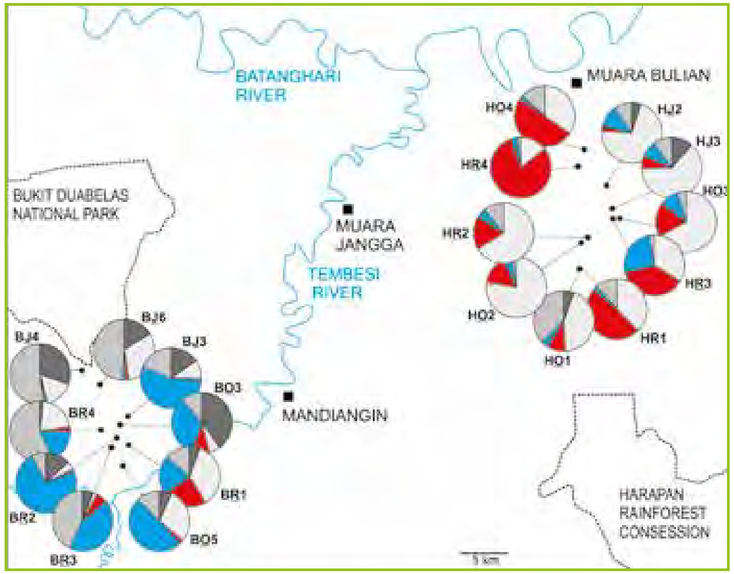



**Figure 25:** Population genetic structure of sexual *Centotheca lappacea* based on AFLPs in land-use systems (Hodac *et al.* 2016).

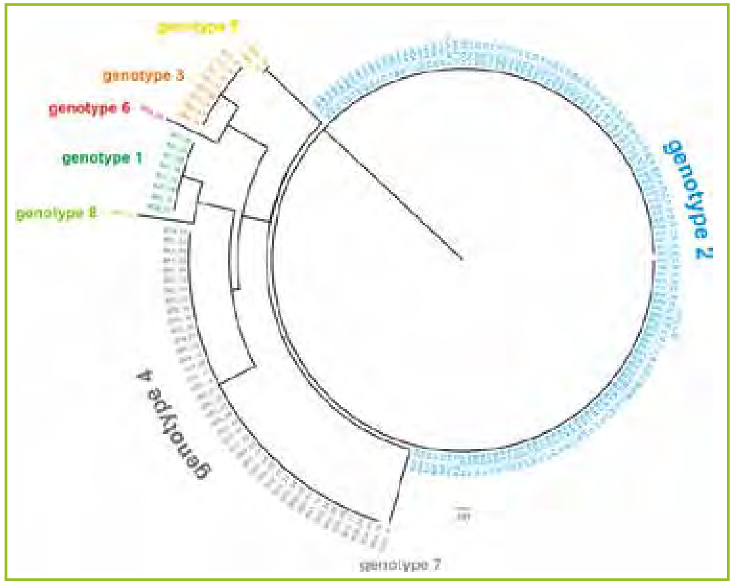



**Figure 26:** Clonality in apomictic *Clidemia hirta* based on microsatellite markers (Opfermann, in preparation).

## Group C

FIELDS OF RESEARCH

- Human dimensions

GROUP COORDINATORS

Meike Wollni, Heiko Faust (UGoe); Nunung Nuryartono (IPB); Rosyani (UNJA)

### C01

TITLE: **Smallholder productivity, market access, and international linkages in rubber and palm oil production in Jambi Province**

TEAM: Principle Investigators: Bernhard Brümmer (UGoe); Rina Oktaviani, Dedi Budiman Hakim (IPB); Zulkifli Alamsyah, Raja Sharah Fatricia (UNJA); Sudarmiyati Tjitrosoedirdjo (Biotrop)

Scientific staff: Anna Mareike Holtkamp, Thomas Kopp (former PhD students)

**Photo 19:** Daily field work – plant counting in Bukit Sari.

RESEARCH SUMMARY

**Farmers – Environmental Efficiency**

The economic outcomes, in particular in the technical efficiency dimension, of the production systems for oil palm and rubber are driven by a number of factors such as political influences, various management and marketing choices, and, not least, the influence of the individual value chain actor.

Transmigrant and autochthon oil palm farmers differ in their production characteristics and in their efficiency level; transmigrant producers reach on average higher efficiencies.

Our estimation indicates a positive influence of institutional settings such as fixed contractual arrangements in oil palm production, and sharecropping arrangements in rubber production.

The interaction between rubber production and the status of the environment or the surrounding ecosystem (for the example of the prevalence of invasive plants) follows an outward-bending trade-off function. In the economically relevant region, an increase in the desired output is accompanied by an increase in the number of invasive plants, corresponding to a higher disturbance of the natural ecosystem (Fig. 27).

The environmental impact – measured through invasive plants – can be altered positively through chemical weeding institutional settings and burning techniques, while Glyphosate usage decreases environmental efficiency.

**Traders – Market Efficiency**

Stakeholders in rubber- and palm oil trade are heterogeneous along several dimensions.

The pass-through of international rubber price change towards local traders happens in an asymmetric way, indicative of market power of the rubber exporters.

While especially rubber traders form complex networks, palm oil traders are constrained by the highly perishable nature of the fresh fruit bunches which limits the channels (Fig. 28).

Traders can either be independent entrepreneurs or agents working for a larger trade.

The traders in our sample buy their rubber input far below its marginal value product which is an indicator of substantial market power

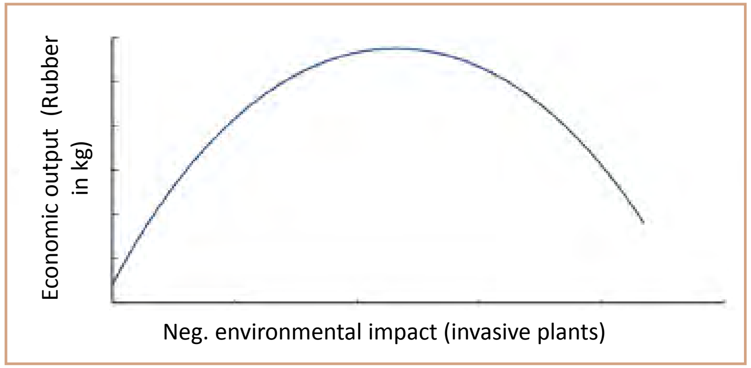



**Figure 27:** Interactive trade-off curve of invasive plants and economic output (rubber).

**Figure 28:** Networks of rubber and palm oil traders in Jambi province.

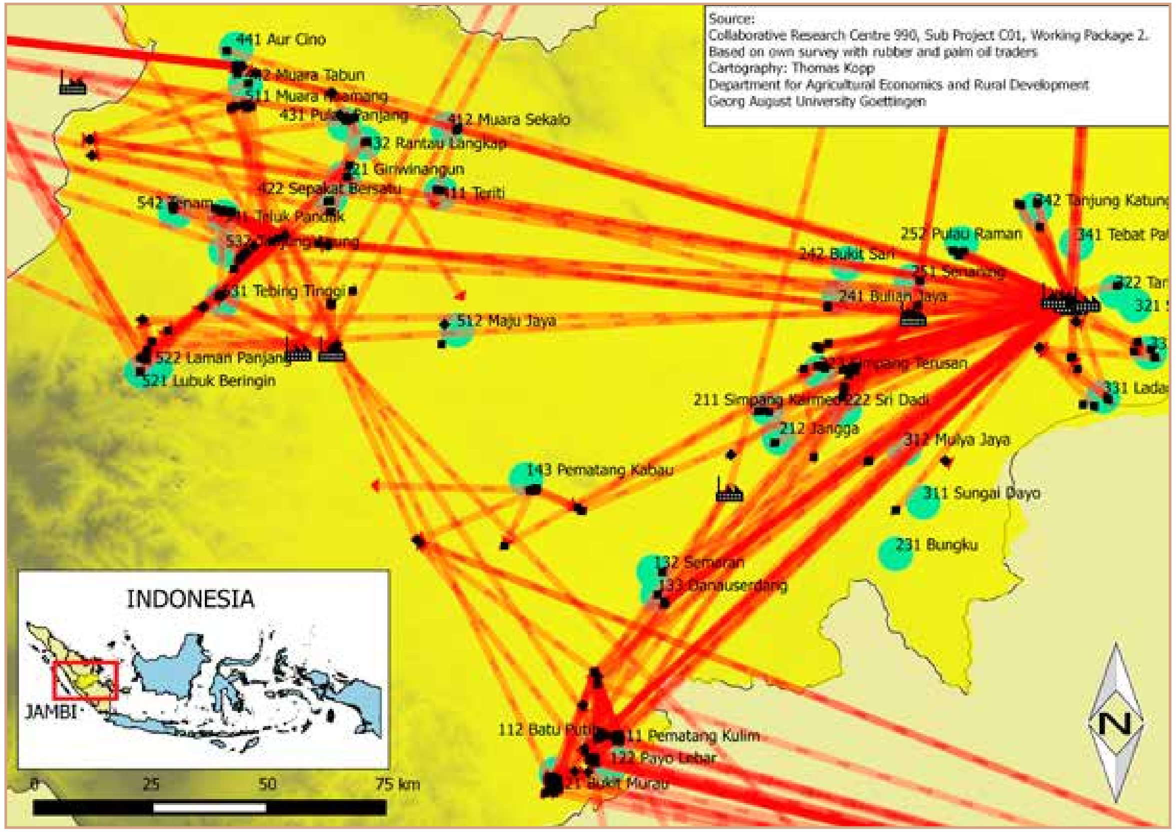



**Photo 20:** Homestay in Lubuk Beringin (Photo: Mareike Holtkamp).

## C02

TITLE: **Historical and current patterns of cultural landscape transformation in Jambi province**

TEAM: Principle Investigators: Heiko Faust, Christoph Dittrich (UGoe); Endriatmo Soetarto, Soeryo Adiwibowo (IPB); Rosyani (UNJA)
Scientific staff: Barbara Beckert, Jonas Hein, Yvonne Kunz, Rina Mardiana (former PhD students)

RESEARCH SUMMARY

**Background**

C02 focuses on historical and current cultural landscape transformation processes and explains its conditions, causes and consequences in Jambi´s frontier and post-frontier areas. Using a political ecology perspective, we draw on access and property rights theories as well as on informality concepts. The results are based on qualitative methods applied on household, village, and provincial level (Faust *et al.* 2013).

We analyzed the political and institutional frameworks regulating access to land as drivers of land use change in their current and historical context. We investigated the impacts of historical layers of land tenure regulations, the effects of current political patterns on the appropriation of natural resources, and the consequences of transnational governance arrangements for mitigating climate change on access to land.

**Photo 21:** Farmers fighting for access to land

**Photo 22:** Trench impeding access to plantation

**Results: Historical and cultural landscape transformation**

Land use in Jambi province is characterized by an overlapping mosaic of resource governance and territorial control. Multiple, unreconciled layers of land tenure regulation and local actors' responses favor a rapid exploitation and thus transformation of landscapes (Kunz *et al.* resubmitted). Long-term consequences of conflicting land regulations remain. Overlapping laws and regulations produce modern antagonisms, foster social polarization, and favor ecological crises.

Competing institutional regimes and power asymmetries lead to disputes over land (Beckert *et al.* 2014, Beckert and Keck 2015, Hein *et al.* 2015, Schwarze *et al.* 2015). People's agency to respond to changes in the politico-legal and social framework is thereby strongly affected. Local actors thus often engage in discourses at different scales in order to enhance their agency.

Local land disputes are increasingly influenced by transnational governance arrangements for mitigating climate change (Hein *et al.* 2015, Hein 2013). The emergence of REDD+ leads to a new transnational scale of forest governance increasing the agency of peasant farmers and at least theoretically providing new legal opportunities for defending their rights. Positions within scales and scalar networks of power are important explanatory factors for accessing land and property in Jambi (Hein *et al.* 2015, Hein and Faust 2014).

**Interdisciplinary achievements**

In cooperation with B10, C03, C04, and C07 we discussed that specialization in agricultural systems leads to trade-offs between economic gains and ecosystem functions (Klasen *et al.* 2015). Through literature review we uncover the importance of cultural information functions of tropical transformation systems (Dislich *et al.* 2015). Together with A02, A03, A04, and B10 we explain local actors' perspectives on changes of water cycles (Merten 2014, Merten *et al.* 2016).

C03

**Photo 23:** Analysing data together. From left to right: Stefanie Steinebach, Rosyani, Brigitta Hauser-Schäublin.

TITLE: **Cultural diversity and culture-specific interactions with tropical lowland rainforests in transformation**

TEAM: Principle Investigators: Brigitta Hauser-Schäublin (UGoe); Rosyani, Eko Setianto, Ningsih Susanti (UNJA)
Scientific staff: Stefanie Steinebach (former Postdoc)

RESEARCH SUMMARY

The drastic change of land use in Jambi Province – from a heavily forested region to an agroindustrial zone – has strongly affected local people (mainly Batin Sembilan in the Harapan region and Melayu-Jambi and Orang Rimba in the Bukit Duabelas region) and their livelihood systems. We realised that the rainforest transformation systems have a thorough impact on the culture of the local people since they have turned their formerly religiously imbued *Lebenswelt* into a mere material resource and means of production according to the demands of the global market.

We have identified a number of factors responsible for this situation and, consequently, the marginalisation of rural local people:

1) Most of local people's land had been appropriated by the state (until the seminal decision by the Constitution Court on May 15, 2013, though this decree has not yet been implemented; see Hauser-Schäublin and Steinebach 2013:6); the customary communities (masyarakat adat) were not recognised as full citizens and became dispossessed.
   Thus, land ownership and land rights have become a sensitive issue and land, a contested resource. Numerous land conflicts are one of the consequences of these developments (Steinebach 2013). Those who reclaimed their land were treated as illegal occupiers of the land held by plantation companies (Steinebach 2013).
2) Today, almost 75 % of the 180,000 ha of land constituting the Harapan region consists of concessions granted to companies for oil palm plantations, timber production and a (contested) reforestation and conservation project, REKI (Restorasi, Ekosistem Indonesia) (Hein 2013; Hauser-Schäublin and Steinebach 2014:10–12). As a consequence, the competition for access to the remaining "free" land is becoming increasingly fierce.
3) In the 1960s, the Indonesian government developed transmigration schemes which were publicised first and foremost as poverty-alleviating measures: Poor, landless families from overcrowded islands were transferred to what the state considered "uninhabited" land (mostly rainforests areas). However, these transmigrants were also used as pioneers who opened up forests for cultivation in co-operation with oil palm plantation companies.
4) The booming cash crop agriculture has resulted in an uncontrolled influx of mostly poor farmers from other parts of the archipelago. They are all seeking access to land in order to participate in the economic profits which the lowland transformation system seems to promise. As a consequence, Jambi's original inhabitants have become a minority because 80 % of the population are migrants. Nevertheless, alliances between local communities and migrants in search for land challenge the implementation of plantations and governmental land policies.

C04

**Photo 24:** Interview with Cocoa Farmer in Central Sulawesi (second from left: Katharina van Treek, doctoral researcher of C04).

TITLE: **Long-term land use, poverty dynamics and emission trade-offs in Indonesia**

TEAM: Principle Investigators: Jann Lay, Stephan Klasen (UGoe); Nunung Nuryartono (IPB); Marhawati Mappatoba (UNTAD)
Scientific staff: Katharina Trapp, Rivayani Darmawan, Dewi Nur Asih, Mohammad Iqbal Irfany (former PhD students)

RESEARCH SUMMARY

The project analyzed the trade-offs and synergies between socio-economic and ecological function in transformed forested landscapes in Sulawesi and Jambi.

In the first phase, the project has consolidated and using three waves of a panel household income survey (2001, 2004, 2006) and the two waves of an expenditure survey (2003, 2007) from Sulawesi. Using these data, Grimm and Klasen (2015) explore the role played by migration induced population pressure for the endogenous adoption of formal land titles and subsequent investments in land in Sulawesi. Using village and household survey data, they provide evidence that migration pressure increased the incentives to formalize landownership which in turn led to increased expenditures for agricultural inputs and investment in trees, terraces, ditches and irrigation systems. The availability of a demand-driven land titling system has been critical for increased agricultural intensification at the rainforest margin which is one way to mitigate the trade-off between income growth and further destruction of the rainforest. Amending these data by an additional survey round of 2013, very recent research suggests that the income gains form cash crop production, here cocoa, may be only static and that poverty and vulnerability of small-holder households may not be reduced sustainably. While some farmers are able to sustain their cocoa profits, others fail to do so and start experiencing production busts, with pests such as the black pod disease and the cocoa pod borer accounting for a large share of the production losses.

Another key activity of the first phase was to work on estimating the household carbon footprint in Indonesia and study its determinants. Irfany and Klasen (2015) and Irfany and Klasen (2016), as well as Jakob *et al.* (2014) find that the overall level of expenditure is the key driver of the household carbon footprint, suggesting an extremely close link between income growth and a consumption-based footprint, mediated by the use of carbon-based energy sources.

**Photo 25:** "Condomization" of Cocoa Pods for Pest Prevention

C06

**Photo 26:** Indonesian assistant of C06 explaining the economic experiment to the farmers.

TITLE: **Farm-level optimization of land use systems in Indonesia under consideration of uncertainty and ecological effects**

TEAM: Principle Investigators: Oliver Mußhoff (UGoe); Yusman Syaukat (IPB); Napitupulu Dompak (UNJA)
Scientific staff: Stefan Moser (former PhD student)

## RESEARCH SUMMARY

In Phase 1 of EFForTS, the scientific project (SP) C06 was mainly concerned with two work packages (WP). In the first WP, we were comparing experimentally measured risk attitudes with the risk behavior in real-life production decisions. This is important for analyzing the relationship of Indonesian small-scale farmers' risk attitude on production and investment decisions. Moreover, it is necessary to test for the external validity of results from economic experiments. For this analysis, we compare the use of risk-increasing and risk-reducing production inputs with the producers' experimentally measured risk attitudes. The applied Just-Pope production function indicates the influence of production inputs on production risk. Additionally, the Holt-and-Laury lottery measures the producers' risk attitude experimentally. We test whether more risk-averse farmers use more risk-reducing and less risk-increasing inputs. Our analyses indicate a) an influence of several production inputs on output risk and b) that farmers experimentally measured risk-aversion seem to correlate with the use of such production inputs (Fig. 29). This justified the external validity of results from economic experiments. A preliminary version of the article is published in the EFForTS Discussion Paper series (Moser and Mußhoff, 2015).
In the second WP, we experimentally tested farmers' reaction towards differently designed incentives for reducing fertilizer intensity. This allows for investigating the efficiency, effectiveness and sustainability of such incentives in an ex-ante policy impact analysis. The advantage of an ex-ante policy impact analysis is that it allows for testing policy measures at low costs before the resources for the policy measures are spent. Therefore, the second WP is a valuable contribution for improving policy measures towards environmental protection. For restricting negative externalities through intensive fertilizer application, effective,

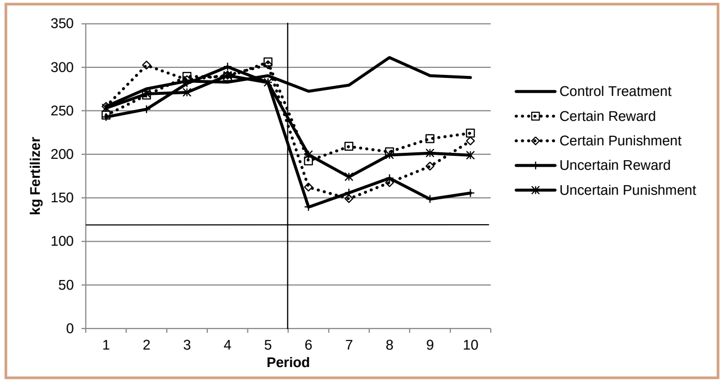



**Figure 29:** Farmers reaction towards differently design incentives for reducing the use of fertilizer.

sustainable and efficient incentives are desirable. We tested differently designed incentives with a business simulation game embedded in a framed field experiment. The tested incentives different in their designs, i. e., either a reward or punishment, varying in their magnitude and probability of occurrence but with constant effects on expected income. However, our results show that participants react differently to these incentives, indicating that the design can contribute significantly to its effectiveness, sustainability and efficiency. A high reward with a low probability to occur was found to be the most effective and sustainable incentive. Moreover, a low and certain reward is indicated for the most efficient design. The respective article is published in the Journal of Agricultural Economics (Moser and Mußhoff, 2016).

C07

**Photo 27:** C07 doctoral researchers Jonida Bou Dib (3rd from right) and Christoph Kubitza (1st from right) during the pre-test of the household survey questionnaires in 2015.

TITLE: **Determinants of land use change and impact on household welfare among smallholder farmers**

TEAM: Principle Investigators: Matin Qaim, Stefan Schwarze (UGoe); Hermanto Siregar (IPB); Zakky Fathoni (UNJA)
Scientific staff: Vijesh Krishna (Postdoc), Michael Euler (former PhD student), Jonida Bou Dib and Christoph Kubitza (PhD students)

RESEARCH SUMMARY

During the first phase of EFForTS, C07 researchers completed three household surveys in Jambi. The first survey, which was implemented in 2012, involved 700 farm households in 45 villages. The second survey, which was implemented in 2015, involved the same 700 farm households. The panel data facilitates the understanding of land-use dynamics and possible changes in livelihood impacts over time. The third survey, which was also carried out in 2015, involved 440 non-farm households in 26 villages. Data from these non-farm households were collected to gain insights into wider socioeconomic effects of land-use changes in rural areas with a particular focus on labour market spill-overs. In addition, C07 researchers cooperated with C08 on collecting and analysing village survey data, and with B09 on analysing bird market and urban household preference surveys. The data are being analysed using various statistical and econometric techniques.

The analyses so far primarily concentrated on analysing the drivers of deforestation and oil palm adoption, as well as the impacts of recent land-use changes on livelihoods of smallholder farm households. While in the 1990s, smallholders were primarily involved in oil palm cultivation through company outgrower schemes (often as part of the government's transmigration programme), most of the adopters today are independent farmers without company contracts (see Fig. 30). Yet, adoption is faster in those villages where some farmers had contractual ties with the palm oil industry in the past. In terms of impacts, we find that oil palm adoption has contributed to higher living standards and better nutrition in smallholder households. However, we also find significant impact heterogeneity. In absolute terms, richer households benefit more than poorer ones. Furthermore, households' access to land, labour, and capital matters. As oil palm is more capital-intensive and less labour-intensive than rubber, households with better access to credit and higher opportunity costs of labour benefit over-proportionally from adoption. Some adopters with good access to land also used the saved labour to expand their farm area cultivated. In the second phase, we will focus more on the co-evolution of land-use, factors markets, and other local institutions.

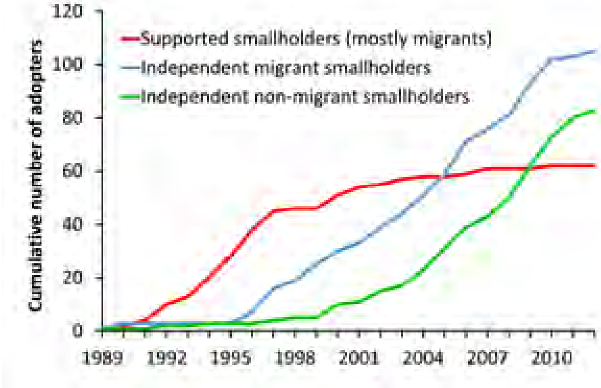



**Figure 30:** Adoption of oil palm in a representative sample of smallholder farmers in Jambi.

C08

**Photo 28:** C08 Focus Group Meeting in September 2015 in preparation of the survey (Meike Wollni – 2nd from right, Rosyani – 3rd from right, Miriam Romero – 3rd from left).

TITLE: **Collective decision making and land allocation at the village level**

TEAM: Principle Investigators: Meike Wollni, (UGoe); Bambang Juanda (IPB); Rosyani (UNJA)
Scientific staff: Marcel Gatto, Miriam Vorlaufer former (former PhD students), Miriam Romero (PhD student)

RESEARCH SUMMARY

**Research activities**

Miriam Romero joined C08 as a doctoral researcher in April 2015. She focuses on the effects of informational and structural interventions on native tree planting among oil palm farmers in Jambi Province.
A baseline survey was implemented in 36 villages from October – December 2015 and covers a total of 823 oil palm farming households.
In addition to details on oil palm farming and tree planting activities, we gathered information on a range of environmental preferences and subjective beliefs.
For the interventions, 6000 saplings were produced (Jelutung, Petai, Durian, Sungkai, Meranti, Jengkol), a movie featuring Pak Bambang Irawan and selected farmer stories was filmed, and a manual containing information on tree planting was developed.
Currently interventions are carried out and a short post-experimental questionnaire is filled out to measure immediate effects of the interventions.
In 12 villages we implement an information campaign (showing the movie and distributing the manual);
In 12 villages – in addition to the information campaign – we implement a structural intervention (distribution of saplings);
12 villages serve as control, where no interventions are carried out.

A comprehensive follow-up survey is planned for the end of the year to collect data on actual adoption of tree planting.


**Photo 29:** Cover page of the manual on tree planting.

## Scientific projects Z02 and INF

### Z02 FIELDS OF RESEARCH

- Monitoring of meteorological variables
- Barcoding the vasuclar plants and their roots of the study sites
- Monitoring of aboveground animal biodiversity
- Function as central unit on the Convention of Biological Diversity (CBD)

### INF FIELDS OF RESEARCH AND DATA MANAGEMENT

- Information system (EFForTS-IS)
- Digital research infrastructure components
- Data sharing framework
- Research data management concept
- Statistical consulting

## Z02 Central Scientific Service Project

TITLE: **Monitoring aboveground biodiversity – Canopy arthropods**

TEAM: Principle Investigators: Stefan Scheu (UGoe), Damayanti Buchori, Iskandar Z. Siregar (IPB), Bambang Irawan (UNJA), Rosichon Ubaidillah (LIPI)
Scientific staff: Jochen Drescher (Postdoc)

### RESEARCH SUMMARY

One major aim of Z02 is the monitoring of canopy arthropod assemblages in EFForTS core plots. The ultimate goal is to establish a collection in which all specimens are identified to species level, including a molecular marker as species barcode as well as the photographic documentation of the species. Given that there will be many species unknown to science in the samples, Z02 is also responsible to organize the description of new species by taxonomic specialists around the world. In two fogging campaigns in dry season 2013 and rainy season 2013/14, we collected an estimated 800.000 specimens belonging to 31 arthropod orders. Since then we have focused on in-detail studies on ants (Formicidae), springtails (Collembola), weevils (Coleoptera) and selected families of parasitic wasps.

Ants (Formicidae): Our samples contained about 71.500 ant specimens belonging to

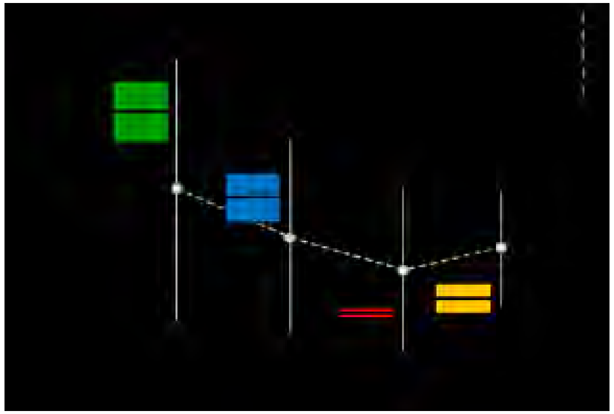


**Figure 31:** Canopy ant species richness and diversity across land-use systems (mean ± SD, ANOVA, Tukey HSD post-hoc test, p<0.01).

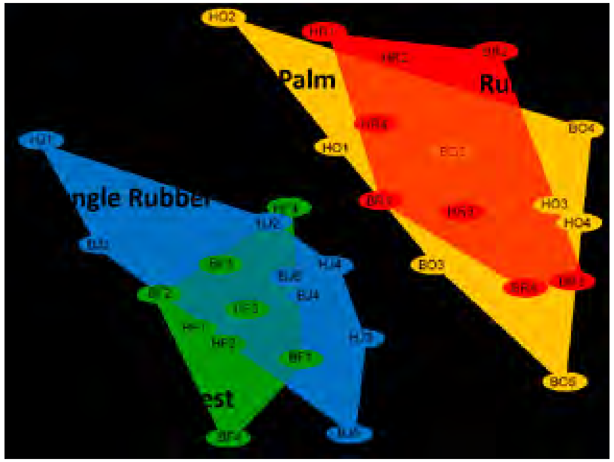



**Figure 32:** Multidimensional scaling plot based on Bray-Curtis distances of presence/absence data of 126 canopy ant morphospecies. Canopy ant community composition in forest and jungle rubber differs significantly from community composition in rubber and oil palm plantations (ADONIS, p<0.001).

**Photo 30:** Members of Z02 identifying beetle specimens in facilities of Jambi University (left: Lailatun Najmi, right: Ratna Rubiana).

126 morphospecies. Rubber and oil palm monocultures contained significantly less ant species than forest or jungle rubber, while species diversity was not significantly affected (Fig. 31). Ant community composition in oil palm and rubber, however, differed significantly from jungle rubber and forest (Fig. 32). Photographic documentation in both UGOE and IPB is under way, and a dichotomous key is in preparation. Genetic barcoding of species has been initiated.
Springtails (Collembola): Our sampling contained about 28.000 Collembola specimens of which about a third have been identified as belonging to over 200 morphospecies from nine families (Brachystomellidae, Cyphoderidae, Entomobryidae, Hypogasturidae, Isotomidae, Odontellidae, Oncopoduridae, Paronellidae, Sminthuridae). Photographic documentation is under way and first specimens have been barcoded.
Weevils (Coleoptera): Our samples contained ca. 3100 weevil specimens from both the dry season sampling and the rainy season sampling. Identification of species has started but still is in an early stage.
Parasitic wasps: We currently focus on about 20.000 specimens of parasitic wasps from five abundant families, i.e. Braconidae, Ceraphronidae, Encyrtidae, Scelionidae and Platygastridae. We mounted specimens (5 individuals per morphospecies) and took pictures to establish a master collection facilitating identification in future.

## INF Information Infrastructure Project

TEAM: Principle Investigators: Wolfram Horstmann, Thomas Kneib, Ramin Yahyapour (UGoe), Bagus Sartono, Suria Darma Tarigan (IPB), Junaidi Sutan (UNTAD), Sandra Yuwana (LIPI)
Scientific staff: Fabian Cremer (former stuff), Thomas Fischer, Timo Gnadt, Paul Magon, Peter Pütz

### RESEARCH SUMMARY

The INF project is responsible for providing integrated support for the complete life cycle of research data collected and generated by EFForTS. In this role INF developed an information system (EFForTS-IS) based on the BExIS software and (a) implemented CRC-specific pages for the EFForTS-IS web interface, (b) created metadata schemata for the researchers, (c) provided trainings for using EFForTS-IS and (d) assisted the researchers individually in specifying metadata and ingesting their data (see Fig. 33).

Along this line, INF developed general workflows as well as individual plans for data management and provided a helpdesk and small service support for researchers. INF also ingested and curated data from STORMA (CRC 552: The Stability of Rainforest Margins in Indonesia, http://storma.uni-goettingen.de) and ELUC (Environmental and land-use change in Sulawesi, Indonesia, http://www.uni-goettingen.de/de/189495.html) into EFForTS-IS. In collaboration with our Indonesian partners, INF supervised the installation and configuration of an Indonesian EFForTS-IS mirror server at LIPI.

INF furthermore assisted the project coordination by developing and adapting workflows and information and communication technologies (ICT) services for project management. It provided consulting and ICT support for subproject developments, such as the sound annotation platform SoundEFForTS of project B09 and the plant database of project B06. INF also substantially contributed to the formulation of the Data Exchange Agreement of EFForTS, and to the development of the EFForTS Open Access Publication Strategy.

**Photo 31:** Embedded Data Manager (Fabian Cremer, former stuff) in the field.

**Photo 32:** EFForTS international delegation in 2012 who worked out the Data Exchange Agreement. First row: Aiyen Tjoa (1st left), Zulkarnain (2nd left), Kerstin Wiegand (4th left), Wolfram Lorenz (6th left). Second row: Bambang Irawan (2nd left), Fabian Cremer (5th left), Heike Neuroth (6th left), Zulkifli Alamsyah (7th left).

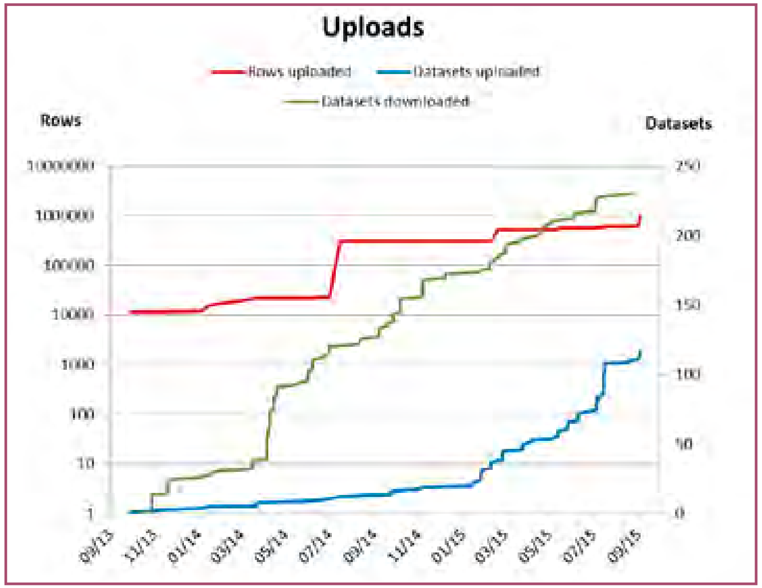



**Figure 33:** EFForTS-IS Uploads & Downloads

## II. Integration of Ecological and Socioeconomic Research

Integration / integrative research activities across disciplines is realized through

- the establishment of a joint enrichment planting experiment (B11)
- four thematic foci / overarching joint hypotheses.

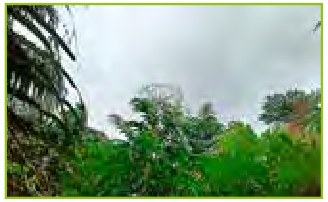
### 1. The enrichement experiment

**B11**

TITLE: **Reproductive strategies of flowering plants in tropical rainforest transformation systems**

TEAM: Principle Investigators: Holger Kreft, Ulrich Brose, Dirk Hoelscher, Yann Clough, Meike Wollni (UGoe); Hendrayanto, Leti Sundawati, Prijanto Pamoengkas (IPB); Bambang Irawan
Scientific staff: Miriam Teuscher (former PhD student), Anne Gérard (PhD student)

**Photo 33:** First tree flowering event in the B11 experiment: infloresences of Peronema canescens in a tree island surrounded by oil palms.



RESEARCH SUMMARY

The transformation of rainforests into oil palm plantations leads to dramatic losses in biodiversity and in ecological functioning. In order to test possibilities for alleviation, we established a biodiversity enrichment experiment by planting tree islands in an oil palm landscape. The plantings comprise four island sizes and six native multi-purpose tree species at different species diversity levels with a total of 56 experimental plots (Fig. 34).
Within the first 2 years after establishment of the enrichment experiment, about 48%

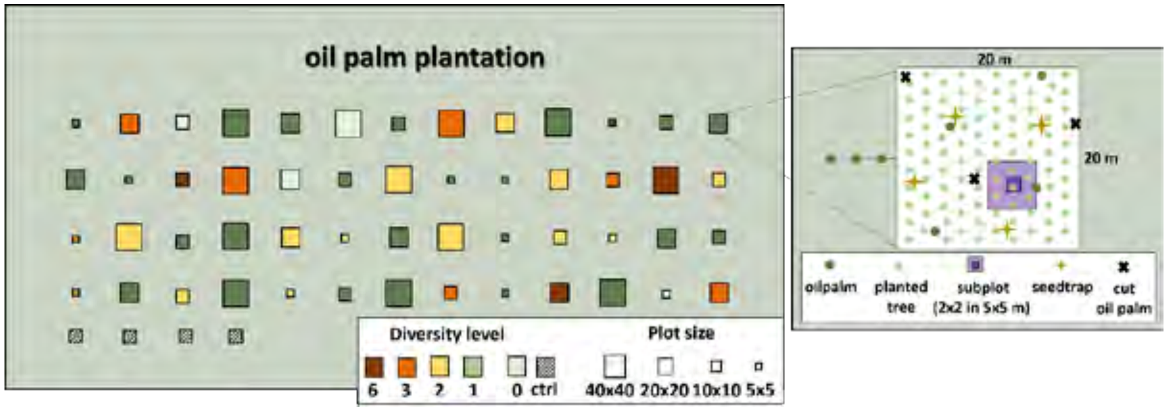



**Figure 34:** Schematic representation of the experimental design of enrichment gaps in a large-scale oil palm plantation. Please note that distances are not according to scale.

of all planted trees died. We observed strong differences between species with Parkia speciosa having the lowest and *Dyera polyphylla* the highest mortality rates. Dead trees have been replaced during the first year after planting. Height increment of surviving trees showed a large variation with a mean of 252 cm and a standard deviation of 166 cm. The tallest tree is already 913 cm high. Peronema canescens started flowering. So far, the dynamics are driven by tree species identities and to a much lesser extend by the experimental treatments, which however may change over the course of the experiment.
The monitoring of oil palm yields showed enhanced yields of palms remaining on the experimental islands and palms in direct proximity to the tree islands. It is suggested that even per unit of land area, in the early stages of enrichment planting, oil palm yield is increased. This will be interesting in planned research on payments for environmental services and ecological-economic trade-offs.
We also aim at a better understanding the role of the landscape matrix for the restoration success. Remnant trees and small forest fragments in the surrounding landscape are crucial but these seed sources are still declining. A monitoring scheme in the 1000 ha surrounding the experiment was established, which is based on terrestrial and airborne assessments.

**Photo 34:** a) Monitoring changes in the landscape matrix surrounding the experiment with an unmanned aerial vehicle (left: Watit Khokhtong). b) Robin Naumann

## 2. Four thematic foci

### Focus 1

TITLE: **Assessment of ecological and socio-economic functions across tropical transformation systems**

REPRESENTATIVES: Yann Clough, Oliver Mußhoff, Edzo Veldkamp (first phase);
Ingo Grass, Oliver Mußhoff (second phase)

RESEARCH SUMMARY

Reconciling biodiversity conservation, ecosystem functioning and increasing human demands is a major challenge in tropical landscapes, and particularly so in the smallholder-dominated land-use mosaics of Jambi Province, Sumatra. Identifying trade-offs and synergies among ecological and socioeconomic functions is a major aim of the interdisciplinary research within Focus 1 of CRC 990. During the first phase of CRC 990 (2012 – 2015), a great number of different ecological and socioeconomic functions were studied across the major land-use systems in Jambi province. The synthesis, led by former Focus 1 speaker Yann Clough, provides strong evidence for losses in biodiversity and ecological functions with rainforest transformation, whereby the expansion of monocultures of rubber and oil palm, associated with higher yields and economic benefits, occurs at the expense of forests and agroforest jungle rubber (Fig. 35; Clough *et al.*, in review). The identification of management options that mitigate these trade-offs or even achieve ecological-socioeconomic synergies are major aims of Focus 1 for the second phase of the CRC in the coming years (Fig. 36).

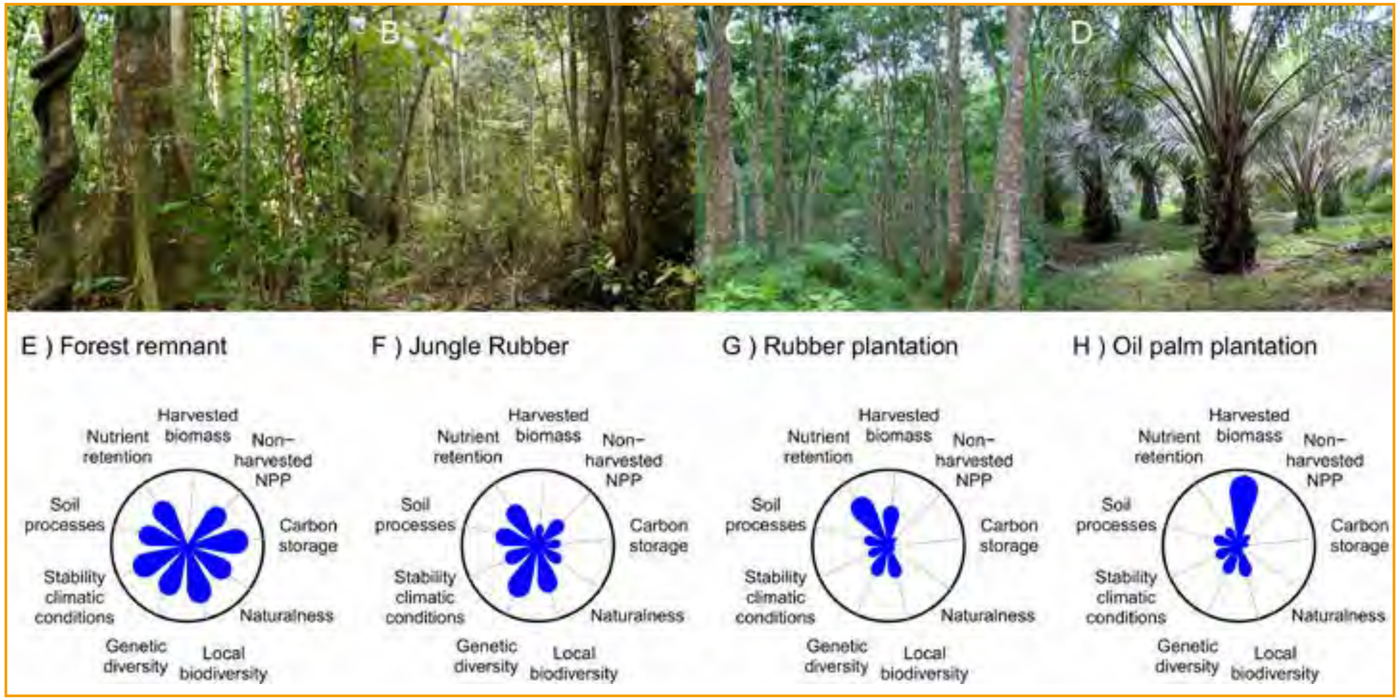



**Figure 35:** Four agricultural land-uses and associated ecological functions in smallholder-dominated landscapes in Jambi Province, Indonesia: forest remnants (A, E), jungle rubber (B, F), rubber plantation (C, G) and oil palm plantation (D, H). Ecological functions are represented as flower diagrams. For each function, the minimum (circle centre) is the 5th quantile and the maximum (circle edge) is the 95th quantile of the standardized ecosystem function indicators, observed in a plot of any land-use types. The outer edge of the flower petals indicates the estimate for the aggregate ecosystem function in a given land use relative to these minima and maxima. Photographs: Yann Clough.

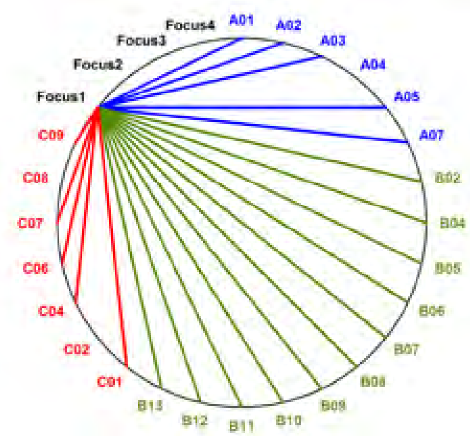



**Figure 36:** Planned contributions of the subprojects to Focus 1 in the second phase.

## Focus 2

TITLE: **Quantifying the effects of spatial, temporal and social heterogeneity on ecological and socioeconomic functions**

REPRESENTATIVES: Matin Qaim and Holger Kreft

RESEARCH SUMMARY

Research in the first phase of the CRC has demonstrated that land-use systems differ significantly in key ecological and socioeconomic functions (Focus 1). However, there is also a high degree of variability in the quantified functions within each land-use system and at the village level (residual variation in a statistical sense) (e. g. Guillaume *et al.* 2015; Teuscher *et al.* 2015) suggesting an important role of spatial, temporal and social heterogeneity. For instance, differences in soil quality, plant and tree age, plot size, spatial configuration and historical land use as well as social factors, local institutions such as land property rights, and access to markets and infrastructure may additionally affect ecological and socioeconomic variables measured for each land-use system. Understanding the role of heterogeneity is thus key for understanding complex socio-ecological systems as a whole, for identifying win-win solutions of efficient, sustainable land-use management and for balancing human needs and ecosystem functions and services in human-dominated landscapes. The study of the effects of spatial, temporal and social heterogeneity on ecological and socioeconomic functions will directly contribute to the development of scaling functions in Focus 3.

Research on heterogeneity will gain in importance in the second phase. The ecological projects will continue to investigate the different land-use systems within the CRC core plot design that are nested within farm, community, and landscape levels. This research will generate data on spatial and temporal variability in ecological and socioeconomic functions allowing more complex and comprehensive analyses and conclusions. Likewise, the continuation of data collection in the socioeconomic projects will generate time series and panel data at plot, farm, household, and village levels, which will allow in-depth analyses of how socioeconomic functions vary in space and time dependent on the social context. Of particular interest is to analyse how heterogeneity across different ecological and socioeconomic functions is correlated. In the second CRC phase, three elements are specifically designed to foster research on heterogeneity: i) the planned extension of the core plot design to riparian areas will add a new dimension of heterogeneity. ii) The management experiment (Z01) will vary experimentally the land-use intensity of oil palm plantations. iii) The biodiversity-enrichment experiment (B11) will enter into a phase where the heterogeneity introduced by the varying levels of tree diversity is expected to show first results

**Hypotheses**

(1) Ecological and socioeconomic functions of a given land-use system differ between landscapes, over time and by social context, i.e. statistically there are interaction effects between land-use systems, landscape, time and socioeconomic factors.

(2) Within land-use systems, there are large differences in profitability, risk, biodiversity and ecological functions between farms and over time, and these can be explained by differences in the ecological and socioeconomic setting and/or management practices of the farm.

(3) Decisions made at the household level about land-use change and management (and associated implications for biodiversity and ecological functions) are affected by local, regional, national, and international economic and institutional conditions.

## Focus 3

TITLE: **Scaling-up of ecological and socioeconomic functions from local to landscape and broader scales**

REPRESENTATIVES: Stephan Klasen & Katrin Meyer (first phase).
Stephan Klasen & Thomas Kneib (second phase).

RESEARCH SUMMARY

Specialization in agricultural systems can lead to trade-offs between economic gains and ecosystem functions. Economic gains can be maximized when production activities are specialized at increasingly higher scales (from the household to the village, region or above), particularly when markets for outputs and inputs function well and allow specialization as well as high levels of food security. Conversely, more specialization likely reduces biodiversity and significantly limits ecosystem functions. When agricultural specialization increases and moves to broader scales as a result of improved infrastructure and markets or other drivers, ecosystem functions can also be endangered at broader spatial scales. Jambi province in Indonesia, a current hotspot of rubber and oil palm monoculture, was taken as a case study to illustrate these issues. We empirically could show that the level of specialization differs across scales with higher specialization at household and village levels and higher diversification towards the province level (Fig. 37).

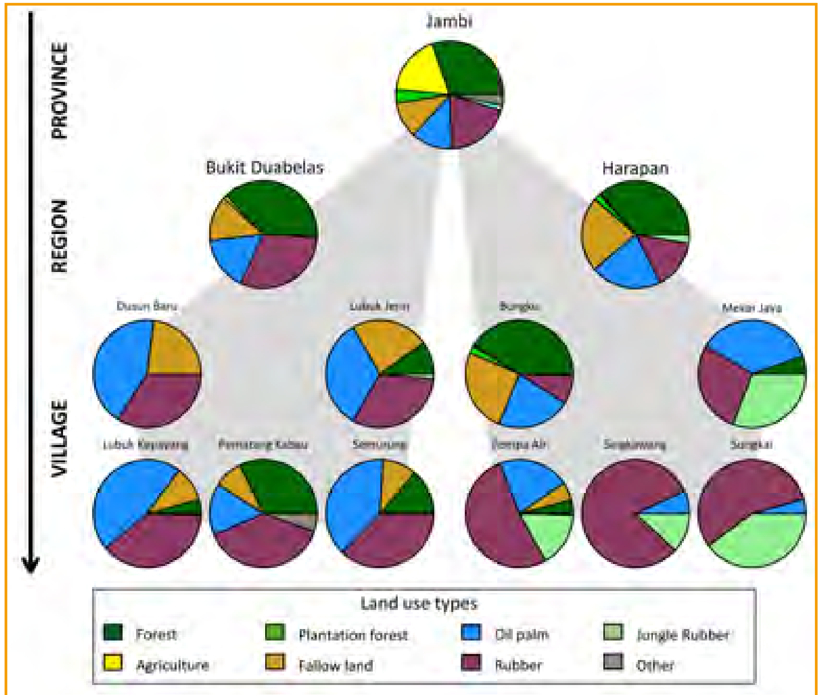



**Figure 37**: Land-use types in Jambi province, Indonesia, in 2011 show that specialization decreased from fine to broad scales, i.e. from the village level (five villages per region, bottom rows) to the region level (two example regions Bukit Duabelas and Harapan, second row) to Jambi province (top row). Data source: Landsat and RapidEye images analysed according to Indonesian ministry guidelines (Ministry of Forestry, 2008).

## Focus 4

TITLE: **Towards more sustainable land use in lowland tropical regions**

REPRESENTATIVES:
Bernhard Brümmer & Teja Tscharntke

RESEARCH SUMMARY

In Phase 1 of the CRC, the detailed assessment of the state and functions of the land-use systems in Jambi province (see Foci 1 to 3) allowed for an assessment of the various ecosystem functions in a socioeconomic context. The relationship between the ecological, economic and social goals of policies were found to be complex, e. g., unclear land property rights led to land-use conflicts as observed around Harapan, or contractual relationships between palm oil companies and smallholder farmers were found to contribute to poverty reduction while hampering some of the social, economic and ecological ecosystem functions of secondary rainforests. The changes in smallholder land-use systems in Jambi were initially driven by governmental activities but are increasingly affected by economic factors, such as favourable palm oil prices. Furthermore, village specific factors and the functioning of the value chain for rubber and palm oil are decisive for the heterogeneity in the socioeconomic transforma-

tion process at the village level. Ecological goods include the on-farm biodiversity, which is greatly affected by weeding and fertilization, as well as economically important services such as biological pest control and pollination of homegarden crops.
Testing the hypotheses in Focus 4 will allow us to develop proposals for policy measures that have the potential to integrate all dimensions of sustainability; instruments devised along these lines will be more viable in the political process and will be more successful in achieving the desired ends with minimal efforts (Fig. 38).

**Hypotheses**

(1) The sustainability outcomes of the existing land-use systems in Jambi are driven by the heterogeneity in individual management practices in the context of market- and policy driven incentives in the transformation process.

(2) The effectiveness of existing policy measures for improving sustainability outcomes is hampered by conflicting relations between policy objectives. The formal and informal goals of stakeholders (e. g., the implementing bureaucracy) will influence both the policy formation and its effectiveness.

(3) Appropriate policy scenarios can be designed that change economic incentives towards systems with higher overall levels of ecological and socioeconomic functions.

(4) Improving the effectiveness of policies depends on the knowledge about the multifaceted trade-off functions, on the design of policy measures, and on accounting for the incentive structures of stakeholders' at all relevant levels and along the temporal scale.

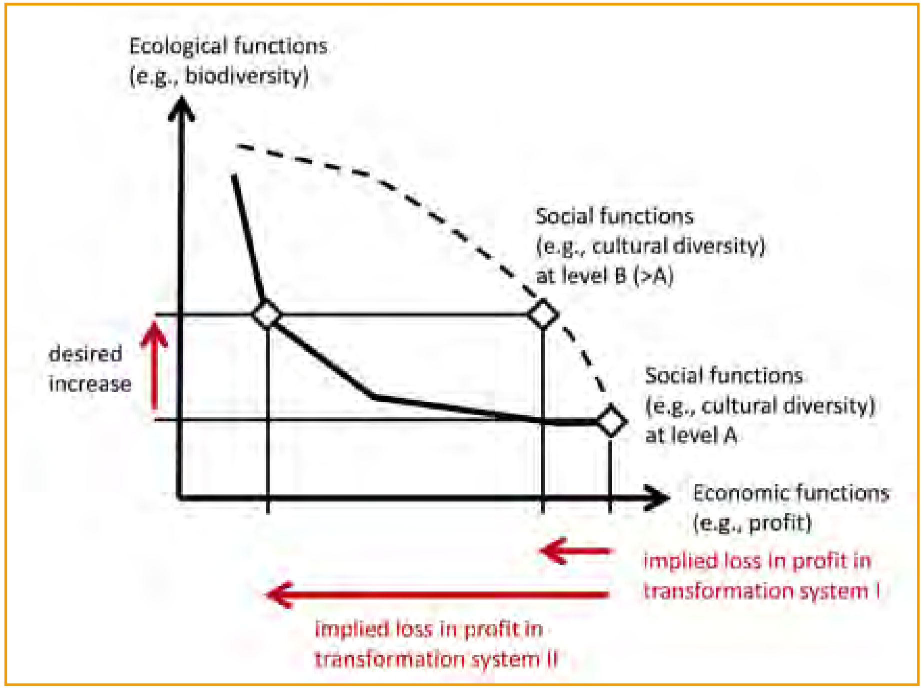



**Figure 38:** Exemplary trade-off relationships between economic and ecological functions, Note: The dotted line corresponds to a scenario as in Clough *et al.* (2011); the continuous black line as in Kleijn *et al.* (2009)

# III. Biodiversity Research, Access to Genetic Resources and Benefit Sharing (ABS)

1. **Complementary research projects of counterparts in 2012 and 2013**
2. **Complementary research projects of counterparts in 2014 and 2015**

The approval of the *Convention on Biological Diversity* (CBD) in 1992 was the first step of a new approach to the biodiversity resources and their use, which includes the national sovereignty principle, mutually agreed term and sharing benefits of the use of biodiversity. The Nagoya Protocol on *Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization* to the Convention on Biological Diversity (ABS) is the legally binding mechanism to implement access and benefit sharing. It was signed by both Germany and the EU on 23 June 2011, and by the Republic of Indonesia on May 11, 2011. The DFG is one of the few funding agencies around the world that has implemented (since 2008) its own guidelines to promote the application of the principles and procedures of ABS among its applicants. The DFG tries to build a bridge between that regime and the scientific community. The DFG approved funding of ABS measures with central research funds.
Since November 2013, EFForTS awarded 33 short-term research grants to counterparts and stakeholders (LIPI, PTPN VI, PT Humusindo, BKSDA, PT REKI, Ministry of Forestry) to strengthen the research cooperation and to complement existing research activities addressing new scientific questions. Also, a research station and a field laboratory have been established and compensation payments were made.

## 1. COMPLEMENTARY RESEARCH PROJECTS OF COUNTERPARTS IN 2012 AND 2013

Research projects of counterparts funded at IPB

| Counterpart / Associate | | Title |
|---|---|---|
| **Supiandi Sabiham** | **A01** | Development and dynamics of rainforest and rainforest transformations in Sumatra during prehistoric and historic times: a case study in peats of Jambi. |
| **Herdata Agusta** | **A02** | Soil water status and its adequacy of higher strata of vegetation in rainforest transformation systems in relation to its rooting system and soil depth. |
| **Tania June** | **A03** | Light use efficiency model for estimating Net Primary Production (NPP) of land use transformation in Jambi. |
| **Akhmad Faqih** | **A03** | The use of regional climate model to study intraseasonal to interannual rainfall variability and diurnal rainfall characteristic in Jambi. |
| **Kukuh Murtilaksono** | **A04** | Study of soil organic carbon forms in several land uses of highly weathered soils in Jambi. |
| **Iman Rusmana** | **A05** | Denitrification, nitrification, and dissimilatory nitrate reduction to ammonium (DRNA) activity and their microbial diversity in tropical agroforestry. |
| **Luki Abdullah** | **A05** | Diversity and carbon storage of shade-tolerant grasses under lowland rainforest transformation systems. |
| **Achmad Farajallah** | **B01** | Freshwater faunal biodiversity: crustacea and macrobenthos in Jambi based on mitochondrial DNA barcoding. |
| **Tri Heru Widarto** | **B01** | Structure, stability, and functioning of macroinvertebrate communities in rainforest transformation system in Sumatra. |

| | | |
|---|---|---|
| **Nisa R. Mubarik** | B02 | Phylogenetic and functional diversity of productivity rhizosphere bacteria from tropical rainforest and rainforest transformation in Jambi. |
| **Anja Meryandini** | B02 | Diversity of xylanase producing bacteria. |
| **Ulfah J Siregar** | B03 | Population genetics of jelutong (*Dyera costulata*) in Jambi. |
| **Utut Widyastuti** | B03 | Genetic diversity of Melastoma sp. in rainforest transformation systems in Jambi, Sumatera (Indonesia). |
| **Triadiati Antono** | B04 | Trace gas fluxes and soil N cycling in heavily weathered soils under lowland rainforest transformation systems in Indonesia. |
| **Elias** | B04 | Tree biomass and carbon mass allometric equation models of rubber tree plantation at Harapan Rainforest, Jambi Province, Sumatra. |
| **I Nengah S Jaya** | B05 | Biomass distribution map using multitemporal and multispectral satellite imageries data in various transformation system in Jambi. |
| **Eva Achmad** | B05 | Identification of secondary forest ecosystem types using remote sensing techniques. |
| **Sri S. Tjitrosoedirdjo** | B06 | Biodiversity and cytotaxonomy of terrestrial ferns in lowland rainforest transformationsystems. |
| **Yohana Sulistyaningsih** | B06 | Identification of secretory structure, histochemistry, and phytochemical compounds of the medicinal plant Hyptis capitata. |
| **Sri Wilarso Budi** | B07 | Functional diversity of mycorrhizal fungi along a tropical land-use gradient: effect of tropical forest transformation land used on mycorrhizal fungal propagule and soil properties and its role on plant growth and productivity in agroecosystem Jambi Province. |
| **Efi Toding Tondok** | B07 | Functional diversity of soil fungi within different lowland rainforest transformation types. |
| **Rika Raffiudin** | B09 | Diversity of bees (*Hymenoptera: Apidae*) in the natural forest and transformations habitats in Harapan Rainforest, Jambi, Sumatra, Indonesia. |
| **Idham S. Harahap** | B09 | Diversity and abundance of termite community in lowland rainforest transformation systems in Jambi. |
| **Tri Atmowidi** | B09 | Insect pollinators and bark beetle diversity in Harapan forest and Bukit Duabelas National Park, Jambi Province, Indonesia. |
| **Suria Tarigan** | B10 | Development of integrated environment modelling using multi-agent system approach in rainforest transformation systems. |
| **Leti Sundawati** | B11 | Biodiversity enrichment tree species selection in rainforest transformation land uses. |
| **Sri Sudarmiyati** | B12 | Studies on the invasive plant species at Harapan Rainforest, Jambi, Sumatra. |
| **Titik Sumarti** | C01 | Study of community local wisdom in natural resources management and sustainable livelihoods strategy on transformation systems of tropical lowland rainforest in Jambi Province. |
| **Rina Mardiana** | C02 | Political and institutional impacts on cultural landscape transformation. |
| **Yusman Syaukat** | C06 | The effects of changes in land use on farmers' livelihood and agricultural sustainability. |
| **Hermanto Siregar** | C07 | Socio-Economic condition of the communities in the national parks Bukit Duabelas and Harapan Rainforest, and the regional economy of Jambi Province. |

Research projects of counterparts funded at UNJA

| | | |
|---|---|---|
| **Yudhi Achnopha** | A01 | A study of floral composition of inland peat swamp forest in the National Park Bukit Duabelas, Jambi, Sumatra, Indonesia. |
| **Muhammad Damris** | A04 | Distribusi fraksi labil karbon organik pada berbagai karakteristik dan penggunaan tanah hutan tropis basah Sumatra Indonesia. |
| **Wiwaha Anas Sukmaja** | B01 | Bird population changes following the conversion of lowland forest to oil palm plantation in the Muaro Jambi district. |
| **Bambang Irawan** | B03 | Distribution pattern and genetic diversity of alstonia scholaris in different transformation systems. |
| **Metha Monica** | B03 | The impact of opening of the palm oil plantation on biodiversity of fish in Jambi Province. |
| **Maksudi** | B04 | Intensification of composting to reduce chemical fertilizer use and increase the income of the farmer in the rural area. |
| **Muhammad Zuhdi** | B05 | Identification and mapping of forested areas and land use systems surrounding the Berbak National Park, Sumatra, Indonesia. |
| **Muhammad Ridwansyah** | C01 | Socio-economic and environmental characteristic of transforming ex-area of forest concessions into rubber and oil palm plantations around the buffer zone of the National Park Bukit Duabelas. |
| **Zulkifli Alamsyah** | C01 | Impacts of socio-economic characteristic of small scale farmer surrounding the forest area on sustainable agriculture in Batanghari district. |
| **Agus Subagyo** | C03 | Tropical rainforest transformation: flora and fauna diversity. |
| **Bambang Hariyadi** | C04 | Tropical rainforest transformation: human interaction to landscape & environment. |

Research projects of counterparts funded at UNTAD and Universitas Brawijaya

| | | |
|---|---|---|
| **Abdul Rauf** | A03 | Energy flux at lowland oil palm plantation. |
| **Aiyen Tjoa** | A05 | Nutrition status of soil and oil palm in big and smallholder plantations and their production at Jambi Regions, Sumatra: a preliminary study. |
| **Sri Utami** | A05 | Nutrient leaching in heavily weathered soils under rainforest transformation systems. |
| **Hafsah** | A05 | Screening of potential weeds grown in oil farm plantation for animal feeds in Jambi Province. |
| **Henry Barus** | B07 | Preliminary work on mycorrhiza status on different land use types in Jambi – Sumatra. |
| **Shahabudin** | B09 | Effect of habitat modification on dung beetle diversity in the tropical land-use gradient in Jambi Province, Sumatra, Indonesia. |
| **Marhawati Mappatoba** | C04 | Income activities of farm household; the cases of oil-palm plantation in central Sulawesi and Jambi, Sumatra, Indonesia. |

## Example

Yohana C. Sulistyaningsih / IPB (affiliated to B06) – Identification of secretory structure, histochemistry, and phytochemical compounds of the medicinal plant *Hyptis capitata*

### Background and methods

*Hyptis capitata* Jacq. is a member of the family *Lamiaceae* and is used in traditional medicine by the *Anak Dalam* tribe of Jambi Province as herbal medicine to treat external and internal wounds (photo 35). This study aims to identify and analyse the secretory structure, histochemistry and phytochemical content in the plants leaves using light microscope and scanning electron microscopy (SEM). Interviews with the Anak Dalam and joined medicinal plant surveys have been carried out in the EFForTS study area in Bukit Duabelas National Park, both inside and outside the project core plots.

### Results

*H. capitata* leaves have secretory structures in form of glandular trichomes and idioblast cells. The secretory structures produced secondary metabolite compounds. Histochemical tests indicated that the peltate trichomes with 4 head cells contain alkaloids and terpenoids. Capitate trichomes are classified into two types. Type I has 1 stalk cell and 2 head cells containing alkaloids, terpenoids and lipophilic compounds. Type II has long stalk cells consisting of 7–10 cells with 1 head cell containing alkaloids and terpenoids. Glandular trichomes generally contain terpenoids and alkaloid compounds. Idioblast cells contained lipophilic compounds. The terpenoid compounds such as limonene, eugenol, farnesol isomers A, d-nerolidol, koumarin, and neophytadiene allegedly play a role in the process of wound or infection healing and act as an antibacterial agent.

**Photo 35:** *Hyptis capitata* Jacq. growth in in open areas in Bukit Duabelas National Park in Jambi Province. (Photos: Katja Rembold)

## 2. COMPLEMENTARY RESEARCH PROJECTS OF COUNTERPARTS IN 2014 AND 2015

Research projects of counterparts funded at IPB

| Name | Counterpart | Title |
|---|---|---|
| **Herdhata Agusta** | **A02** | Soil water dynamics in oil palm and rubber plantations in relation to slope and vegetation cover |

The objectives were to assess the soil water infiltration capacity and the spatial distribution of soil moisture. Soil water infiltration was measured with a double-ring infiltrometer (see photo 36) at different slopes and positions in the plantations and soil water content was analysed gravimetrically. Water infiltration rate in oil palm plantations, especially in the inactive pathway (*gawangan mati*) is much higher than in the active pathway (*pasar pikul*). The designed strips in plantations for collecting organic material after periodical harvests and maintenance purposes inhibit water runoff and facilitates more infiltration of water into the soil. It is indicated that good management can improve soil water infiltration, and thus alleviate a severe hydrological problem associated with conventional oil palm cultivations.
This research continues in 2016, funded by the Indonesian Directorate General of Higher Education (DIKTI).

**Photo 36:** Measurement of soil water infiltration with a double-ring infiltrometer.

| | | |
|---|---|---|
| **Kukuh Murtilaksono** | **A04** | Dissolved organic carbon in the Bukit Duabelas National Park and the relationship with the soil properties and its toposequence |

In forest ecosystems, most of the organic matter supplied to the organic (O) horizon is mineralized to $CO_2$. However, a portion of organic matter is leached as dissolved organic carbon (DOC) as soil water percolates. The DOC transported to the mineral soil horizons may be mineralized, leached or adsorbed onto mineral surfaces. The objective of this research was to characterize the DOC in the Bukit Duabelas National Park and to reveal the effect of soil properties, soil depth and the landscape position on DOC fluxes.
Six sites with different landscape positions – namely two soil profiles at the top, two soil profiles at the middle of the slope, and two soil profiles at the foot of the slope (near a creek) – were selected in the Bukit Duabelas National Park. Soil samples were collected in the A, AB and Bt horizons. The selected soil properties – namely SOC, total N, cation exchange capacity (CEC), soil texture, dithionite-citrate-bicarbonate-extractable iron (Fe) and aluminium ($Fe_d$ and $Al_d$), oxalate-extractable Fe and Al ($Fe_o$ and $Al_o$), organically-bound Fe and Al ($Fe_p$ and $Al_p$) – were analysed. The soil solutions were collected beneath the A, AB and Bt horizons once per month during one year and DOC concentrations was determined.

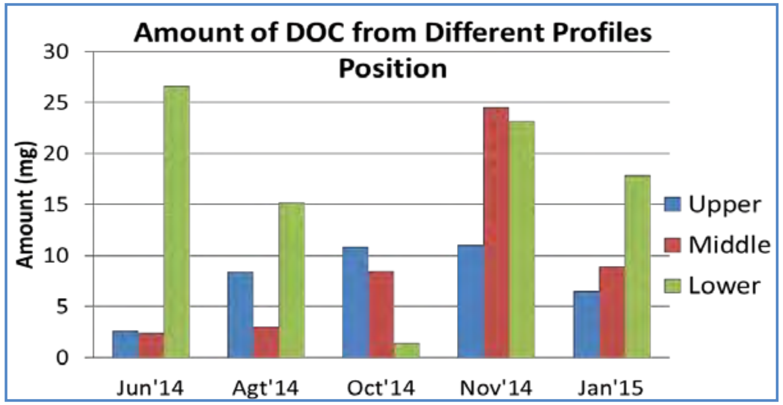



**Figure 39:** Cumulative dissolved organic Carbon (DOC) amount depending on landscape position.

The results showed that the concentration and amount of DOC in the soil profile on the lower slope were higher than those on the upper and the middle slopes (Fig. 39). The concentration and amount of DOC in the AO horizon were higher than those in both the AB and Bt horizon. The result of Pearson correlation showed positive correlations between DOC fluxes with organic-C, total-N, and Cation Exchange Capacity (CEC), but negative correlations with pH, and Fe dithionite-citrate-bicarbonate (Fed) content. The results suggested that the increase of SOC, total N and CEC increased DOC and the increase of pH and Fed decreased DOC.

| **Noor Farikhah Haneda** | **B01** | The role of ants in tropical lowland rainforest transformation ecosystem |
|---|---|---|

The transformation of forest into plantation systems represents a major ecosystem disturbance expected to affect the diversity of soil fauna and its impact on litter decomposition. Therefore, soil fauna diversity could be used as an indicator for environmental quality. The ecosystems studied in this research project are used to describe changes in ecosystem function from forest to non-forest systems. This research project was conducted in Bungku village, Bajubang sub district, Batanghari Regency, Jambi. The objectives of this research project were to investigate the diversity and role of soil fauna in litter decomposition across four ecosystem types; namely secondary forest (BF), oil palm plantations (BO), rubber plantations (BR), and jungle rubber (BJ).

Decomposition rates differed between the four ecosystem types over a 12-week period (Fig. 40), with the highest rate of litter decomposition in each ecosystem occurring within period 1 (from week 2 up to week 4). Decomposition rates were higher in the initial weeks and tended to decrease over the duration of the experiment in line with the decreasing amount of litter. Changes in soil fauna diversity facilitated decomposition across ecosystem types. Lighter soil texture (sandy clay loam as compared to clay) of secondary forest might be an important factor contributing to higher abundance of soil fauna in this ecosystem type. Interestingly, the C/N (carbon / nitrogen) ratio of the leaf litter varied over the duration of the experiment, indicating increasing decomposition of the litter material.

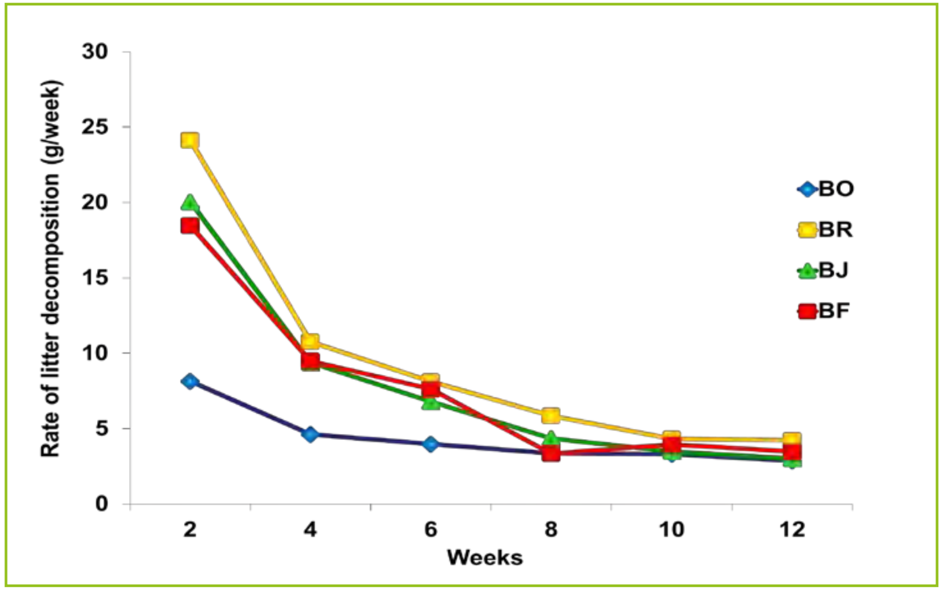



**Figure 40:** Rate of litter decomposition in secondary forest (BF), oil palm plantations (BO), rubber plantations (BR), and jungle rubber (BJ).

| **Nisa Rachmania Mubarik** | **B02** | Biodiversity inventory, collection and preservation (in-situ and ex-situ): prokaryotes and leaf blight pathogenic fungi on oil palm |
|---|---|---|

Chitin is a major component of fungi cell wall, mycelia, stalks and spore. It is hydrolysed by chitinase. This study was conducted to measure the ability of chitinase-producing bacteria to degrade chitin of fungal pathogens such as *Curvularia affinis* and *Colletotrichum gloeosporioides*. Chitinase and β-glucanase serve as a biological control agent of fungi pathogenic for oil palms. The fungi *C. affinis* and *C. gloeosporioides* cause anthracnose, leaf blight, and rotting on oil palm leaves. For this study, two *Bacillus* strains isolated from soil of an oil palm plantation in Jambi were selected as chitinase and β-glucanase producers. The optimum of chitinase production of *B. thuringiensis* strain SAHA 12.08 was at 60 h of incubation. Maximum temperature and pH of chitinase activity were

35° C and 7.0, respectively. The precipitation of chitinase with 30 % ammonium sulphate yielded a 2.35-fold activity increase. The chitinase was stable at the optimum temperature for 180 minutes. The zymogram analysis revealed that the chitinase had a molecular mass of 82 kDa (see Fig. 41). The optimal β-glucanase production of the other strain *B. subtilis* SAHA 32.6 was reached after 12 h of incubation. Maximum temperature and pH of β-glucanase activity were 45° C and 7.0, respectively. The β-glucanase was precipitated with 60 % ammonium sulphate. This treatment resulted in a 1.43-fold activity increase. Both, the precipitated chitinase of *B. thuringiensis* SAHA 12.08 and the β-glucanase of *B. subtilis* SAHA 32.6, could inhibit the growth of *C. affinis* and *C. gloeosporioides* by using *in vitro* tests. In conclusion, both isolates and also the analysed enzymes derived from the isolates showed potential for an application as a biocontrol agent for fungal pathogens of oil palm plants.

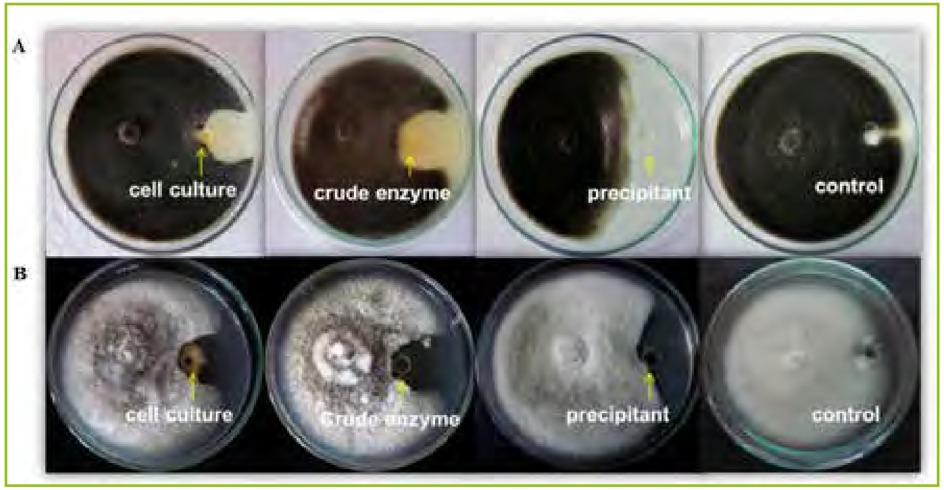



**Figure 41:** The antagonistic activity of chitinolytic *B. thuringiensis* SAHA 12.08 against *C. affinis* (A) and *C. gloeosporioides* (B) after 7 days incubation on PDA medium. Aquadest used as negative control. Precipitated enzyme by using 30% ammonium sulphate.

| | | |
|---|---|---|
| **Ulfah Siregar** | **B03** | Genetic diversity and evolutionary relationship of *Dyera costulata* and *Dyera lowii* in Jambi, Indonesia based on AFLP markers |

The status and evolutionary relationship of two indigenous Jelutung trees, i. e. *Dyera costulata* (Miq.) Hook.f and *Dyera lowii* are less known. Meanwhile their economic value have raised concern about their conservation from overharvesting. This study aimed at clarifying the status, structure, distribution and diversity of the two Jelutung trees in their natural habitats in Jambi Province, Indonesia. Six study sites were selected, which represent gradual transformation habitats of the two tree species, i. e. from dry upland forest to peat swamp forest, as well as from relatively low disturbance to locally managed forest. Vegetation analysis were performed in 1 ha plots consisted of 20 m x 20 m square plots and line transects.

Results showed that in three dry upland forests only *D. costulata* was found, while *D. lowii* was only grown on the other three peat-swamp forests, without any overlapping population suggesting an existence of ecological barrier. In high diversity conservation forest (H ranges 3.335–3.940) both species were not dominant (IVI = 3.347–18.763) and found only in narrow stripes of a remnant population. Meanwhile in more disturbed forest area or locally managed jungle (H ranges 1.820 –3.564), the two species were becoming more dominant (IVI ranges 20.736 –127.271), presumably due to preference of local community. In their closest to nature habitat both species have uniform distribution pattern, however human intervention has changed the distribution pattern into clumping. Based on the distribution and local adaptation of the two species implication of allopatric speciation is discussed.

(Procedia Environmental Sciences 33: 393-403, 2016)

| | | |
|---|---|---|
| **Triadiati** | **B04** | Contribution of coarse roots and deadwood to soil carbon and total carbon stock in lowland rainforest transformation systems on Jambi, Sumatra |

Rapid transformation of natural forests into other land-use forms in lowland Sumatra, Indonesia, strongly reduces aboveground biomass and nutrient cycling. The consequences for carbon and nitrogen stocks of dead wood remain poorly understood. This study examined the carbon (C) and nitrogen (N) stocks in natural forest and jungle rubber (rubber agroforests with natural shade tree cover) and nutrient quality stored in dead wood. Standing and fallen dead wood was defined as coarse woody debris with diameter ≥ 10 cm and classified into three decay stages of wood. Biomass was estimated using allometric equations. Nutrient concentrations of carbon, nitrogen, C: N ratio and lignin were examined in each decay stage and utilized to convert biomass into nutrient stocks.

**Results**

Total carbon and nitrogen stocks in the natural forest (4.5 t C $ha^{-1}$, 0.05 t N $ha^{-1}$, respectively) were three times higher than those in the jungle rubber (1.5 t C $ha^{-1}$, 0.02 t N $ha^{-1}$, respectively). The stocks of carbon and nitrogen at early and advanced wood decay in the natural forest were also higher than those in the jungle rubber. The high lignin stock in dead wood of the natural forest was presumed as the long-term carbon storage. Decay stages showed different nutrient concentrations. With advancing wood decay stage the nitrogen concentration increased and C: N ratio decreased, while concentrations of carbon and lignin were variable. Abundance of dead wood biomass as well as carbon and lignin stocks were found to be higher in the early decay stage compared to the advanced decay stage; this indicated that dead wood was slowly decayed. High inputs of dead wood in natural forest indicated a good soil health, thus replacing natural forest with jungle rubber strongly reduces total carbon and nitrogen stocks. These stocks are an important source of nutrient turnover to the soil.

| | | |
|---|---|---|
| **I Nengah Surati Jaya** | **B05** | Spatial patterns of forest and land-cover change in Jambi province (Sumatra, Indonesia) from 1990 to 2011 |

I Nengah Surati Jaya, Tatang Tiryana, Christoph Kleinn, Dian Melati, Lutz Fehrmann, César Pérez-Cruzado.

We analysed the spatial pattern and driving factors of land use and land cover change (LULC) from land/forest cover to cultivation of palm oil, rubber, timber and smallholder rubber agroforestry in the EFForTS core plots of the Harapan and Bukit Duabelas landscapes. The objectives of the study were to (1) identify the changes of LULC in the Jambi Province, to (2) determine changes of the spatial pattern of secondary forest, jungle rubber, oil palm and rubber plantation from 1990 to 2013, and (3) to specify the driving factors of deforestation.
Four different LULC maps produced for the years 1990, 2000, 2011 and 2013 were used for the study. Visual interpretation techniques using Landsat imageries (Landsat TM, ETM+ and ORI/TIRS) were done at the Forest Resources Inventory Remote Sensing Laboratory at the Forestry Faculty, Bogor Agricultural


**Figure 42:** The Mean Patch Size (MPS) and Aggregation Index (%)

University (IPB) to map the LULC. Furthermore, additional data such as ground truth, Rapid Eye images from 2013, and the land cover classification system as commonly used by the Ministry of Forestry of Indonesia (MoF, 2008) have been used as guidance.

The study found that there was significant land use and land cover changes from 1990 to 2013 (see Fig. 15, p. 17). The secondary forest has declined significantly during this period (Fig. 42) and was largely transformed into oil palm and rubber plantations. In-depth interviews revealed that the driving forces of land use changes were mainly related to the development of estate crop by both local community and big estate companies.

| **I Nengah Surati Jaya** | **B05** | Compiling the values of published wood specific gravity for the tree species / genus present in the CRC core plots and B05 inventory plots. |
|---|---|---|

Edwine Setia Purnama, César Pérez-Cruzado, Dian Melati, Katja Rembold, I Nengah Surati Jaya, Tatang Tiryana, Lutz Fehrmann, Christoph Kleinn

**Background and methods**

Wood specific gravities (WSG) of trees in tropical forest ecosystems vary considerably with species and taxonomic groups. WSG is an important variable in biomass estimation and it is notoriously difficult to determine. The common practice to use gross average WSG values introduces uncertainty into forest biomass estimation.

**Objective**

To help reducing such uncertainty, this study compiled WSG values of the tree species identified within the B05 sample plots and the EFForTS study areas. The main objective was to contribute improving biomass estimates by using specific WSG values per species or genus or taxonomic group.

**Approach**

The underlying species lists were collected from secondary forests, jungle rubber, rubber plantation, and permanent plots of PT REKI. WSG value were searched for each species using various references, including the wood density database of ICRAF (World Agroforestry Center), PROSEA (volume 1, 2 and 3) and the Indonesian wood atlas (I to IV).

**Results**

Of the 861 species on the sample plots and study sites, 855 have been identified either at species level, genus level, or family level. A summary is depicted in Figure 43. For 6 species, an identification was not possible. Figure 44 compares the WSG values as identified for different timber classes. The compiled WSG values varied considerably and the ranges show a clear trend in terms of commercial timber value: the WSG of "major commercial" trees ranges from 0.36 to 0.90 g/cm$^3$, for the "minor commercial timbers" from 0.33 to 0.98 g/cm$^3$, and for the "lesser-known species" from 0.21 to1.06 g/cm$^3$.

While it is acknowledged that the WSG does also vary within individual trees and between individual trees of the same species, one may expect that these species (or family or genus) specific WSG values will contribute improving biomass estimates.

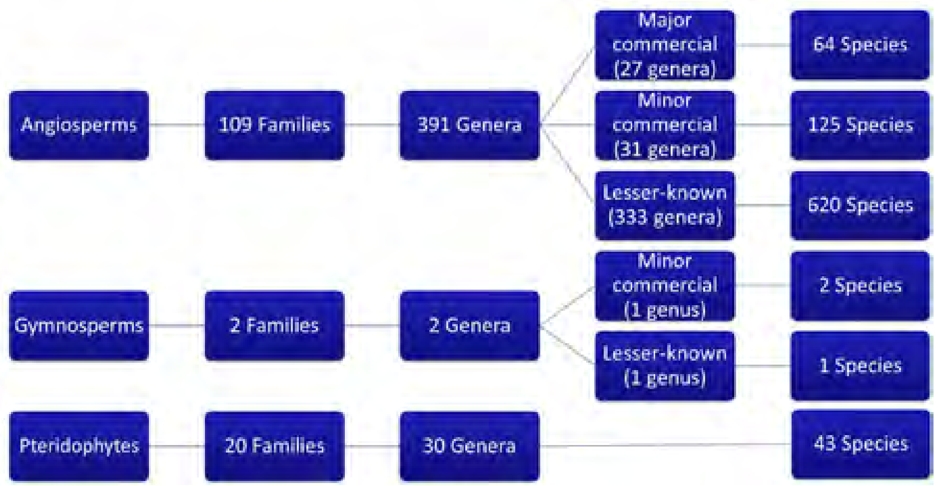



**Figure 43:** Taxonomic breakdown of the 855 different tree species that were identified on the inventory plots and study sites of CRC990

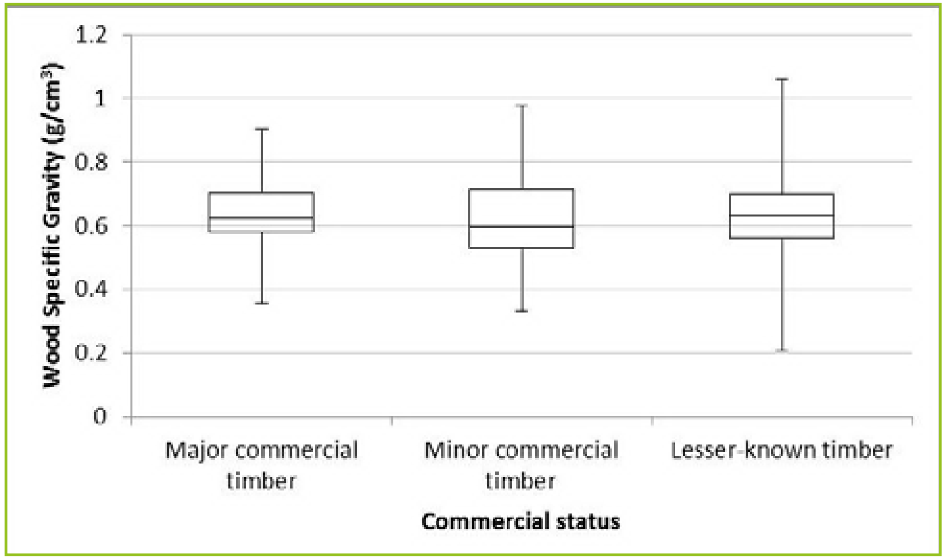



**Figure 44:** Comparison of WSG values for different timber classes.

| | | |
|---|---|---|
| **Sri Wilarso Budi** | **B07** | Diversity of arbuscular mycorrhizal fungi in Bukit Duabelas and Harapan Forest, Jambi Province |

**Background and methods**

Mycorrhizal fungi play important roles in fostering plant nutrition and growth. The presence and functionality of mycorrhizal symbiosis in agrosystems can be affected by several factors such as vegetation removal, agricultural practices, soil properties and application of fertilizers. The objective of the present study was to determine the diversity of arbuscular mycorrhizal fungi (AMF) in lowland rain forests located in Bukit Duabelas National Park and Harapan Forest Jambi Province in comparison with rubber and oil palm plantations and agro-forest systems (see photo).

**Results**

The number of AMF spores per soil mass was lowest in the lowland rain forests in both areas, Bukit Duabelas and Harapan. The abundance of AMF spores was negatively related to the availability of phosphorous (P) in the soil as well as to soil organic matter. The disturbance of the ecosystems by intense management seemly influenced spore abundances. In contrast, the diversity of spores, based on their morphology, was higher in the soil of lowland rain forests than in the other land use systems. Further research on AMF diversity in soil is currently being conducted. It is also necessary to investigate whether increases in spore abundance indicate loss in soil fertility in rubber or oil palm plantations or loss of host species.


**Photo 37:** Examples for spores extracted from soil of Harapan and Bukit rain forests (HF and BF). Please note that the size, color and shape of the spores differ because they represent different arbuscular mycorrhizal fungal species.

The objective of the present study is to determine the diversity of arbuscular mycorrhizal fungi (AMF) in lowland rain forest located in Bukit Duabelas National Park and Harapan Rainforest in Jambi Province. Analysis of the number of AMF spores showed that there was variation in four types of ecosystems, both in Bukit Duabelas and Harapan Rainforest. The number of spores in the forest ecosystem was lower than in rubber plantations, oil palm plantations and jungle rubber, both in Bukit Duabelas and in Harapan Rainforest. The disturbance of ecosystems seems to influence the abundance and distribution of AMF spores. On the contrary, based on the morphology of the spores, the number of different spore types found in the forest ecosystem was higher than in the other ecosystems, both in Bukit Duabelas and in Harapan Rainforest. This means that the transformation of land may decrease the diversity of AMF species, but increase the number of spores. Further research is needed to know whether the transformation of ecosystems to rubber or oil palm plantations decreases soil fertility.

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| **Rahayu Widyastuti** | **B08** | Seasonal changes of soil microarthropod populations in microhabitats of oil palm plantations of Southern Sumatra |

We investigated variations of soil microarthropod communities and functional properties of the soil of oil palm plantations as affected by seasonal abiotic changes. Additionally, the role of microhabitats as refuges for soil animals during climatic extremes was investigated. Four oil palm plantations in the Harapan landscape were investigated. Soil samples were taken every 30 days during a period of 12 months and soil animals were extracted by using modified Kempson extractors. Soil microarthropods from various microhabitats (e. g., shaded area, frond litter accumulation, detritus and epiphytes) were sampled once during the wet season and once during the dry season. Abundances of soil animals were counted, Collembola and Oribatida were determined to family level. Density of Oribatida distinctly fluctuated with season. It was lowest in February, the month with the lowest precipitation. Presumably, Oribatida moved deeper into the soil during dry months to avoid harsh environmental conditions. Diversity of Oribatida also significantly varied between microhabitats. It was at a maximum in lanes where palm fronds were piled up reaching 4,560 individuals $m^{-2}$, whereas in open areas Oribatida density was only 1,570 individuals $m^{-2}$. Generally, Oribatida were dominated by Scheloribatidae, Mycobatidae and Galumnidae. Notably, patterns in Collembola resembled those in Oribatida. Overall, the results suggest that the soil decomposer community of oil palm plantations suffers from shortage in habitat and resources, and this results in decomposer communities sensitively responding to climatic variations. To foster decomposer communities and buffer effects of climatic variations residue management strategies increasing the living space of decomposers and improving food availability need to be adopted.

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| **Damayanti Buchori** | **B09** | Ecological services of transformed ecosystems: the role of ants in different land-use systems in Jambi |

Land-use change causes undesirable effects such as biodiversity decline, altered community structure and reduced ecosystem services. Changes in species composition and disrupted trophic interactions between pests and their natural enemies may indicate decreases in ecosystem services. We studied the effect of forest habitat transformation on the community structure of ants, which include major biological control agents. We focused on four types of land use: forest, jungle rubber, rubber plantations and oil palm plantations, around Harapan Forest (Harapan) and Bukit Duabelas National Park (TNBD), Jambi, Indonesia. Each type of land use was replicated four times, with a plot size of 50 m x 50 m at each of the altogether 32 sites.
Ants were collected using hand-collecting in combination with tuna and sugar baiting on three strata i.e. leaf litter, soil and tree. We found 104 ant species from both the Harapan (Fig. 45b) and TNBD (Fig. 45a) landscape. Surprisingly, number of ant species per plot did not exhibit significant differences between land-use types, both in Harapan and TNBD. However, species composition of ants was significantly different among land-use types. Forest and jungle rubber communities are relatively similar to each other (but still different), and distinct from community composition in oilpalm and rubber plantations. We conclude

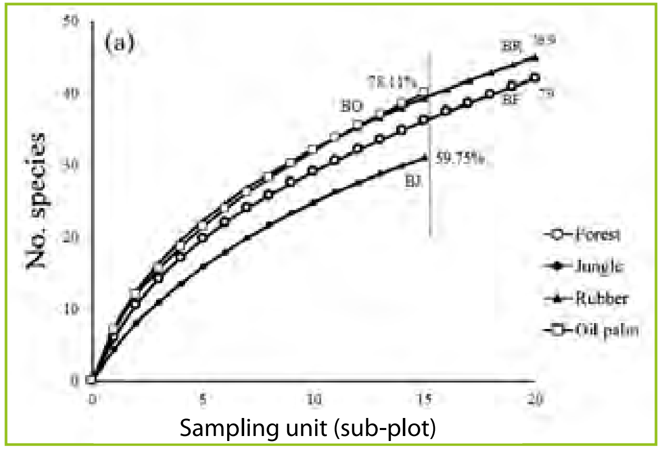


**Figure 45 (a):** Bukit Duabelas National Park
Species accumulation curves of ant species found four land use types within the two study sites, Bukit Duabelas National Park and Harapan Forest. The dashed line indicates ant species richness from 15 sub-plots.

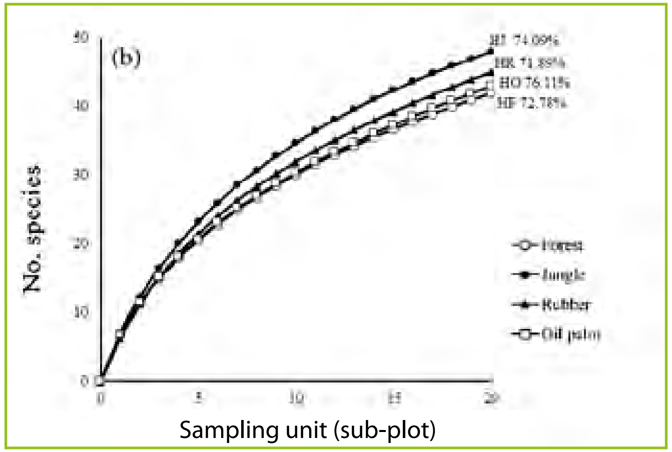


**Figure 45 (b):** Harapan Forest
Species accumulation curves of ant species found four land use types within the two study sites, Bukit Duabelas National Park and Harapan Forest. The dashed line indicates ant species richness from 15 sub-plots.

that conversion of remnant forested habitats to plantations would result in a net loss of ant species, even when ant species richness in plantations and forested habitats are similar.

| Suria Darma Tarigan | B10 | Rainforest transformation systems and assessment of their impact on water ecosystem services in Merangin Tembesi Watershed in Jambi |
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The impact of continuing rainforest transformation on hydrological functioning and other ecosystem functions in South East Asia remains uncertain. In our study area, which is one of the hotspots of Indonesia's recent oil palm boom, residents believe that the increase in oil palm production has resulted in more frequent flooding in the rainy season and water scarcity in the dry season by the high surface runoff and subsequent decrease in groundwater discharge. We measured surface runoff in oil palm plantations, rubber monoculture, shrublands, agroforest and secondary forest. In addition, we measured hydrological parameters in a small-scale watershed experiment of two mitigation options: frond pile management and silt pit treatment. The results were used to parameterize a SWAT model with the aim of simulating a) the impact of oil palm expansion on surface runoff on the watershed scale, and b) the impact of mitigation options to reduce the surface runoff.

The results showed higher soil water infiltration (and therefore reduced runoff) with frond pile management (Fig. 46) and in combination with silt pit treatment. The SWAT model was successfully validated (Nash-Sutcliff efficiency of 0.8) and based on the SWAT simulation, frond pile management in combination with silt pit treatment significantly reduces runoff.

**Photo 38:** Low water table

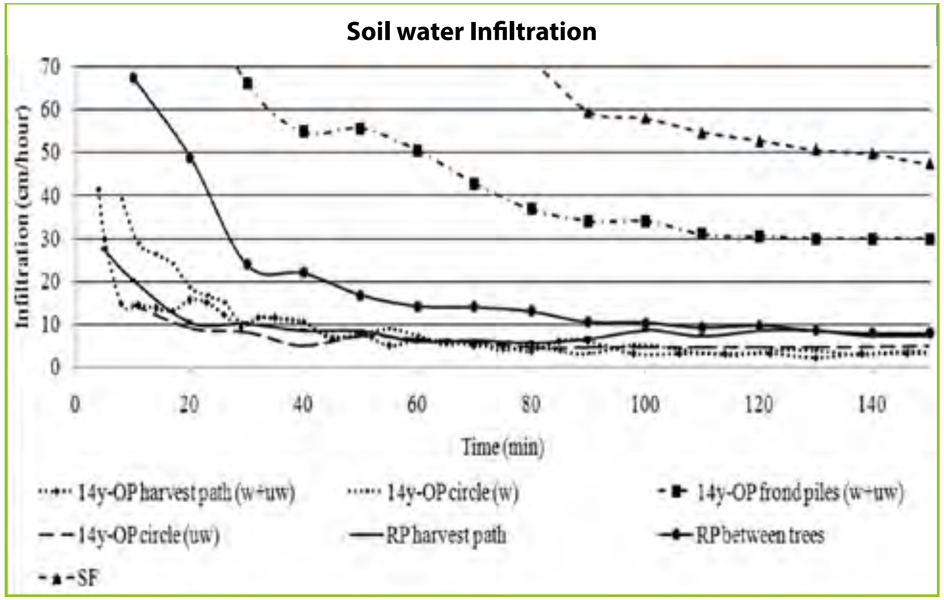


**Figure 46:** Infiltration in different forest transformation systems: OP – oil palm, RP – rubber monoculture, SF – secondary forest, w – weeded, uw – unweeded, 14y – 14-year-old.

| **Nunung Nuryartono** | C04 | Consumption pattern of the poor households in Jambi Province |
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Food is a necessity because it is a basic need. To meet the food needs for all at all times the area of food policy became a key area for the central and local government interventions. The present study used the data of National Socio-Economic Survey (SUSENAS) 2008–2010 in Jambi to estimate a Linear Approximation of the Almost Ideal Demand System (LA-AIDS) to analyse food demand pattern with a focus on s staple food consumption to detect substitution and complementarity patterns. The objectives of this study were to describe the pattern of food consumption of poor households, identify factors that influence food consumption patterns of poor households, and analyse changes in food consumption of poor households due to changes in prices, income, and socio-demographic characteristics.
The analysis showed that in rural areas, the share of food expenditure is higher compared to urban areas: About 80 % in rural areas while in urban area about 75 % (in 2008). Poor households spend most of their income for food consumption (ranging from 62 –77 %, (between 2008 and 2010). The share of food expenditure by poor households in Batang Hari district is highest compared to other districts. Among staples, the highest share of food expenditure is on rice with 20 – 45 %. Rice is the main source of staple food (and source of carbohydrate). Because the share of food consumption of poor households is still high, they are likely to be exposed to and suffer from food price volatility. In case that the government will reduce fuel subsidies (which has happened), food prices are likely to increase, and appropriate measures for protecting the vulnerable should be taken ("food social safety net for the poor"). In addition, the phenomenon of volatility in food prices should also be a concern.

| **Damayanti Buchori** | Z02 | Population structure of the invasive Yellow Crazy Ant *Anoplolepis gracilipes* across land-use systems in Jambi, Sumatra, Indonesia |
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Jochen Drescher (UGoe), Stefan Scheu (UGoe), Rion Apriyadi (IPB), Rizky Nazarreta (IPB)

The invasive Yellow Crazy Ant *Anoplolepis gracilipes* is commonly found in agricultural landscapes in Southeast Asia. It forms large polygynous and ploydomous supercolonies which in their extreme can span over dozens of kilometres, containing thousands of queens. Its geographical origin is still under dispute, as is its potential use as a biocontrol agent in oil palm plantations. Our aim was to study its spatial distribution and population structure in Jambi Province (large scale) and Bogor Botanical Garden (small scale). Sampling in Jambi was done between April and August 2013 in EFForTS core plots as well as in nearby plots. Ants were collected from PVC plates baited with honey (Fig. 47) and presence/absence of *A. gracilipes* and other ants was noted after 30min and 60min (Fig. 48). In Bogor, baited PVC plates with honey were distributed in a 50*50m grid throughout the entire Botanical Garden to map the spatial distribution of *A. gracilipes* colonies (Fig.49). *A. gracilipes* was encountered at ca 70 bait plates or 25% of the entire area of Bogor Botanical Garden, and between 10 –20 individuals sampled in 99.8 % EtOH p. A. We furthermore measured intercolonial aggression between workers of 5 putative supercolonies using standard behavioural assays. Ant samples from Jambi Province and Bogor Botanical Garden were brought to molecular biological facilities at the University of Göttingen. We extracted DNA from 8 individuals per sample which we then genotyped using 6 variable microsatellite markers specifically designed for *A. gracilipes*. Our results suggest that our initial assignment of individual nests to putative supercolonies was largely correct, and that overall intra- and intercolonial genetic variability is similar to previous findings from northern Borneo and north-eastern Australia. While the work on population structure of *A. gracilipes* in Jambi is currently on halt due to shortages in manpower, the work on *A. gracilipes*' population structure in Bogor Botanical Garden resulted in a master thesis by Rion Apriyadi MSc.

**Figure 47:** A PVC plate baited with honey has attracted *A. gracilipes* workers. The usually smooth sides of the bait plates were roughened up with sandpaper to ease access of small ant species who might otherwise slide down. Ca. 55 individuals of *A. gracilipes* are shown on this picture.

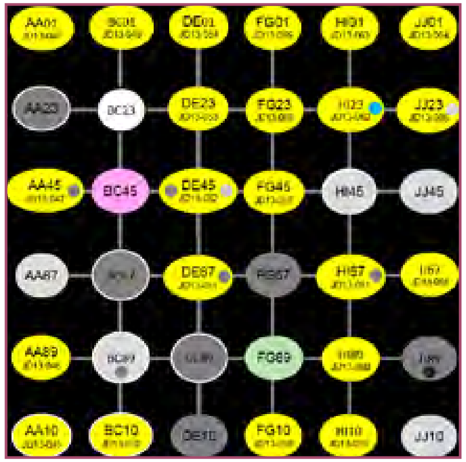


**Figure 48:** Example of a distribution map of *A. gracilipes* in core plot HR3. Yellow ellipses represent intersections of the 10 m x 10 m core plot grid at which *A. gracilipes* was found during baiting, and contain the code of the intersection and the code of the Ethanol vial that was used for sampling. Ellipses with colours other than yellow were not visited by *A. gracilipes* nut by other ant species during the 60 m of baiting.

**Figure 49:** Distribution of *A. gracilipes* in Bogor Botanical Garden (Aerial view, Google maps). Triangles represent the position of bait plates at which *A. gracilipes* was found, and numbers indicate the ethanol vial used for sampling.

**Master thesis**

Apriyadi, Rion 2014. Struktur populasi semut invasive *Anoplolepis gracilipes* Smith (Hymenoptera: Formicidae) di Kebun Raya Bogor. Sekolah Pascasarjana, Institut Pertanian Bogor.

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| **Damayanti Buchori** | **Z02** | Barcoding and photographic documentation of Ant (*Formicinae*) and Springtail (Collembola) collections from EFForTS core plots. |

Jochen Drescher (UGoe), Stefan Scheu (UGoe), Rosichon Ubaidillah (LIPI), Amanda Mawan (IPB), Rizky Nazarreta (IPB)

This ABS research project targeted parts of the canopy arthropod collection of Z02 (see page 33). Specifically, the objectives of this study were: (1) the establishment of barcodes for ants and springtails from the Z02 collection, (2) photographic documentation of the Z02 ant collection and (3) the merging of data from Z02 and B01 collections.
Amanda Mawan and Rizky Nazarreta came to work on this ABS project at facilities of the University of Göttingen from April until mid-July 2015. Regarding aim (1): DNA was extracted from about half of the 1200 ant specimen transferred to Göttingen, while roughly the other half was set aside for mounting and photography. For Collembola, prepared first barcodes of combined sequences of mitochondrial and ribosomal genes for 5 abundand Collembolan morphospecies. Molecular biological analyses of ants and springtails is currently on halt due to shortages in manpower. Regarding aim (2): Almost two thirds of the ant collection transferred to Göttingen have so far been mounted and photographed

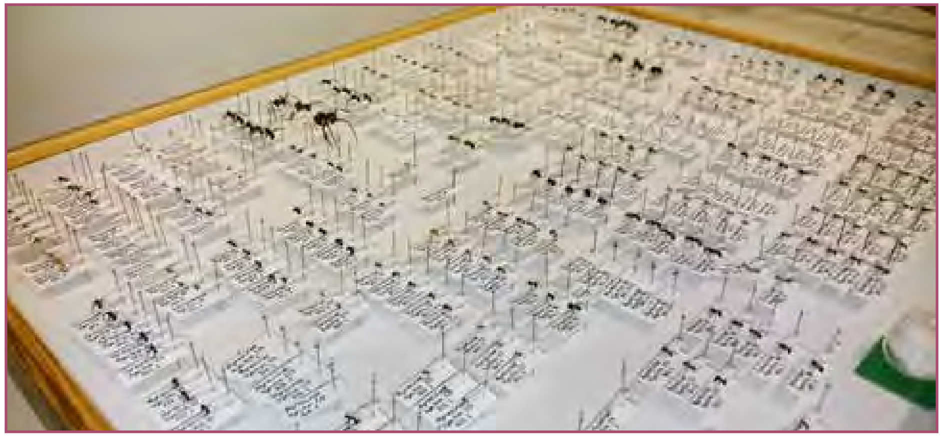

**Figure 50:** Mounted canopy ant specimen collection at the University of Göttingen.

(Fig. 50–52), and both mounting and photographic documentation are still ongoing. Regarding aim (3): The merging of data from Z02 and B01 ant collections has not been achieved during this ABS measure. However, the re-identification of ant samples from B01 and the subsequent merging of datasets in a common database is currently in progress as a Bachelor thesis at the University of Göttingen. We expect to be able to merge and jointly analyze datasets of Z02, B01 and B09 ant collections until end 2016.

**Figure 51:** *Vollenhovia* sp. (Formicidae:Myrmicinae) in lateral view. Note that due to the small size of the ant specimen, it had to be mounted directly on the tip of a needle.

**Figure 52:** *Anochetus graeffei* (Formicidae:Ponerinae) in lateral view. Note the large trap-jaw mandibles and the visible sting of this predatory ant.

Research projects of counterparts funded at UNJA

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| **Asmadi Saad** | **A01** | Tropical modern pollen collection as a tool to interpret the quarternary fossil pollen records in Sumatra, Indonesia |

Collections of modern pollen samples and pollen-vegetation relation studies represent the basic research tool of any palynological research. Objectives of this research were to (1) develop a pollen and spore collection at the University of Jambi (UNJA) and (2) to carry out vegetation analysis and set new pollen-spore traps in defined locations related to the A01 scientific project (Jambi Province, Sumatra). Vegetation surveys were carried out from May to September 2015 and in May 2016 in the Kerinci National Park (Danau Njalau and Lingkat) and in the Bukit Sari Natural Recreational Park. A total of 20 pollen traps were installed in

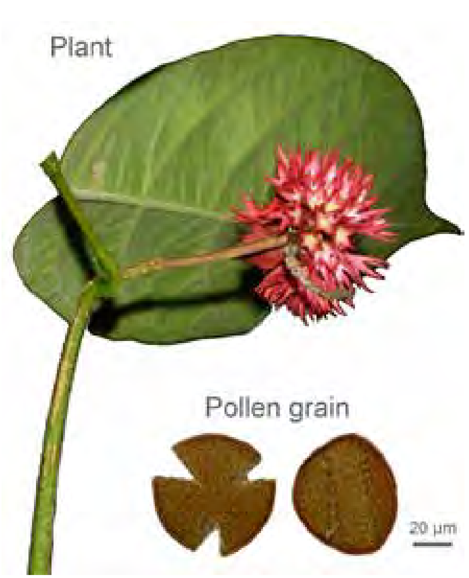


**Photo 39:** Clerodendrum deflexum plant and pollen collected for the reference collection at UNJA.

**Photo 40:** Team at UNJA installing pollen traps in Mendahara Ilir (Jambi, Sumatra). From right to left: Verawati, Handriyani, Reza Mardhony and Erik Suwananda.

2014 in the Kerinci National Park, in the Bukit Sari Natural Recreational Park, in Sungai Buluh, in the oil palm plantation of PTPN VI and in Mendahara Ilir. After one year the pollen traps were collected and are currently under study to reconstruct the pollen rain production and distribution at the different sites as compared to the vegetation composition in the plots. Flowers for pollen reference collection were taken from Kerinci, Bukit Sari, Mendahara Ilir, Sungai Buluh and Muara Jambi Temple. So far ca. 150 pollen taxa have been added to the collection in UNJA. The number will increase as the collection is still ongoing.

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| **Damris Muhammad** | **A04** | UV and FTIR characterization of dissolved organic carbon in soil extracts and leachates from tropical lowland rainforest transformation systems |

The properties of dissolved organic carbon (DOC) are diverse and complex in nature with varying structural, functional and molecular weights. Tropical lowland rainforest transformation may lead to major modifications of soil properties, including DOC, in the forest floor. The aim of this study was to characterize spectroscopic properties of DOC from the soil using hot and cold water as extraction agents. The spectroscopic properties were determined by a combination of spectroscopic techniques (UV-Vis and FTIR). Soil samples were collected from the forest transformation systems of Bukit Duabelas National Park from 0–10, 10–20 and 20–30 cm soil depths with three replicates. Dissolved organic carbon was extracted from the soil using a soil-water ratio of 1:5. Fractions of the supernatant were used for a 15-day incubation study and analysed at day 1, 5, 10 and 15. The total DOC in top soil (0–10 cm) of natural forest (378µg C/g soil) was slightly higher than the rubber plantation (370 µg C/g soil) and jungle rubber (375 µg C/g soil), but considerably higher than in the oil palm plantation (304 µg C/g soil) (Fig. 53). Depth profiles of total DOC decreased following the soil depth of each forest transformation systems. Hot water extractable DOC was slightly higher than cold water. A UV Spectrum of DOC showed a sharp peak at 235 nm and indicated the presence of aromatic hydrocarbon. Incubation up to 15 days decreased the UV peak gradually. This indicates that the majority of DOC was mineralized with-in two weeks. However, hot and cold water extracts showed variation in response to incubation, probably indicating different characteristics of DOC in the extracts. More lab works is needed on spectroscopic properties of DOC to gather FTIR data analysis.

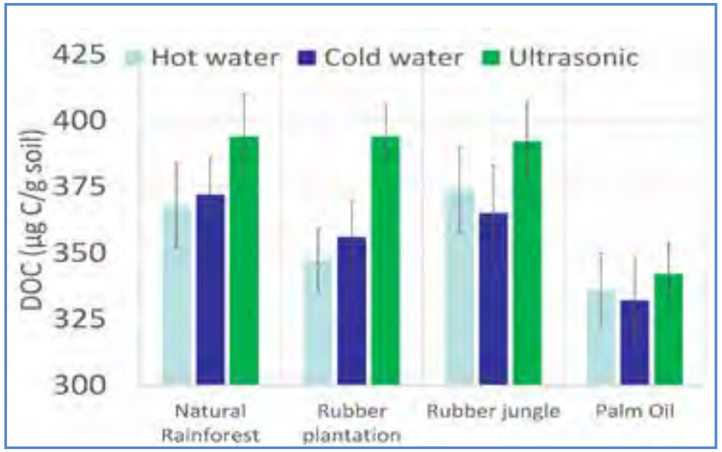


**Figure 53:** Dissolved organic carbon (DOC) content from three extractions methods under four transformation systems.

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| **Bambang Irawan** | **B03** | Flowering and fruiting ecology of ironwood (*Eusideroxylon zwageri* Teijsm. & Binn.) |

Ironwood (*Eusideroxylon zwageri* Teijsm. & Binn.; it is known colloquially in English as Bornean ironwood, bulian, billion or ulin) belongs to the family of Lauraceae. *E. zwageri* is one of the most important construction woods in Indonesia due to the excellent resistance to bacterial, fungal, insect and marine borer attack. The growth of ironwood is slow in comparison to other tree species. Knowledge of the flowering ecology of *E. zwageri* is limited although this information is very important for the management of *E. zwageri* regeneration. The study on the flowering and fruiting ecology of *E. zwageri* has been conducted to (1) investigate the relationship between climatic and edaphic factors influencing the flowering of *E. zwageri* and to (2) study the flowering and fruiting phenology of *E. zwageri*. The study has been conducted in four locations, namely (1) in the Durian Luncuk Conservation Area, (2) the Senami Forest, (3) at Bungku, and (4) in the Sridadi Village. Purposive sampling has been applied. The size of the plots was one hectare, both in Durian Luncuk and in Senami Forest. The mature trees inside the plots were observed regularly, once every two weeks. Two flowering trees growing in Bungku and Sridadi were observed regularly to obtain data on flowering and fruiting phenology. Growth rate and morphological characteristics of the shoots and the leaves were also recorded once every two weeks.

The results showed that the mean diameter at breast height (DBH) of flowering trees in the Senami Forest was 20.14 cm, while in the Durian Luncuk Conservation Area it was 39.55 cm. Additionally, the percentage of flowering trees in Durian Luncuk was slightly higher (59.79 %) compared to those in the Senami Forest (51.90 %). The inflorescence reached maximum growth in eight weeks. Alternatively, fruit length and diameter reached maximum growth 18 weeks after pollination. Fruit shedding occurred at 30 weeks after pollination. Leaf length and width reached maximum growth eight weeks after initiation. There was no leaf shedding up to 30 weeks of observation.

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| **Revis Asra** | B06 | Diversity of dragon's blood palm (*Daemonorops spp.*) in Bukit Duabelas National Park, Sumatra, Indonesia |

### Background and methods

Bukit Duabelas National Park (TNBD) is one of the habitats of the dragon's blood palm (*Daemonorops* spp.) which has its name from the red resin. The resin is a non-timber forest product of high economic value as it can be used as dye or for medicinal purpose. There are 115 genera of the genus *Daemonorops* but only 12 of which belong to the group of dragon's blood palm. The resin is extracted from the fruits by the indigenous Anak Dalam tribe and then sold to local traders. The large number of rivers and streams in the TNBD provides a suitable habitat for dragon's blood palms. The objectives of this research were to identify the species, the number of clumps per plots, the number of individuals per clump, to classify the age of each clump, to map the distribution of each individual/clump, and to analyse possibilities for cultivation to support economic benefits for the Anak Dalam tribe. We used purposive random sampling methods within the four EFForTS core plots in TNBD (BF1–4) and in Rotan Jernang demonstration plot within the National Park which is a protected area for dragon's blood palms.

**Photo 41:** Revis Asra – studying the diversity of dragon's blood palm (*Daemonorops* spp.) in Bukit Duabelas National Park, Sumatra, Indonesia.

### Results

*Daemonorops* spp. was absent from all EFForTS core plots, but one clump of 15 individuals of the species *Daemonorops draco* was found in the demoplot. Ten of the 15 individuals were female, what was indicated by the fruit of the dioecious plants. Three of the plants classified as 'youngest', five individuals as 'young', two individuals as 'mature', and two individuals as 'aged'.

| **Wilyus** | **B08** | Potential of entomopathogenic fungi in rainforest transformation systems In Jambi Province |
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The use of entomopathogenic fungi as control agents for herbivore pest insect is a promising alternative to chemical pest control. Since they function as natural antagonists of pest species they are assumed to be environmentally safe and are receiving increased interest as biological pest control agents worldwide. Forest are an important production systems for timber and other forest goods. Compared to arable systems they are inhabited by diverse flora and fauna, and this also applies to entomopathogenic fungi. Therefore, using entomopathogenic fungi as natural pest control agents in forests is promising. We explored the potential of entomopathogenic fungi in rainforest transformation systems in Jambi Province from January – December 2014. Entomopathogenic fungi were captured by collecting insects infected by fungi and by biting of entomopathogenic fungi from soil using instar larvae of T*enebrio molitor*. Entomopathogenic fungi were cultured on Glucose-Yeast-Agar, isolated and identified in Pest Protection Laboratory and Agribisnis Laboratory University of Jambi. The results showed that at the study sites six genera of entomopathogenic fungi occur, namely *Metarhizium*, Beauveria, *Verticillium*, *Nomureae*, *Paecilomyces* and *Sorosporella*. Each of these fungi are promising candidates for developing biological control species and their usefulness for fighting against insect pest species is currently explored.

| **Sunarti** | **B10** | The Distribution of soil organic carbon and its relevance for soil water content in oil palm plantations |
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Expansion of oil palm plantations is assumed to be responsible for degradation of hydrological functions, but there is not enough comprehensive data to verify this. The objectives of this research were to identify the distribution of soil organic carbon (SOC) and water content, and to evaluate their relationship at several soil depths across an age gradient of oil palm plantations. A field survey was carried out for the identification of the oil palm age gradient and soil samplings. The research was conducted in smallholder oil palm plantations at Bungku Village, Batanghari District, Jambi Province between February and June 2014. Soil samples were collected from several ages of oil palm plantations (0, 1, 5, 7, 10, and 16 years) from 0 – 30, 31 – 60, and 61 – 90 cm of soil depth, with three replicates, respectively. Laboratory analysis was conducted to determine soil texture, bulk density, organic carbon and water content.

The smallholder oil palm farmers at Bungku Village managed their plantations with outdated technology, and oil palms were grown mostly unweeded. Results indicated that soil in different ages of oil palm plantations was differently compacted. Soil bulk density (SBD) was 1.12 – 1.59 g $cm^{-3}$ and soil organic carbon (SOC) was very low-low (0.29 – 1.60 %), with a negative linear relationship between soil depth and SOC (Table 1). Low SOC was responsible for low soil water availability in oil palm plantations. The relationship between SOC and soil water content (field capacity, permanent wilting point, and available water) in oil palm plantations of different ages was not always linear. We need more comprehensive research on hydrological functions of soil in oil palm plantations of different ages, on determining factors, and on the autocorrelation of determining factors.

**Table 1:** Distribution of bulk density (SBD) and soil organic carbon (SOC) from several ages of oil palm plantations (0, 1, 5, 7, 10, and 16 years) from 0 – 30, 31 – 60, and 61 – 90 cm of soil depth, Bungku Village, Batanghari District, Jambi Province, Indonesia.

| Age-Gradient of Oil Palm | 0 – 30 cm | | 31 – 60 cm | | 61 – 90 cm | |
|---|---|---|---|---|---|---|
| | SBD (g $cm^{-3}$) | SOC (%) | SBD (g $cm^{-3}$) | SOC (%) | SBD (g $cm^{-3}$) | SOC (%) |
| 0 Year | 1.43 | 1.60 | 1.45 | 0.90 | 1.51 | 0.67 |
| 1 Year | 1.22 | 1.40 | 1.31 | 0.93 | 1.37 | 0.61 |
| 5 Year | 1.12 | 0.88 | 1.19 | 0.59 | 1.39 | 0.29 |
| 7 Year | 1.44 | 1.17 | 1.49 | 0.64 | 1.42 | 0.54 |
| 10 Year | 1.27 | 0.90 | 1.31 | 0.56 | 1.43 | 0.45 |
| 16 Year | 1.22 | 1.32 | 1.28 | 0.85 | 1.59 | 0.66 |

| Rosyani | C02 | Suku Anak Dalam (SAD) communities, their institutional transformations and their impacts on environmental changes around the National Park Bukit Duabelas (TNBD) |
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The Police of Government in Jambi Province has resettled the SAD, who once lived semi-nomadically inside the forest. The SAD live in Pematang Kabau village; one group resides at Jl. Singosari /KOPSAD and the other at Jl. Kutai Ujung. The locations are around 1 km from the National Park Bukit Duabelas (TNBD). Each location is held by the "Tumenggung" who serves as a political authority or customary leader.

This research will try to answer these questions: what impact does the SAD resettlement have on the immediate neighbourhood of transmigrant communities, and how are their environmental interactions with their oil palm plantations. On the other hand, this research clarifies how economic and ecological changes influence the SAD life and their value systems in general. Institutional transformation has occurred as the SAD have become settled/sedentary, which will be followed by the transformation of their environmental values. The changes in land-use perception and institutional paradigms will have further consequences for the lives of the SAD.

The research methods include the Focus Group Discussion (FGD) approach and direct interviews with SAD groups who live in Kutai and Singosari streets. Descriptive analysis is applied by using the "Delphi Method Analysis". The sources of the data are primary and secondary data. Primary data is directly collected from SAD community informants using in-depth interviews and participant observation methods during the fieldwork. Literature (journals, books) and unpublished reports are used as secondary data.

The impact of economic changes is seen from the activities carried out by the SAD to support their life. There are 27 household resettlements in the Singosari area; 55.55 % of SAD activities are made up of planting and harvesting rubber inside the area of the TNBD. 25.93 % of the SAD are working for the oil palm plantation company. The other 18.52 % work as farmers in the oil palm plantation on the boundary area of the Bukit Duabelas National Park. In the Kutai area, there are 44 SAD; 77.27 % of SAD activities are made up of planting and harvesting rubber inside the area of the Bukit Duabelas National Park, and 22.73 % work as farmers in the oil palm plantation of the boundary area at the Bukit Duabelas National Park. Although the government assistance is not sufficient to fulfil their needs, the SAD still have opportunities to earn income from the Bukit Duabelas National Park. It is a positive thought to locate the resettlement adjacent to the National Park.

Social activities, such as education, are considered substantial for the SAD. 90.14 % of SAD mentioned that they need education for their families and want their children to go to school. 9.86 % of SAD did not give their answers. Education for SAD children is held twice a week. Some SAD families go to elementary school in Pematang Kabau Village. The adat is still running together with the governmental regulations.

Environmental impact on the SAD is shown by the changes in their perception, as they are not only dependent on the forests but also plant oil palm on their land. They own the house but not the land. They have orchards around the housing but there are no activities that utilise them. Another environmental impact is poor quality of water from the river around their houses. This happens because of the use of detergent and disposal of domestic waste into the river. Environmental problems still exist because the SAD have not been able to fully adapt to the new environment. In addition, the health department has not fully empowered the SAD regarding environmental health.

**Photo 42:** Prof. Rosyani (1st right) interviewing Suku Anak Dalam (SAD) communities around the National Park Bukit Duabelas).

Research projects of counterparts funded at UNTAD
and Universitas Brawijaya

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| **Aiyen Tjoa / Sri Rahayu Utami** | **A05** | Field decomposition of pruned oil palm frond and its nutrient release pattern |

The analysis of litter quality and quantity and its rate of decomposition are important for the understanding of nutrient cycling and sustainable plant productivity. Very little is known about the decomposition of oil palm fronds and its nutrient release. This study focused on senescence pruned oil palm (*Elaeis guineesis Jacq.). Nutrient content and rate of pruned frond decomposition* was investigated for 12 months, between April 2014 and April 2015. The senescence oil palm fronds from 4 plots were cut down. Only the leaflets from the middle part of the frond, without the stalk and rachis were used in this study. The litter bag technique was used to study the rate, decomposition and nutrient release of pruned palm oil fronds. One hundred twenty five grams of fresh pruned senescence leaf of oil palms were transferred into 192 nylon bags of 35 cm x 35 cm size, numbered and placed on the field (see picture). Eight bags were retrieved monthly at random from each plot over 1 year. Leaves left in the litterbags were removed and extraneous materials, such as soil, visible animals and fine roots were washed out. The samples were then dried at 65°C to a constant weight to determine the final weight of the remaining and ground for chemical analysis.
The senescence pruned oil palm leaflets decomposed linearly with time. The material decomposed very rapidly with 90–95 % mass losses after 12 months (Fig. 54). Nutrient release from pruned oil palms was different for the various elements. Nutrient release followed the order K>Mg>Ca>P>S. The release of the nutrients from the pruned leaflets was relatively quick especially for K, with 70 % of K released during the first month of decomposition (Fig. 55).

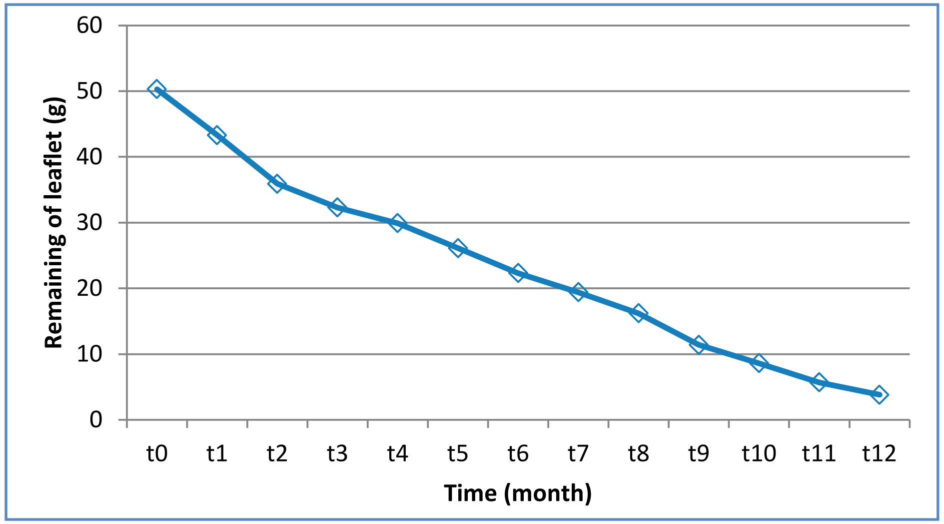


**Figure 54:** Remaining of the leaflets at different time of decomposition

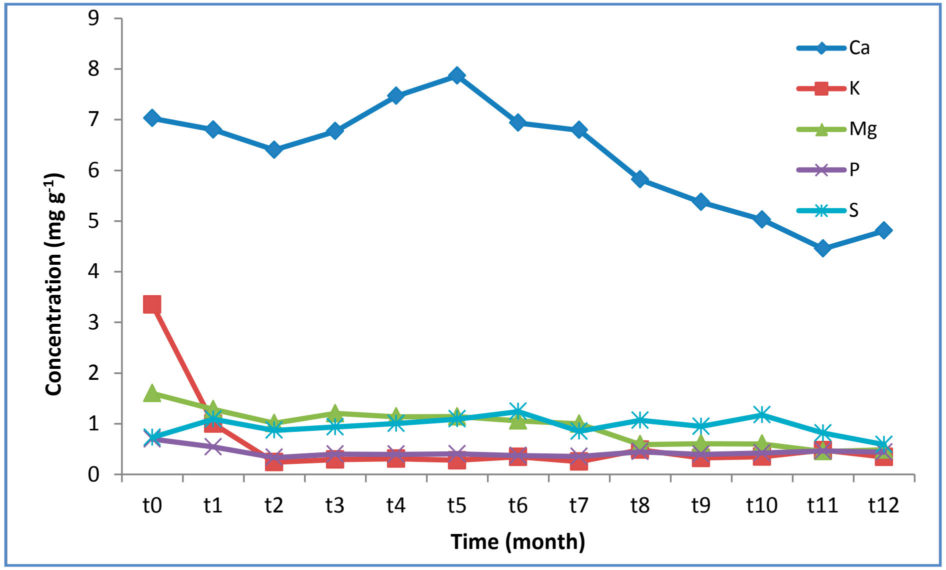


**Figure 55:** Remaining nutrients concentration at different time of decomposition

Research projects of counterparts funded at LIPI

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| **Sri Rahayu** | **B03** | Genetic diversity and DNA barcode-based identification of Hoya (Apocynaceae:Asclepiadoideae) in different transformation systems in Jambi |

Hoya species diversity in Jambi can be utilized by the local people as a new economic source (i. e., promoting it as an ornamental plant that can be exported overseas), in addition to research and development for future biomedicines. The information on hoya species and genetic diversity in Jambi is still very limited. Knowledge of the degree of impact of habitat changes to the species and genetic diversity of hoya in Jambi is lacking and is urgently needed to formulate appropriate conservation strategies and sustainable utilization of the species. Hoya species diversity has been assessed by field surveys at four different transformation systems: i. e., forest, jungle rubber, rubber plantations and oil palm plantations in the three locations Bukit Duabelas, Bukit Harapan and Bukit Sari in Jambi. We collected 58 total specimens from about 9 species of hoya and 2 species of *Dischidia*, which were mainly found in the forest. There was only one individual sample of *Dischidia cf. imbricata*, which was found in a jungle rubber plantation in Bukit Sari. There were species differences between locations, while only a single species, *Hoya cf. revolute*, was found in all locations. Most samples found were sterile, so identification was not clear yet. Only one species found was fertile and easily identified as *Hoya rintzii*. We are investigating the genetic diversity using microsatellite markers, as well as developing DNA barcode-based identification using rbcL and matK markers.

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| **Sri S. Tjitrosoedirdjo**<br>**SEAMEO BIOTROP** | **B06** | Distribution of invasive alien plant species and recommendation for management action at Bukit Duabelas, Jambi, Sumatra |

**Background and methods**

Vegetation surveys of invasive plant species (IPS) in relation to the according management system were conducted in Jambi (Sumatra, Indonesia) within 8 of the EFForTS core plots in the Bukit Duabelas landscape (BF3, BF4, BJ4, BJ5, BR3, BR4, BO2, BO4). The aims of this study were (1) to gather a list of invasive plant species from four land-use systems (forest, jungle rubber, rubber plantations, oil palm plantations) in Jambi; (2) to determine their distribution in each land-use system; and (3) to conduct a risk analysis for the most important IPS. Spatial distribution patterns were created with a horizontal vegetation profile diagram of each plot. A scoring system of risk analysis was conducted based on the protocol of risk management of invasive plant species.

**Results**

We found 76 species of IPS belonging to 30 families within the study plots. Most invasive species were from America and Asia and only few from Africa or other regions (Fig. 56). The number of IPS varied between sites and land-use systems, but generally a high risk of IPSs infestations was found in disturbed and open areas. IPS were not found inside the natural forest plots indicating that the forest plots are in good condition. Oil palm plantations (28 sp.) and rubber plantations (27 sp.) had higher numbers of invasive plant species than jungle rubber (10 sp.) (Table 2). Especially the two IPS *Dicranopteris linearis* and *Clidemia hirta* have the potential to spread into natural forests following disturbance. Intervention of IPS cannot be avoided if the forest is disturbed by illegal logging or other human intervention. Therefore, reforestation of the disturbed areas is recommended to prevent the spread of IPS. The result will be used for providing recommendations on the management of invasive plant species.

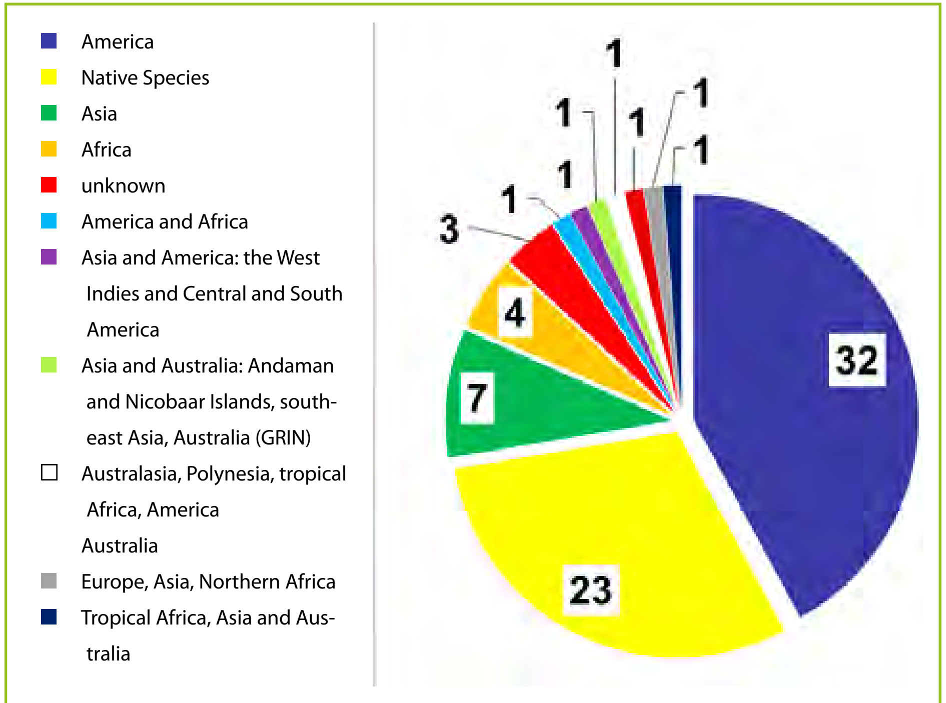


**Figure 56:** Natural origin of the 76 invasive plant species found within four land-use systems of the Bukit Duabelas landscape.

**Table 2:** The number of invasive plant species on each ecosystems type

| No. | Ecosystems type | No. of family | No. of genera | No. of species |
|---|---|---|---|---|
| 1 | Lowland forest | 0 | 0 | 0 |
| 2 | Jungle rubber | 6 | 10 | 10 |
| 3 | Rubber plantation | 13 | 24 | 27 |
| 4 | Oil palm plantation | 13 | 27 | 28 |

PT Restorasi Ekosistem Indonesia

Research projects of stakeholders funded at PT REKI

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| **Luce** | **B04** | Nutrient input and decomposition in high and low quality lowland secondary tropical rain forests |

Nutrient cycling is crucial to the effective functions of tropical forest ecosystems but the effect of forest degradation on litter fall as a major component of nutrient cycling is not well understood. The objectives of this study were 1) to determine the amount (fresh and dry mass) of litter fall in low and high secondary forests in the HRF, to 2) determine the total nutrient content of litter fall and the proportion returning to soil through decomposition, and to 3) determine the rate of decomposition of litter fall in each forest type. This research is expected to produce a detailed comparison of nutrient cycling in high secondary and low secondary forests, and reveal how these processes relate to nutrient input to the soil.

The result of this study show that the elements C, N and P accumulated in the top soil of both high and low secondary forest, while the base cations leached and accumulated in the lower strata. It was found that litter fall input was important to determine the magnitude of nutrient input to the soil. The nutrient input (after 9 month decomposition) was 0.16 % higher in high secondary forest than in low secondary forest. The litter production was higher in high secondary forest, while the litter nutrient contents in high secondary forest were similar to the low secondary forest. The decomposition was faster in low secondary forest compared to high secondary forest but the nutrient input after 9 month decomposition was higher in high secondary forest.

Research projects of stakeholders funded at the Ministry of Forestry

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| **Lutfi Izhar** | C02 | Forestry Partnership as Conflict Resolution of PT. REKI Concession in Jambi Province |

Acute forest-tenure conflicts in forest areas are increasing. Permits for use of forest areas seem to be a trigger of conflict between communities and concessionaires. Consortium and ownership have been used as legal ways to obtain forest utilization licenses from the government. People with limited capital claim have been already living in and cultivating forest areas for their living before concessionaires acquired legal permits. Each of them try to defend their right to forest areas. The objective of the research is to identify the encroachment group and to study the implementation effectivity in forest partnership as a means of conflict resolution in the concession areas of PT REKI. This research employs literature, survey and field studies to obtain data and information related to the implementation of government policy and conflict resolution. The data will be analysed descriptively with studies based on facts in the field, and policy concepts that have been issued by the Ministry of Forestry will be scrutinized.

The results indicate that implementing empowerment of local communities through partnerships forestry concepts, which is stated in the Ministry of Forestry Regulation No. P.39/Menhut-II/2013, is effective. The partnership pattern of implementation concept can be found in concession areas of PT REKI, which is between PT REKI and the Suku Anak Dalam (SAD) group. Specifically, PT REKI supplies the facilities and tools to SAD that support ecosystem restoration of Hutan Harapan. Based on a number of surveys, it is known that the societal structure in the concession areas can be classified into these categories: 1) the poor worker/labourer; 2) the poor farmers (≤2 ha); 3) the farmers (≤ 10 ha); 4) farmer businessman/investor (100–200 ha); 5) out comers with special visiting frequency; 6) the society who informally has the land but lives in out concession of PT REKI. Both the society groups and PT REKI still have not found the conflict finishing agreement, which is about forestry partnership. Those parties are still in the negotiation process. The implementation of forestry partnership as a means of conflict resolution in the PT REKI concession needs to be encouraged, along with serious actions from all parties, to achieve the best conflict resolution.

**Photo 43:** Left: An oil palm plantation in the concession of PT REKI. Right: Village and rubber plant in the concession of PT REKI.

# IV. Publications

1. **Journal articles**
2. **Other Publications**

In Phase 1 of EFForTS 85 scientific papers have been published. Our counterparts at IPB, UNJA and UNTAD were first authors of 8 publications and co-authors of 40 publications.

## 1. JOURNAL ARTICLES

| | |
|---|---|
| Counter-part **B09** at IPB | **Rubiana R, Rizali A, Denmead LH, Alamsari W, Hidayat P, Pudjianto DH, Clough Y, Tscharntke T, Buchori, D** (2015) Agricultural land use alters species composition but not species richness of ant communities. *Asian Myrmecology 7: 73–85*. |
| Counter-part **B03** at IPB | **Siregar UJ, Imran MF, Hamzah, Siregar IZ, Finkeldey R** (2016) Distribution and local adaptation of two indigenous jelutung trees (*Dyera costulata* and *D. lowii*) in Jambi, Indonesia: implication for allopatric speciation. *Procedia Environmental Sciences 33: 393-403.* |
| Counter-part **B10** at IPB | **Tarigan S, Sunarti, Widyaliza S** (2015) Expansion of oil palm plantations and forest cover changes in Bungo and Merangin Districts, Jambi Province, Indonesia. *Procedia Environmental Sciences 24: 199-205.* |
| Counter-part **B04** at IPB | **Violita, Kotowska MM, Hertel D, Triadiati, Miftahudin, Anas I** (2015) Transformation of lowland rainforest into oil palm plantations results in changes of leaf litter production and decomposition in Sumatra, Indonesia. *Journal of Biodiversity and Environmental Sciences 6: 546-556.* |
| **B04**, B07, A05 | **Abou Rajab Y, Leuschner C, Barus H, Tjoa A, Hertel D** (2016) Cacao cultivation under diverse shade tree cover allows high carbon storage and sequestration without yield losses. *PLoS ONE 11(2): e0149949.* |
| **B10** | **Alexander P, Rounsevell MDA, Dislich C, Dodson JR, Engström K, Moran D** (2015) Drivers for global agricultural land use change: The nexus of diet, population, yield and bioenergy. *Global Environmental Change 35: 138-147.* |
| **A05** | **Allen K, Corre MD, Tjoa A, Veldkamp E** (2015) Soil nitrogen-cycling responses to conversion of lowland forests to oil palm and rubber plantations in Sumatra, Indonesia. *PLoS ONE 10(7): e0133325.* |
| **B01** | **Barnes AD, Weigelt P, Jochum M, Ott D, Haneda NF, Brose U** (2016) Species richness and biomass explain spatial turnover in ecosystem functioning across tropical and temperate ecosystems. *Philosophical Transactions of the Royal Society B. 371: 20150279.* |

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| **B01** | **Barnes AD, Jochum M, Mumme S, Haneda NF, Farajallah A, Widarto TH, Brose U** (2014) Consequences of tropical land use for multitrophic biodiversity and ecosystem functioning. *Nature Communications 5: 5351.* |
| **C02** | **Beckert B, Keck M** (2015) Palmöl für den Weltmarkt: Landkonflikte in Sumatras Post-Frontier.<br>*Geographische Rundschau 67(12): 12–17.* |
| **C02** | **Beckert B, Dittrich C, Adiwibowo S** (2014) Contested land: An analysis of multi-layered conflicts in Jambi province, Sumatra, Indonesia.<br>*ASEAS 7(1): 75–92.* |
| **A01**, **B08** | **Biagioni S, Krashevska V, Achnopha Y, Saad A, Sabiham S, Behling H** (2015) 8000 years of vegetation dynamics and environmental changes of a unique inland peat ecosystem of the Jambi Province in Central Sumatra, Indonesia.<br>*Palaeogeography, Palaeoclimatology, Palaeoecology 440: 813-829.* |
| **B09** | **Cumming GS, Buerkert A, Hoffmann EM, Schlecht E, von Cramon-Taubadel S, Tscharntke T** (2014) Implications of agricultural transitions and urbanization for ecosystem services. *Nature 515: 50 – 57.* |
| **B12** | **Dellinger A, Essl F, Hojsgaard D, Kirchheimer B, Klatt S, Dawson W, Pergl J, Pyšek, P, van Kleunen M, Weber E, Winter M, Hörandl E, Dullinger S** (2016)<br>Niche dynamics of alien species do not differ among sexual and apomictic flowering plants.<br>*New Phytologist 209: 1313 –1323.* |
| **Z02**, **B06**, A05, B09, C02, B04, B05, B08, A03, C07, Z01, C03, B10 | **Drescher J & Rembold K, Allen K, Beckschäfer P, Buchori D, Clough Y, Faust H, Fauzi AM, Gunawan D, Hertel D, Irawan B, Jaya INS, Klarner B, Kleinn C, Knohl A, Kotowska MM, Krashevska V, Krishna V, Leuschner C, Lorenz W, Meijide A, Melati D, Nomura M, Pérez-Cruzado C, Qaim M, Siregar IZ, Steinebach S, Tjoa A, Tscharntke T, Wick B, Wiegand K, Kreft H, Scheu S** (2016)<br>Ecological and socioeconomic functions across tropical land-use systems after rainforest conversion.<br>*Phil. Trans. R. Soc. B 371: 20150275.* |
| **B08** | **Ermilov SG, Sandmann D, Klarner B, Widyastuti R, Scheu S** (2015a) Contributions to the knowledge of oribatid mites of Indonesia. 1. The genus Allogalumna (Galumnidae) with descriptions of two new species (Acari, Oribatida).<br>*ZooKeys 529: 71– 86.* |
| **B08** | **Ermilov SG, Sandmann D, Klarner B, Widyastuti R, Scheu S** (2015b) Contributions to the knowledge of oribatid mites (Acari, Oribatida) of Indonesia. 3. The genus Galumna (Galumnidae) with description of a new subgenus and seven new species.<br>*ZooKeys 539: 11–51.* |
| **B08** | **Ermilov SG, Sandmann D, Klarner B, Widyastuti R, Scheu S** (2015c) Contributions to the knowledge of oribatid mites of Indonesia. 2. The genus Pergalumna (Galumnidae) with description of a new species and key to known species in the Oriental region (Acari, Oribatida).<br>*ZooKeys 529: 87–103.* |
| **A03**, B04 | **Fan Y, Roupsard O, Bernoux M, Le Maire G, Panferov O, Kotowska MM, Knohl A** (2015) A sub-canopy structure for simulating oil palm in the Community Land Model (CLM-Palm): phenology, allocation and yield.<br>*Geoscientific Model Development 8: 3785–3800.* |
| **C07**/C08 | **Gatto M, Wollni M, Qaim M** (2015) Oil palm boom and land-use dynamics in Indonesia: The role of policies and socioeconomic factors.<br>*Land Use Policy 46: 292–303.* |

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| C04 | **Grimm M, Klasen, S** (2015) Migration pressure, tenure security and agricultural intensification. Evidence from Indonesia. *Land Economics 91 (3): 411–434.* |
| A04 | **Guillaume T, Maranguit D, Murtilaksonoa KM, Kuzyakov Y** (2016) Sensitivity and resistance of soil fertility indicators to land-use changes: New concept and examples from conversion of Indonesian rainforest to plantations. *Ecological Indicators 67: 49–57.* |
| A04 | **Guillaume T, Damris M, Kuzyakov Y** (2015) Losses of soil carbon by converting tropical forest to plantations: Erosion and decomposition estimated by δ 13 C. *Global Change Biology 21: 3548–3560.* |
| A05 | **Hassler E, Corre MD, Tjoa A, Damris M, Utami SR, Veldkamp E** (2015) Soil fertility controls soil-atmosphere carbon dioxide and methane fluxes in a tropical landscape converted from lowland forest to rubber and oil palm plantations. *Biogeosciences 12: 5831-5852.* |
| C02 | **Hein J, Adiwibowo S, Dittrich C, Soetarto E, Faust H** (2015) Rescaling of Access and Property Relations in a Frontier Landscape. Insights from Jambi, Indonesia. *The Professional Geographer, doi: 10.1080/00330124.2015.1089105.* |
| C02 | **Hein J, Faust H** (2014) Conservation, REDD+ and the struggle for land in Jambi, Indonesia. *Pacific Geographies 41: 20–25.* |
| B12, B03 | **Hodac L, Ulum FB, Opfermann N, Breidenbach N, Hojsgaard D, Tjitrosoedirdjo SS, Vornam B, Finkeldey R, Hörandl E** (2016) Population genetic structure and reproductive strategy of the introduced grass Centotheca lappacea in tropical land-use systems in Sumatra. *PLoS ONE 11(1): e0147633.* |
| C04 | **Irfany MI, Klasen, S** (2015) Inequality in emissions: evidence from Indonesian households. *Environmental Economics and Policy Studies doi: 10.1007/s10018-015-0119-0.* |
| C04 | **Jakob M, Steckel JC, Klasen S, Lay J, Grunewald N, Martínez-Zarzoso I, Renner S, Edenhofer O** (2014) Feasible Mitigation Actions in Developing Countries. *Nature Climate Change 4(11):961-968.* |
| Focus 3 C04, B10, C07, C02, B05, C03 | **Klasen S, Meyer K, Dislich C, Euler M, Faust H, Gatto M, Hettig E, Melati DN, Jaya INS, Otten F, Pérez-Cruzado C, Steinebach S, Tarigan S, Wiegand K** (2016) Economic and ecological trade-offs of agricultural specialization at different spatial scales. *Ecological Economics 122: 111–120.* |
| C04 | **Klasen S, Priebe J, Rudolf R** (2013) Cash crop choice and income dynamics in rural areas: evidence for post-crisis Indonesia. *Agricultural Economics 44:349–364.* |
| A02, B07 | **Köhler M, Hanf A, Barus H, Hendrayanto, Hölscher D** (2014) Cacao trees under different shade tree shelter: effects on water use. *Agroforestry Systems 88 (1): 63–73.* |
| C01 | **Kopp T, Prehn S, Brümmer B** (2016) Preference Erosion – The Case of Everything But Arms and Sugar. *The World Economy, doi: 10.1111/twec.12374.* |
| B04 | **Kotowska MM, Leuschner C, Triadiati T, Hertel D** (2015) Conversion of tropical lowland forest lowers nutrient return with litterfall, and alters nutrient use efficiency and seasonality of net primary productivity. *Oecologia 180(2): 601–618.* |

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| **B04** | **Kotowska MM, Leuschner C, Triadiati T, Selis M, Hertel D** (2015) Quantifying above- and belowground biomass carbon loss with forest conversion in tropical lowlands of Sumatra (Indonesia).<br>*Global Change Biology 21: 3620–3634.* |
| **B04**, B07 | **Kotowska MM, Hertel D, Abou Rajab Y, Barus H, Schuldt B** (2015) Patterns in hydraulic architecture from roots to branches in six tropical tree species from cacao agroforestry and their relation to wood density and stem growth.<br>*Frontiers in Plant Science 6: 191.* |
| **B08** | **Krashevska V, Klarner B, Widyastuti R, Maraun M, Scheu S** (2015) Impact of tropical lowland rainforest conversion into rubber and oil palm plantations on soil microbial communities.<br>*Biology and Fertility of Soils 51: 697-705.* |
| **C02** | **Kunz Y, Hein J, Mardiana R, Faust H** (2016) Mimicry of the legal: Translating de jure land formalization processes into de facto local action – Experiences from Jambi province, Sumatra, Indonesia<br>ASEAS – Austrian Journal of South-East Asian Studies 9(1) – accepted. |
| **B09** | **Maas B, Karp DS, Bumrungsri S, Darras K, Gonthier D, Huang JCC, Lindell CA, Maine JJ, Mestre L, Michel NL, Morrison EB, Perfecto I, Philpott SM, Şekercioğlu ÇH, Silva RM, Taylor PJ, Tscharntke T, Van Bael SA, Whelan CJ, Williams-Guillén K** (2015) Bird and bat predation services in tropical forests and agroforestry landscapes. *Biological Reviews 91(2): 1469.* |
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| **C06** | **Moser S, Mußhoff O** (2015) Ex-ante Evaluation of Policy Measures: Effects of Reward and Punishment for Fertiliser Reduction in Palm Oil Production.<br>*Journal of Agricultural Economics 67: 84–104.* |
| **B01** | **Mumme S, Jochum M, Haneda NF, Brose U, Barnes AD** (2015) Functional diversity and stability of litter-invertebrate communities following land-use change in Sumatra, Indonesia. *Biological Conservation 191:750-758.* |
| **A02**, A03 | **Niu FR, Röll A, Hardanto A, Meijide A, Köhler M, Hendrayanto, Hölscher D** (2015) Oil palm water use: calibration of a sap flux method and a field measurement scheme. *Tree Physiology 35: 563–573.* |
| **B05** | **Nölke N, Fehrmann L, I Nengah S, Tiryana T, Seidel D, Kleinn C** (2015) On the geometry and allometry of big-buttressed trees – a challenge for forest monitoring: new insights from 3D-modeling with terrestrial laser scanning.<br>*iForest – Biogeosciences and Forestry 8(5): 574–581.* |
| **B05** | **Pérez-Cruzado CP, Fehrmann L, Magdon P, Cañellas I, Sixto H, Kleinn C** (2015) On the site-level suitability of biomass models.<br>*Environmental Modelling & Software,73: 14–26.* |
| **A02**, A03 | **Röll A, Niu FR, Meijide A, Hardanto A, Hendrayanto, Knohl A, Hölscher D** (2015) Transpiration in an oil palm landscape: effects of palm age.<br>*Biogeosciences 12: 9209-9242.* |

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| **B07**, A05 | **Sahner J, Budi SW, Barus H, Edy N, Meyer M, Corre MD, Polle A** (2015) Degradation of Root Community Traits as Indicator for Transformation of Tropical Lowland Rain Forests into Oil Palm and Rubber Plantations. *PLoS ONE 10(9): e0138077.* |
| **B02**, A05, B08, | **Schneider D, Engelhaupt M, Allen K, Kurniawan S, Krashevska V, Heinemann M, Nacke H, Wijayanti M, Meryandini A, Corre MD, Scheu S, Daniel R** (2015) Impact of lowland rainforest transformation on diversity and composition of soil prokaryotic communities in Sumatra (Indonesia). *Frontiers in Microbiology 6: 01339.* |
| **C07** | **Sibhatu KT, Krishna V, Qaim M** (2015) Production diversity and dietary diversity in smallholder farm households. *PNAS 112 (34): 10657-10662.* |
| **C07** | **Sibhatu KT, Krishna V, Qaim M** (2015) Reply to Remans et al.: Strengthening markets is key to promote sustainable agricultural and food systems. *PNAS 112 (54): e6083.* |
| **C07** | **Sibhatu KT, Krishna V, Qaim M** (2015) Reply to Berti: Relationship between production and consumption diversity remains small also with modified diversity measures. *PNAS 112 (42): e5657.* |
| **B11**, C08, B01 | **Teuscher M, Vorlaufer M, Wollni M, Brose U, Mulyani Y, Clough Y** (2015) Trade-offs between bird diversity and abundance, yields and revenue in smallholder oil palm plantations in Sumatra, Indonesia. *Biological Conservation 186: 306–318.* |
| **B09** | **Tscharntke T, Milder JC, Schroth G, Clough Y, DeClerck F, Waldron A, Rice R, Ghazoul J** (2014) Conserving Biodiversity Through Certification of Tropical Agroforestry Crops at Local and Landscape Scales. *Conservation Letters 8 (1): 14–23.* |
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## 2. OTHER PUBLICATIONS

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| **C04** | **Darmawan R, Klasen S, Nuryartono N** (2016) Migration and deforestation in Indonesia. *EFForTS discussion paper series 19.* |
| **C04** | **Irfany MI, Klasen, S** (2014) Affluence and emission trade-offs: evidence from Indonesian household carbon footprint. *Courant Research Centre: Poverty, Equity and Growth – Discussion Papers No. 161: 1–22.* |
| **C04** | **Irfany MI, Klasen S, Yusuf RS** (2015) The consumption-based carbon footprint of households in Sulawesi, Jambi and Indonesia as a whole in 2013. *Courant Research Centre: Poverty, Equity and Growth – Discussion Papers No. 186.* |
| **B05** | **Melati DN, Jaya INS, Zuhdi M, Pérez-Cruzado CP, Fehrmann L, Kleinn C** (2014) Remote Sensing based monitoring of land transformation in Jambi Province, Sumatra. *In C. Kleinn & L. Fehrmann (Eds.), The Ecological and Economic Challenges of Managing Forest Landscapes in a Global Context (pp. 227–239). Bogor & Jakarta, Indonesia: Cuvillier Verlag.* |

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| **INF** | **Cremer F, Engelhardt C, Neuroth H** (2015) Embedded Data Manager – Integriertes Forschungsdatenmanagement: Praxis, Perspektiven und Potentiale. *Bibliothek Forschung und Praxis 39(1):13–31.* |
| **B10**, A05, C02, A03, B06, C03, B09 | **Dislich C, Keyel AC, Salecker J, Kisel Y, Meyer KM, Corre MD, Faust H, Hess B, Knohl A, Kreft H, Meijide A, Nurdiansyah F, Otten F, Pe'er G, Steinebach S, Tarigan S, Tscharntke T, Tölle M, Wiegand K** (2015) Ecosystem functions of oil palm plantations: a review. *EFForTS discussion paper series 16.* |
| **B10** | **Dislich C, Hettig E, Heinonen J, Lay J, Meyer KM, Tarigan S, Wiegand K** (2015) Towards an integrated ecological-economic land-use change model. *EFForTS discussion paper series 17.* |
| **C07** | **Euler M, Krishna VV, Schwarze S, Siregar H, Qaim M** (2015) Oil palm adoption, household welfare and nutrition among smallholder farmers in Indonesia. *EFForTS discussion paper series 12.* |
| **C07** | **Euler M, Schwarze S, Siregar H, Qaim M** (2015) Oil palm expansion among smallholder farmers in Sumatra, Indonesia. *EFForTS discussion paper series 8.* |
| **C02**, C01, C07, C03, C08, C04, C06 | **Faust H, Schwarze S, Beckert B, Brümmer B, Dittrich C, Euler M, Gatto M, Hauser-Schäublin B, Hein J, Holtkamp AM, Ibanez M, Klasen S, Kopp T, Krishna V, Kunz Y, Lay J, Mußhoff O, Qaim M, Steinebach S, Vorlaufer M, Wollni M** (2013) Assessment of socioeconomic functions of tropical lowland transformation systems in Indonesia. *EFForTS discussion paper series 1.* |
| **C07**/C08 | **Gatto M, Wollni M, Qaim M** (2014) Oil Palm Boom and Land-Use Dynamics in Indonesia. *EFForTS discussion paper series 6.* |
| **C08** | **Gatto M, Wollni M, Rosyani, Qaim M** (2015) Oil Palm Boom, Contract Farming, and Village Development: Evidence from Indonesia. *EFForTS discussion paper series 10.* |
| **C03** | **Hauser-Schäublin B, Steinebach S** (2014) Harapan: A "no man's land" turned into a contested agro-industrial zone. *EFForTS discussion paper series 4.* |
| **C03** | **Hauser-Schäublin B** (2013) Culture and entitlements between heterogeneity and self-ascription. *Göttingen Studies in Cultural Property 7: 63–81.* |
| **C02** | **Hein J** (2013) Reducing Emissions from Deforestation and Forest Degradation (REDD+), Transnational Conservation and Access to Land in Jambi, Indonesia. *EFForTS discussion paper series 2.* |
| **B10** | **Hettig E, Lay J, Sipangule K** (2015) Drivers of households' land-use decisions: A critical review of micro-level studies in tropical regions. *EFForTS discussion paper series 15.* |
| **C01** | **Holtkamp M** (2014) Vereinbarkeit von kleinstbewirtschafteten Palmöl- und Gummiplantagen mit nachhaltigem Landmanagement? *BfN-Skripten 370: 169 –174.* |

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|---|---|
| **C04**, B10, C07, C02, B05, C03 | **Klasen S, Meyer KM, Dislich C, Euler M, Faust H, Gatto M, Hettig E, Melati DN, Jaya NS, Otten F, Perez-Cruzado C, Steinebach S, Tarigan S, Wiegand W** (2015) Economic and ecological trade-offs of agricultural specialization at different spatial scales. *Courant Research Centre: Poverty, Equity and Growth – Discussion Papers No. 178.* |
| **B02** | **Klingenberg H, Martinjak R, Glöckner FO, Daniel R, Lingner T, Meinicke P** (2013) Dinucleotide distance histograms for fast detection of rRNA in metatranscriptomic sequence. *In: Beißbarth T, Kollmar M, Leha A, Morgenstern B, Schultz A-K, Waack S, Wingender E (eds.). German Conference of Bioinformatics 2013 (GCB'13). Open Access in Informatics (OASIcs) 34, Dagstuhl Publishing, Germany, pp 80–89.* |
| **C01** | **Kopp T, Brümmer B** (2015) Moving Rubber to a Better Place – and Extracting Rents from Credit Constrained Farmers along the Way. *EFForTS discussion paper series 9.* |
| **C01** | **Kopp T, Alamsyah Z, Fatricia RS, Brümmer B** (2014) Have Indonesian Rubber Processors Formed a Cartel? Analysis of Intertemporal Marketing Margin Manipulation. *EFForTS discussion paper series 3.* |
| **C07** | **Krishna VV, Euler M, Siregar H, Fathoni Z, Qaim M** (2015) Farmer heterogeneity and differential livelihood impacts of oil palm expansion among smallholders of Sumatra, Indonesia. *EFForTS discussion paper series 13.* |
| **C07** | **Krishna VV, Pascual U, Qaim M** (2014) Do emerging land markets promote forestland appropriation? *EFForTS discussion paper series 7.* |
| **C06** | **Moser S, Mußhoff O** (2015) Comparing the use of risk-influencing production inputs and experimentally measured risk attitude: Do decisions of Indonesian small-scale rubber farmers match? *EFForTS discussion paper series 14.* |
| **C06** | **Moser S, Mußhoff O** (2014) A framed field experiment about policy measures: Testing the effectiveness of rewards or punishments with different probabilities as incentives in palm oil production. *EFForTS discussion paper series 5.* |
| **B02** | **Nacke H, Daniel R** (2014) Approaches in metagenome research: progress and challenges. *In: Nelson K (ed) Encyclopedia of Metagenomics. Springer Science + Business Media, New York, pp 1–7.* |
| **C07**, B10, C01, C02, C06, C03, C04, C08 | **Schwarze S, Euler M, Gatto M, Hein J, Hettig E, Holtkamp AM, Izhar L, Kunz Y, Lay J, Merten J, Moser S, Mußhoff O, Otten F, Qaim M, Soetarto E, Steinebach S, Trapp K, Vorlaufer M, Faust H** (2015) Rubber vs. oil palm: an analysis of factors influencing smallholders' crop choice in Jambi, Indonesia. *EFForTS discussion paper series 11.* |
| **C03** | **Steinebach S** (2013) "Today we occupy the plantation, tomorrow Jakarta." Indigeneity, land and oil palm plantations in Jambi. In: Adat and indigeneity in Indonesia. Culture and entitlements between heterogeneity and self-ascription. Hauser-Schäublin, B. (ed.) Göttingen Studies in Cultural *Property 7: 63–81. Universitätsverlag Göttingen.* |
| **B09** | **Tscharntke T, Clough Y** (2013) Lassen sich Biodiversitätsschutz und landwirtschaftliche Nutzung im Randbereich tropischer Regenwälder verbinden? Rundgespräche der Kommission für Ökologie, Bd. 42 »Schutz und Nutzung von Tropenwäldern«, S. 65–74 by Verlag Dr. Friedrich Pfeil, München. ISBN 978-3-89937-156-7 |
| **C08** | **Vorlaufer M, Ibanez M, Juanda B, Wollni M** (2015) Conservation vs. equity – Can payments for environmental services achieve both? *EFForTS discussion paper series 18.* |

# V. Early Career Support: Education and Promotion of Junior Researchers

1. **Dissertations**
2. **Master theses**

EFForTS offers an excellent opportunity for young researchers to build an academic career. So far, 23 doctoral researchers have completed their theses at the University of Göttingen whereas 20 dissertations will be finalised shortly. At IPB Bogor 4 doctoral researchers concluded their work while 11 theses are ongoing (see Tables 3 and 4).

Similarly, our collaborative research centre offers a fruitful environment for the education and training of bachelor and master students. At our partner universities in Bogor, Jambi and Tadulako 83 bachelor and 53 master students did their final thesis projects within EFForTS. At the University of Göttingen 38 master students completed their graduation work within EFForTS (see Tables 5 and 6).

## 1. DISSERTATIONS

**Table 3:** Dissertations University of Göttingen

| Project | Name, Surname | Type of funding | Title of the thesis |
|---|---|---|---|
| A01 | **Siria Biagioni** | DFG | *Long-term dynamics of tropical rainforests, climate, fire, human impact and land use in Indonesia* (**completed** 05/2015). |
| A01 | **Christina Ani Setyaningsih** | ERASMUS | Late quarternary vegetation, climate, fire and human impact in different landscapes of central Sumatra, Indonesia (**on-going**, since 11/2014). |
| A02 | **Alexander Röll** | DFG | *Changes in eco-hydrological functioning after tropical rainforest transformation to rubber and oil palm plantations* (**completed** 09/2015). Short-listed for 'Deutscher Forstwissenschaftspreis 2016' |
| A02 | **Niu Furong** | China Scholarship | Transpiration by rubber and oil palm plantations: refining methods and delineating differences (**on-going**, since 10/2012). |
| A02 | **Afik Hardanto** | DIKTI – Ministry Higher Education Indonesia | Water use patterns of oil palm and rubber plantation at different site conditions (**on-going**, since 04/2013). |
| A03 | **Yuanchao Fan** | ERASMUS | Modeling oil palm monoculture and its associated impacts on land-atmosphere carbon, water and energy fluxes in Indonesia (**completed** 04/2016). |
| A03 | **Clifton Sabajo** | ERASMUS | The effects of land transformations on biophysical variables in a tropical region (**on-going**, since 09/2012). |

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| A04 | **Thomas Guillaume** | DFG | *Stock, turnover and functions of carbon in heavily weathered soils under lowland rainforest transformation systems* (**completed** 11/2015). |
| A05 | **Evelyn Hassler** | DFG | Soil trace gas fluxes in tropical landscape converted from lowland forest to rubber and oil palm plantations (**on-going**, since 03/2012). |
| A05 | **Kara Allen** | DFG | *Impacts of land-use conversion in Sumatra, Indonesia, on soil nitrogen cycling, soil nutrient stocks and ecosystem dynamics* (**completed** 09/2015). |
| A05 | **Syahrul Kurniawan** | DGHE – Directorate General of Higher Education Indonesia | *Conversion of lowland forests to oil palm and rubber plantations changes nutrient leaching and nutrient retention efficiency in highly weathered soils of Sumatra, Indonesia* (**completed** 03/2016). |
| B01 | **Andrew Barnes** | DFG | *Land-use impacts on biodiversity and ecosystem functioning of complex multitrophic communities* (**completed** 11/2015). |
| B01 | **Malte Jochum** | DFG | *Macro-invertebrate communities in tropical lowland rainforest transformation systems* (**completed** 02/2016). |
| B03 | **Natalie Breidenbach** | DFG | Plant genetic diversity in tropical lowland transformation systems (**on-going**, since 03/2012). |
| B04 | **Martyna Kotowska** | DFG | *Carbon pools and sequestration in vegetation, litter dynamics and hydraulic anatomic properties in rainforest transformation systems in Indonesia* (**completed** 05/2015). |
| B04 | **Yasmin Abou Rajab** | DFG | Shade trees in cacao agroforestry systems: influence on roots and net primary production (**on-going**). |
| B05 | **Dian Melati** | DFG | Estimation of above ground biomass and species richness (**on-going,** since 07/2012). |
| B07 | **Josephine Sahner** | DFG | Functional diversity of mycorrhizal fungi along a tropical land-use gradient (**on-going**, since 05/2012). |
| B07 | **Edy Nur** | ERASMUS | *Community structure of Arbuscular Mycorrhizal Fungi in temperate grassland and tropical land-use systems* (**completed** 08/2015). |
| B09 | **Fuad Nurdiansyah** | DAAD | Improving Oil Palm Local and Landscape Management for Controlling Pests and Diseases using Biocontrol Methods (**completed** 05/2016). |
| B09 | **Kevin Darras** | DFG | Bird diversity, functions and services across Indonesian land-use systems (**completed** 05/2016). |
| B09 | **Lisa Denmead** | DFG | Ant Diversity, Function and Services across Tropical Land-use Systems in Indonesia (**completed** 03/2016). |
| B10 | **Elisabeth Hettig** | DFG | Evidence from Indonesia: Cash-crop induced land-use change. Determinants and implications (**on-going**, since 09/2012). |
| B11 | **Miriam Teuscher** | DFG | *Ecological impacts of biodiversity enrichment in oil palm plantations* (**completed** 12/2015). |
| B11 | **Anne Gérard** | DFG | Impacts of biodiversity enrichment plantings in oil palm plantations: early tree performance, plant diversity effects and changes in oil palm yield (**on-going**, since 08/2013). |
| B11 | **Watit Khokthong** | Scholarship, Thai Government | Remnant forests and trees in the landscape surrounding the biodiversity enrichment experiment: spatial distribution and temporal dynamics (**on-going**, since 04/2015). |

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|---|---|---|---|
| B12 | **Nicole Opfermann** | DFG | Reproductive strategies of weeds in Sumatra, Indonesia (**on-going,** since 02/2013). |
| C01 | **Anna Mareike Holtkamp** | DFG | Technical and environmental efficiency of smallholder palm oil and rubber production (**on-going**, since 06/2012). |
| C01 | **Thomas Kopp** | DFG | *Functioning of local markets on the regional scale: Rubber and Palm Oil in Jambi Province, Indonesia* (**completed** 05/2015). |
| C02 | **Barbara Beckert** | Institute Prof. Dittrich – UGoe | A Geographical Analysis of the Current Cultural Landscape Transformation (**on-going**, since 04/2012). |
| C02 | **Jonas Hein** | DIE (German Development Institute) | The international climate negotiations and their implications for forest policies and resource access in Indonesia (**completed** 04/2016). |
| C02 | **Yvonne Kunz** | DFG | Cultural landscape transformation – a historic geographical analysis (**completed** 04/2016). |
| C04 | **Katharina van Treeck** | DFG | Sustainability of cocoa cultivation among small-holders in Central Sulawesi (**on-going**, since 07/2012). |
| C04 | **Rivayani Darmawan** | DFG | *Essays on community driven development in Indonesia* (**completed** 12/2014). |
| C04 | **Dewi Nur Asih** | DIKTI – Ministry Higher Education Indonesia | Linkage between land-use change and poverty dynamics in Sulawesi (**on-going**, since 11/2012). |
| C04 | **Mohammed Irfany Iqbal** | ERASMUS | *Drivers of the Indonesian household carbon footprint* (**completed** 11/2014). |
| C06 | **Stefan Moser** | DFG | *Analysing smallholders' behaviour on Sumatra: An ex ante policy analysis and investigation of experiments' external validity under consideration of risk* (**completed** 07/2015). |
| C07 | **Michael Euler** | DFG | *Oil palm expansion among Indonesian smallholders – adoption, welfare implications and agronomic challenges* (**completed** 05/2015). |
| C07 | **Christoph Kubitza** | DFG | Determinants and welfare impacts of land-use transformation among smallholder farmers in Indonesia (**on-going**, since 04/2015). |
| C07 | **Jonida Bou Dib** | DAAD | Effects of oil palm expansion and related land-use changes on non-farm households in rural Indonesia (**on-going**, since 10/2014). |
| C08 | **Marcel Gatto** | Institute Prof. Qaim – UGoe | *Land-use dynamics, economic development, and institutional change in rural communities – Evidence from the Indonesian oil palm sector* (**completed** 02/2015). |
| C08 | **Miriam Vorlaufer** | DFG | *Designing incentive mechanisms for sustainable land management: empirical evidence from Indonesia* (**completed** 05/2015). |
| C08 | **Miriam Romero** | DFG | Designing incentive mechanisms for sustainable land use: The role of environmental education and extension (**on-going**, since 06/2015). |
| Z02 | **Fitri Yola Amandita** | Self | DNA barcoding of vascular plants from Jambi, Sumatra (**completed 2015**). |

**Table 4:** Dissertations IPB Bogor

| Name of counterpart (IPB) | Name of Student | Title of the thesis |
|---|---|---|
| Prof. Anja Meriyandini - **B02** | **Marini Wijayanti** | *Bacterial diversity and lipase producing bacteria in forest and oil palm plantation at Sarolangun Jambi, Indonesia.* (**completed 2015**) |
| Prof. Nisa Mubarik - **B02** | **Risky Hadi Wibowo** | Diversity of chitinolitic bacteria from tropical rain forest and transformation forest in Jambi and the potential of chitin degrading enzymes of Gnoderma boninense. – Keragaman Bakteri Kitinolitik Asal Hutan Hujan Tropis dan Potensi Enzim Pendegradasi Kitin pada Ganoderma Boninense. (**on-going**) |
| Prof. Nisa Mubarik - **B02** | **Zulfarina** | Diversity of microbes enrolled in nitrogen cycling and their activities in tropical rain forest and transformation forest in Jambi. – Keragaman mikroba yang berperan dalam siklus nitrogen dan aktivitasnya di kawasan hutan tropis dan hutan transformasi jambi. (**on-going**) |
| Prof. Triadiati Antono - **B04** | **Violita** | *Nitrogen dynamic in oil palm plantation and natural forest in Sarolangun, Jambi. – Dinamika nitrogen pada sistem transformasi hutan alam menjadi perkebunan kelapa sawit di Sumatera, Indonesia.* (**completed 2015** – English abstract) |
| Prof. I Nengah Surati Jaya - **B05**,<br>Prof. Hendrayanto - **A02**,<br>Prof. Suria Darma Tarigan - **B10** | **Bejo Slamet** | *Interception and runoff in tropical lowland forest transformation systems in Jambi. – Intersepsi dan aliran permukaan pada transformasi hutan hujan tropika dataran rendah Jambi.* (**completed 2015** – English abstract) |
| Prof. I Nengah Surati Jaya - **B05** | **Eva Achmad** | *Estimation and biomass classification of lowland forest transition ecosystem in Jambi Province. – Estimasi dan klasifikasi biomassa pada ekosistem transisi hutan dataran rendah di provinsi Jambi.* (**completed 2013** – English abstract) |
| Prof. I Nengah Surati Jaya – as co-supervisor of - **B05** / Prof. Kleinn | **Dian Melati** | Spatio-temporal analysis on land transformation in a forested tropical landscape in Jambi Province, Sumatra. (**on-going**) |
| Prof. Tri Atmowidi - **B09** | **Andy Darmawan** | Struggle of earthworms for existence through deforestation in Bungku (Jambi) and Mount Gede (West Java). (**on-going**) |
| Prof. Sri Sudarmiyati Tjitrosoedirdjo - **B06** | **Fuad Bahrul Ulum** | Dispersal patterns and reproductive strategy of Centotheca lappacea (L.) Desv. – a weedy grass rapidly invading plantations on Sumatra. (**on-going**) |
| Prof. Soeryo Adiwibowo - **C02** | **Rina Mardiana** | The Agrarian political ecology in Jambi Province, Indonesia – state property regime transformation and its dynamic implication on agrarian concessions. (**on-going since 08/2013** – funded by ERASMUS). |
| Prof. Hermanto Siregar - **C07** | **Dicky Firmansyah** | Socio-economic condition of community in the National Park Bukit Duabelas and Harapan Rainforest, and the regional economy of Jambi Province. (**on-going**) |

## 2. MASTER THESIS

**Table 5:** Master theses University of Göttingen

| Project | Name of student | Title of the thesis | completed / ongoing |
|---|---|---|---|
| A01 | **Katharina Reuter** | A study on yearly pollen production and plant phenology in rainforest transformation systems in Sumatra (Indonesia). transformation systems in Sumatra (Indonesia). | 2015 |
| B01 | **Steffen Mumme** | Alteration of functional diversity along a land-use gradient in Sumatra, Indonesia | 2015 |
| B01 | **Lukas Jurkschat** | Length-mass regression of temperate and tropical invertebrates | 2015 |
| B04 | **Selis Meriem** | Contribution of dead wood to biomass and carbon stocks and it's biochemical contents in lowland rainforest transformation systems on Sumatra, Indonesia | 2014 |
| B04 | **Yuna Pransiska** | Vertical root distribution and contribution of coarse roots to the soil carbon pool in lowland rainforest transformation systems on Sumatra, Indonesia | 2014 |
| B05 | **Setia Edwine Purnama** | Evaluation of remotely sensed data in determining forest structure and its biomass – case studies from Jambi, Sumatra and Central-Kalimantan | 2014 |
| B06 | **Christian Altenhövel** | Diversity of vascular epiphytes in lowland rainforests and oil palm plantations in Sumatra, Indonesia | 2013 |
| B06 | **Lukas Beeretz** | Diversity of vascular epiphytes along a forest distance gradient<br>Diversity of vascular epiphytes along a disturbance gradient in lowland rainforests of Sumatra, Indonesia | 2015 |
| B06 | **Judith Krobbach** | Diversity and Dynamics of epiphytes and associated ants in oil palm plantations in Sumatra, Indonesia | 2014 |
| B06 | **Arne Wenzel** | Diversity of vascular epiphytes in lowland rainforests and jungle rubber agroforestry systems in Sumatra, Indonesia | 2015 |
| B06 | **Yayan Wahyu Kusuma** | Phylogenetic Diversity of Understory Plant Communities in Different Land Use Systems in Sumatra, Indonesia | 2015 |
| B06 | **Anu Singh** | Distribution patterns of alien naturalized plant species in Harapan Rainforest (Sumatra, Indonesia) | start 2016 |
| B06 | **Linda Hilgers** | Functional tree diversity in forest and oil palm plantations in Sumatra (Indonesia) | start 2016 |
| B06 | **Till Montag** | Functional tree diversity in jungle rubber and rubber plantations in Sumatra (Indonesia) | start 2016 |
| B09 | **Dominik Ganser** | Ecosystem services provided by epiphytic plants in oil palm plantation systems of Sumatra, Indonesia | 2014 |
| B09 | **Manuel Toledo Hernandez** | Management of homegardens in Indonesian agricultural landscapes and its impact on invertebrate diversity and herbivore predation | 2014 |
| B09 | **Arite Hildebrandt** | Dietary and functional analysis of birds in transformation systems of Jambi, Sumatra, Indonesia | 2014 |
| B09 | **Walesa Edho Prabowo** | The bird community response to different land-uses in Jambi, Sumatra, Indonesia<br>in Jambi, South Sumatera, Indonesia | 2013 |

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|---|---|---|---|
| B09 | **Neil Jun Lobite** | Influence of tropical lowland rainforest transformation systems to the community, genetic and trophic structure of bats in Jambi, Sumatra | on-going |
| B10 | **Martin Bruneß** | Cash crop choice and land use at the rainforest margins: an assessment of household welfare dynamics in central Sulawesi | 2014 |
| B11 | **Robin Naumann** | Exploration of tropical landscape structures by an unmanned aerial vehicle in Sumatra | 2015 |
| B11 | **Jennifer Arns** | Herbivory and its effects on tree growth and tree survival in an enrichment planting experiment in Jambi, Sumatra | 2016 |
| B11 | **Birte Cordts** | Plant seed rain in remnant forests and oil palm plantations surrounding the biodiversity enrichment experiment (Jambi, Sumatra) | on-going |
| B12 | **Fuad Bahrul Ulum** | Ploidy levels and reproductive behaviour in natural populations of *Centotheca lappacea* from Jambi, Indonesia | 2014 |
| C01 | **Riska Pujiati** | The impact of free trade agreements on commodity trade flows. Case study: international palm oil trade | 2014 |
| C01 | **Rakhma Melati Sujarwo** | Choice of marketing channels by small traders: the case of rubber traders in Jambi Province, Indonesia | 2014 |
| C02 | **Jennifer Merten** | Land use change and rural water supply in the tropics. Perceptions and impacts of oil palm expansion in Sumatra, Indonesia | 2014 |
| C02 | **Katrin Martens** | Social-cultural obstacles on the journey to accomplish a sustainable palm oil market in Indonesia | start 2016 |
| C06 | **Seraphim Freiherr von Loë** | The effect of farmer's time preferences on measures to enhance soil organic matter: an experimental approach | 2014 |
| C06 | **Dörte Rüther** | An experimental investigation of farmer's time preferences – a method comparison | 2014 |
| C07 | **Triana Gita Dewi** | Farm profitability and resource use in rubber and oil palm smallholders of Batanghari, Jambi, Indonesia | 2013 |
| C07 | **Puspi Eko Wiranthi** | Determinants of household food security: a comparative analysis of eastern and outside eastern Indonesia | 2013 |
| C07 | **Evita Fathia Luthfina** | Sea farming and its contribution to poverty alleviation: an empirical study from Indonesia | 2014 |
| C07 | **Ami Sukma Utami** | The analysis of horticultural diversification in Koto Tinggi village, West Sumatera, Indonesia | 2013 |
| C08 | **Thomas Fagan** | The socioeconomic determinants of windfall expenditure patterns: an analysis from the Jambi Province of Indonesia | 2015 |
| C08 | **Sandra Tappendorf** | Trust and gender: comparing experimental and survey evidence from rural Sumatra | 2015 |
| Z02 | **Rion Apriyadi** | Struktur populasi semut invasive Anoplolepis gracilipes Smith (*Hymenoptera: Formicidae*) du Kebun Raya Bogor | 2013 |
| Z02 | **Lailatun Najmi** | Diversity of weevils (*Coleoptera: Curculionidae*) across land-use systems in Jambi, Sumatra | on-going |

**Table 6:** Master thesis Indonesia

| Counterpart (IPB and UNJA) | Name of student | Title of the thesis |
|---|---|---|
| Ahmad Faqih - A03 | **Rahmi Ariani** | The influence of the MJO on diurnal cycle of rainfall over Sumatra in boreal winter (**completed**). |
| Kukuh Murtilaksono - A04 | **Syamsul Arifin** | The dynamics of dissolved organic carbon as influenced by the toposequence and the relationship with soil properties in the Bukit Duabelas National Park (**completed**). |
| Kukuh Murtilaksono - A04 | **Gilang Sukma Putra** | The dynamics of dissolved organic carbon as influenced by the toposequence and the relationship with soil properties in the Bukit Duabelas National Park (**on-going**). |
| Kukuh Murtilaksono - A04 | **Ginanjar Ika Septi-awan** | The dynamics of dissolved organic carbon as influenced by the toposequence and the relationship with soil properties in the Harapan Rainforest (**on-going**). |
| Kukuh Murtilaksono - A04 | **Achmad Adi Surya Sustama** | The dynamics of dissolved organic carbon as influenced by the toposequence and the relationship with soil properties in the Harapan Rainforest (**on-going**). |
| Achamad Farajallah - B01 | **Lora Purnamasari** | Keanekaragaman spesies udang air di berbagai tipe habitat, Jambi (**completed**). |
| Achamad Farajallah - B01 | **Vendi Eko Susilo** | Keanekaragaman kepiting air tawar (ordo Decapoda: Brachyurda) di kabupaten Batanghari dan Sarolangun, provinsi Jambi (**completed**). |
| Anja Meryandini - B02 | **Azizah Hikmah Safitri** | Grouping of palm oil plants (*Elaeis guineensis* Jacq) origin of West Java by simple sequence repeats (SSR) markers (**completed**). |
| Anja Meryandini - B02 | **Ariandi** | Produksi Manooligosakarida dari Bungkil Kopra Menggunakan Mananase Streptomyces sp. BF 3.1 (**com-pleted**). |
| Anja Meryandini - B02 | **Nur Kholis** | Karakterisasi xilanase sterptomyces sp. Bo 3.2 dan produksi xilooligosakarida dari xilan tangkai tembakau (**completed**). |
| Nisa Rachmania Mubarik - B02 | **Muhammad Asril** | Partial purification of bacterial chitinase as biocontrol of leaf blight disease on oil palm (**completed**). |
| Nisa Rachmania Mubarik - B02 | **Nazhariz Nurza Harca** | Isolation and identification of nitrogen fixing and indole acetic acid producing bactria from oil plantation in Jambi Indonesia (**completed**). |
| Ir. Hamzah - B03 | **Niken Rubiastuti** | The effect of phosphorus fertilizer and soil ameliorant on growth oj jelutung (*Dyera lowii*) seedling (**com-pleted**). |
| Iskandar Z Siregar - B03 | **Rajitha Handayani** | Pengujian Barcode DNA pada Jenis Dipterokarpa terancam punah di Hutan Harapan Provinsi Jambi (**com-pleted**). |
| Ulfah J Siregar - B03 | **Arniana Anwar** | Variasi morfologi daun dan sekuens ITS2 pada Jelutung darat (*Dyera Costulata* (miq.) Hook.f.) dan Jelutung rawa (*Dyera Polyphyla* (Miq.) Steenis) (**completed**). |
| Ir. Elias - B04 | **Tohir Wijaya** | Tree biomass and carbon mass allometric equation models of rubber tree community forest at Desa Bungku, Jambi Province, Sumatra (**completed**). |

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| Triadiati Antono - **B04** | **Selis Meriem** | Contributionn of deadwood to soil carbon stock in lowland rain forest transformation system in Jambi, Sumatra (**completed**). |
| I Nengah Surati Jaya - **B05** | **Putu Ananta** | Spatial model of deforestation in Jambi province for the period 1990~2011 (**completed**). |
| Sri Sudarmiyati Tjitrosoedirdjo - **B06** | **Indah Wahyuni** | Distribution of invasive plant species in different land-use systems in Sumatra, Indonesia (**completed**). |
| Bambang Hariyadi - **B06** | **Azwar Anas** | Studi fitososiologi hutan pamah di zona inti bagian tengah Taman Nasional Bukit Duabelas, Jambi (**completed**). |
| Sri Wilarso Budi - **B07** | **Fatimah** | Arbuscular mycorrhizal propagule potential in different ecosystemsas estimated by the most probable number method (**completed**). |
| Rahayu Widyastuti - **B08** & Yayuk R. Suharjono (LIPI) | **Yuni Lisafitri** | Population dynamics of Oribatida in response to seasonal change in oil palm plantations in Jambi Province (**completed**). |
| Rahayu Widyastuti - **B08** & Yayuk R. Suharjono (LIPI) | **Joko Warino** | Respond of Collembola towards the seasonal change in oil palm plantation in Jambi Province (**completed**). |
| Rahayu Widyastuti - **B08** & Yayuk R. Suharjono (LIPI) | **Titik Triwahyuni** | Abundance and diversity of microarthropods in microhabitat of oil palm in Jambi Province (**completed**). |
| Rahayu Widyastuti - **B08** & Yayuk R. Suharjono (LIPI) | **Hidayatuz Zuamah** | Kenaekaragaman collembola sebagai bioindikator kualitas tanah di perkebunan kelapa sawit rakyat kec. Bajubang Provinsi Jambi (**completed**). |
| Rahayu Widyastuti - **B08** & Yayuk R. Suharjono (LIPI) | **Widrializa** | Kelimpahan dan keanekaragaman collembola pada empat penggunaan di Lanskap Hutan Harapan, Jambi (**completed**). |
| Rahayu Widyastuti - **B08** & Yayuk R. Suharjono (LIPI) | **Intan Widyaningrum** | Keragaman oribatida sebagai bioindikator kesuburan tanah di kawasan pekebunan kelapa sawit kecamatan Bajubang Provinsi Jambi (**completed**). |
| Damayanti Buchori, Idham S. Harahap & Ir. Pudjianto - **B09** | **Ratna Rubiana** | Pengaruh Transformasi Habitat terhadap Keanekaragaman dan Struktur Komunitas Semut di Jambi (**completed**). |
| Rika Raffiudin - **B09** | **Rosi Ramadani** | Foraging behaviour, pollen identification and nest development of TRIGONA stingless bee in oil palm and rubber plantaions in Jambi (**completed**). |
| Tri Atmowidi - **B09** | **Fahri** | Diversity and abundance of Cerambycid beetles (Coleoptera) inthe four major land use types found in Jambi Province, Indonesia (**completed**). |
| Tri Atmowidi - **B09** | **Erlinda Hafini Siregar** | Diversity and abundance of insect pollinators in different land use types in Jambi, Indonesia (**completed**). |
| Surya Darma Tarigan - **B10** | **Stevany Putri** | Direct runoff prediction on Bungku micro watershed, Batanghari district using the soil conservation service – curve number model (**completed**). |
| Surya Darma Tarigan - **B10** | **Susi Widyaliza** | Kajian dampak hidrologi ekspansi perkebunan sawit di DAS Batang tabir menggunakan SWAT (**completed**). |

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|---|---|---|
| Leti Sundawati & Prijanto Pamoeng-kas - B11 | **Rince Muryunika** | Growth of Meranti (*Shorea leprosula*), Mahagony (*Swietenia macrophylla*) and Jabon (*Anthocepalus cadamba*) in oil palm agroforestry of PT. Humusindo, Jambi, Indonesia (**completed**). |
| Soeryo Adiwibowo - IPB | **Bayu Budi Andriani** | The polotical ecology of land control over conservation forest, Jambi (case study of Sultan Taha Saifuddin) (**completed**). |
| Rina Mardiana - associated to C02 | **Rai Sita** | Pertarungan kuasa dan legitimasi klaim atas sumberdaya hutan (kasus hutan sekitar restorasi ekosistem di kabupaten BatanghariProvinsi Jambi) (**completed**). |
| Ervizal A.M. Zuhud - C03 | **Aminah** | Conservation of Jelutong (*Dyera* spp.) by Suku Anak Dalam at PT REKI Harapan Rainforest, Jambi (**on-going**). |
| Nunung Nuryartono - C04 | **Sigit Yusdianto** | Food consumption pattern of the poor in Central Sulawesi, Indoensia (**completed**). |
| Nunung Nuryartono - C04 | **I Made Sanjaya** | Food Consumption pattern of the poor in Jambi, Indonesia (**completed**). |
| Yusman Syaukat - C06 | **Achmad Firman Wa-hyudi,** | Analisis ekonomi dan risiko konversi tanaman karet ke kelapa sawit: studi kasus di kecamatan pemayung, Kabupaten Batang Hari, Jambi (**completed**). |
| Hermanto Siregar - C07 | **Edwin Mahatir** | Peranan komoditas kelapa sawit dalam perekonomian wilayah berwawasan lingkungan provinsi Jambi: per-bandingan analisis input-output tahun 2000 dan 2010 (**completed**). |
| Damayanti Buchori - Z02 | **Lailatun Najmi** | Diversity of weevils (*Coleoptera: Curculionidae*) across land-use systems in Jambi, Sumatra (**on-going**). |

# VI. Central Meetings of the EFForTS: Workshops, Retreats, Colloquia, Symposia and Trainings

Central meetings of the EFForTS play an essential role for the promotion of scientific exchange between the researchers, for fostering the international collaboration with the partners in Indonesia, and for supporting young academics, for example through the organization of PhD colloquia (Table 7).

**Table 7:** Central meetings of the EFForTS: workshops, retreats, colloquia, symposia and trainings

| Year | Key events |
|---|---|
| **Status Workshops in Bogor and Jambi** | |
| 2012, 2013, 2014, 2015 | Annual status workshops were held in Bogor and Jambi, Indonesia:<br>- Signing of agreements and memoranda of understanding.<br>- Consolidation of research focal points of project groups.<br>- Presentation of research results of ABS – funded projects.<br>- Key finding of Phase 1 and integration of interdisciplinary scientific concept for the 2$^{nd}$ phase. |
| **Retreats in Göttingen** | |
| 2012, 2013, 2014 | Bi-annual retreats were conducted in Göttingen:<br>- Progress report and status of research including outlook/next steps.<br>- Strategic development of Phase 2 (SWOT analyses, internal evaluation, and interdisciplinary collaboration with Indonesian Consortium). |
| **International Symposia in Jambi** | |
| 2014 | A two-day international symposia was held at Jambi: *Oil-palm livestock integration towards sustainable and future oil palm plantation management systems* in Jambi:<br>- Consolidation of complementary research activities of counterparts addressing new scientific questions. |
| **DAAD Alumni and Student Workshop in Bogor** | |
| 2014 | In collaboration with CIFOR and IPB, B05 implemented the 4th International DAAD Alumni and Student Workshop on *"Ecological and Economic Challenges of Managing Forested Landscapes in a Global Context – Focus: Asia"* in Bogor and Jakarta. |
| **Doctoral colloquia in Göttingen** | |
| 2013, 2014, 2015 | Doctoral colloquia and seminars were conducted monthly during the semester:<br>- *Topics and speakers see website of EFForTS.* |
| **Doctoral / Postdoctoral Workshop (self-organized) in Göttingen** | |
| 2014 | A three-day workshop entitled *"Enhancing interdisciplinary understanding and collaboration amongst the PhDs and Postdocs"* was conducted to:<br>- Create synergies among the different disciplines and research topics,<br>- Discuss and comprehend a diverse set of research questions across disciplines and their approach to answer questions. |
| **Technical workshops and trainings in Bogor and Jambi** | |
| 2013 | A one-day training on *DNA Barcoding* was given by Fitri Yola Amandita (former doctoral researcher of Z02) at IPB. |
| 2014 | A two-week workshop on *Determination of Soil Animals* was held at IPB by Bernhard Klarner (Postdoc of B08) and Rahayu Widyastuti (Counterpart B08). |

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| 2014 | A two-day training on *R* was given by Andrew Barnes and Malte Jochum (former doctoral researchers of B01) at the J.-F. Blumenbach Institute in Göttingen. |
| 2014 | A two-day workshop on *Palynology* was given by Hermann Behling (PI of A01) and Asmadi Saad (Counterpart of A01) at UNJA. |
| 2014 | A two-day workshop on *Agent-based modelling* was given by Claudia Dislich (former Postdoc of B10) at IPB. |
| 2014 | A two-day training course on *Terrestrial Laser Scanning* (TLS) was given by B05 at IPB. |
| 2014 | A one-day workshop on "*Implementation of the Nagoya Protocol*" was held at IPB. |
| 2014 | A one-day workshop on "*Scientific practice and policy interfacing related to the management of lowland rainforest transformation systems*" was held at IPB.<br>The workshop resulted in 8 policy briefs and 2 technical guidelines – see Chapter 6. |
| 2014 | In collaboration with the National Park Bukit Duabelas UNJA conducted two workshops on "*Jernang (Dragon blood) cultivation and processing*". |
| **EFForTS Seminar Series in Bogor and Jambi** | |
| 2013, 2014, 2015 | Regular seminar series were conducted during the semester at IPB Bogor and at UNJA, Jambi.<br>*Topics and speakers see website of EFForTS Indonesia.* |

## VII. Public Relation and Knowledge Transfer

EFForTS has developed a PR strategy to disseminate scientific knowledge and key findings to the scientific community, college students, stakeholders & local communities, and the interested general public (Table 8).

**Table 8:** Public relation work and knowledge transfer

| **Public relation work** | |
|---|---|
| Binational websites at Göttingen and at IPB Bogor including an active Facebook site | EFForTS set up an internet platform and websites that serves as source of information and as download-archive for the access to databases, publications and information materials.<br>- *Göttingen*<br>- *IPB Bogor*<br>- *Facebook* |
| Documentary | A 16-minute film documentation (German, English and Bahasa Indonesia) of the work of EFForTS in Indonesia was produced by *Eulefilm* to raise visibility and external impact. Target group is the interested and educated general public, stakeholders and decision makers.<br>The documentary is published on the *EFForTS website* and on youtube.com.<br>It has also been shown at the second Science Night of the University of Göttingen in January 2015. |
| Second Science Night, University of Göttingen (January 2015) | *The project* has been presented to a wider local public (approx. 19.000 visitors): film presentation (see above), lecture about "Wild birds in Sumatra – functions and diversity" (an audio documentation), picture and poster exhibition, discussion forum and display of products containing palm oil and rubber. |
| DFG biodiversity exhibition "Vernetzte Natur" | EFForTS participated in the *DFG biodiversity exhibition "Vernetzte Natur"*. The kick-off event took place in Bonn on November 19, 2013.<br>The exhibition visualises in an interactive way the major questions addressed by recent functional biodiversity research and explains why this topic is of regional, national and international importance.<br>*The exhibition* was also hosted by CBL-SeTSAF, University of Göttingen (Feb 19 – Apr 17, 2015; |
| EFForTS Sumatra Plant Database | *The EFForTS Sumatra Plant Database* (test version) was set up as an open-access plant database providing: list of families, list of species, single species view, and search by keyword. The EFForTS Sumatra Plant Database provides valuable descriptive species information for educational purposes in universities and schools of Indonesia.<br>*Rembold, K. & Kreft, H. 2015. EFForTS Sumatra Plant Database. www.sumatranplants.uni-goettingen.de. University of Göttingen, Germany.* |
| Sound EFForTS | *Sound EFForTS* was set up as an internet audio platform for soundscape biodiversity identification.<br>*Darras, K. 2014. Sound EFForTS. University of Göttingen.* |
| Common Wayside Plants of Sumatra | The booklet can be used as teaching material and information basis for common wayside plants of Sumatra.<br>It can be downloaded from the *website of EFForTS.* |

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| Database on soil invertebrates | The database on oribatid mites and other soil invertebrates was set up for documentation and education purposes of the counterparts in Indonesia (origin, taxonomy, list of species, single species view). |
| EFForTS-WebGIS | *The EFForTS-WebGIS* was set up as platform for exchanging spatial data among the EFForTS researchers, for visualizing spatial data and to create maps which can be shared within the research groups or made publicly available. |
| Scientific community and stakeholders | Presentations of key findings at seminars, conferences, lectures in all partner universities and stakeholder institutions. Some activities are highlighted in Chapter 6 (see above).<br>Training courses at all partner universities (see Chapter 6). |
| Publications, press releases, public awareness raising | *Scientific papers* (see Chapter 4) *and website of EFForTS*<br>- Newsletter: the EFForTS annual newsletter outlines the current status of scientific research and development of the project, and is published on the website.<br>- Press releases: a) in the *Tribun Jambi* and on local TV – Jambi, Indonesia, b) at the University of Göttingen (International Newsletter and uni-inform).<br>- Poster, Flyer, T-Shirts, photo calendar: poster or signboards were installed at research plots; flyers were distributed to the interested public and stakeholders to raise public awareness. Imprinted T-shirts (with acronym of EFForTS, logos of participating institutions and funding agency DFG) were handed to collaborative farmers, employees, local assistants) to promote corporate identity and interest in the project. |
| Public symposium and podium discussion in Berlin, Germany | At the 74th Sarasehan of the Indonesian Embassy in Berlin entitled *"Zwischen Regenwald, Kautschuk, Ölpalmen und Wirtschaftswachstum: ein deutsch-indonesisches Forschungsprojekt stellt sich vor"*, Dr. Jochen Drescher and Fuad Nurdiansyah presented EFForTS and answered questions from the audience. |

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| RISE (Research Internship in Science and Engineering) – a DAAD-DFG Cooperation | To promote the advancement of junior academics, the RISE program offers doctoral students of CRCs the possibility to invite and supervise undergraduate students from the United States, Canada and the UK. RISE interns work with doctoral students in the field of their research and who serve as their mentors.<br>Two doctoral researchers of EFForTS – Phase 1 have been granted a research internship:<br>- Tom Kopp – PhD student of C01 – invited and supervised the research internship of Stephanie Eisner form the University of Texas, Austin, USA (July to August 2013) entitled "*Impact of agro fuel production on food security and welfare*".<br>- Siria Biagioni – PhD student of A01 – invited and supervised the research internship of Peter Meyer Reimer from the Goshen College, Goshen, Indiana, USA (June to August 2014) entitled "*Holocene dynamics of tropical rainforest, climate, fire, human impact and land use in Sumatra, Indonesia*". |

**Policy briefs and technical guides**

The University's education and research in Indonesia is closely linked to community needs. Therefore, Indonesian counterparts are directly involved in community service coordinated by the research and community centres within the partner institutions. Lecturers and students of EFForTS spend a work share to contribute to small scale businesses, teaching in communities or student work programs. These activities offer a direct transfer of knowledge and skills from researchers to the community and have been used as tool to disseminate EFForTS related information, as well as a means of gathering (feedback) information.

1. Konservasi Air Di Kebun Sawit – *Water conservation in palm oil plantation* (**Herdhata Agusta**, Faculty of Agriculture, IPB – counterpart of **A02**).
2. Perencanaan Penggunaan Lahan untuk Menjaga Keberlanjutan Sumberdaya Air DAS Batanghari – *Land allocation for the sustainability of ecosystem services in Jambi* (**Surya Tarigan**, Faculty of Agriculture, IPB – counterpart of **B10**).
3. Pengelolaan Fauna Tanah di Kebun Kelapa Sawit – *Management of soil fauna in oil palm plantations* (**Noor Farikhah Haneda**, Faculty of Agriculture, IPB – counterpart of **B01** and **Tri Heru Widarto & Ahmad Farajalah** – Faculty of Mathematics and Natural Sciences, IPB).
4. Strategi Pengembangan Agroforestry Berbasis Kelapa Sawit di Propinsi Jambi – *Agroforestry development strategy based on palm oil in Jambi* (**Leti Sundawati** – counterpart of **B11** & **Rince Muryunika & Priyantono Pamoengkas**, Faculty of Forestry, IPB).
5. Menjaga Komponen Biota Air Tawar yang ada di Aliran Air yang Melintasi Wilayah Perkebunan – *Keeping freshwater biota components in water flow across the plantation* (**Achmad Farajallah** – counterpart of **B01** **& Daisy Wowor**, Faculty of Mathematics and Natural Sciences, IPB).
6. Kelapa Sawit: Benarkah Sangat Buruk Bagi Lingkungan? – *Palm oil: is it true that is has a bad environmental impact?* (**Tania June**, Faculty of Mathematics and Natural Sciences, IPB – counterpart of **A03**).
7. Peran Serasah di Perkebunan Kelapa Sawit Sebagi input hara tanah – *The role of litter as soil nutrient inputs in palm oil plantations* (**Triadiati Antono**, Faculty of Mathematics and Natural Sciences, IPB – counterpart of **B04**).
8. Konservasi Tumbuhan Hoya Di Jambi Melalui Promosi Pemanfaatannya – *Conservation of Hoya species in Jambi through promotion of utilization* (**Sri Rahayu**, LIPI and **Iskandar Z. Siregar**, Faculty of Forestry, IPB – counterpart of **B03**).

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1. Lowland rainforest
2. Rubber agroforestry (jungle rubber)
3. Rubber plantation
4. Oil palm plantation (Photos1-4: Katja Rembold)

5. Oil palm plantation aerial photograph (Photo: Ana Meijide)

6. Land preparation for the establishment of oil palms (Photo: Eulefilm, Sabine Eckelmann)
7. Harvest of oil palm bunches (Photo: Eulefilm, Sabine Eckelmann)
8. Harvest of oil palm bunches (Photo: Anne Gérard)
9. Weighing of harvested oil palm bunches by smallholders in village (Photo: Sabine Eckelmann)



10. Oil palm factory for processing of palm oil (Photo: Barbara Wick)
11. Products containing palm oil – listed by Greenpeace (Photo: Sabine Moeller, Greenpeace)
12.+13. Rubber tapping, (Photos: Sabine Eckelmann)
14. Weighing of latex bundles processed from natural rubber by smallholders in village (Photo: Sabine Eckelmann)

15. Collection of latex bundles in factory, Jambi, Indonesia (Photo: Stefan Scheu)
16+17. Processing of latex in rubber factory, (Photo: Stefan Scheu)
18. Products containing latex (Photo: Sealworld Pvt. Ltd. 2014 | Powered by SADACNET)

All pictures taken in Jambi, Indonesia.