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Tabebuia Bulletin

Platform for Biodiversity and Ecosystem Monitoring and Research in South Ecuador

former MRp|SE NewsLetter

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In the Science News: a network analysis and progresses towards reliable and easy to measure indicators for biodiversity, climate change and land-use alternations in the tropical mountain rainforest (left), as well as characteristics of pine fields in the páramo ecosystem (right). Photos: Jörg Bendix, Ingeborg Haug

In this Issue

Coordinators' Corner

News since May 2015

Jörg Bendix[1], Erwin Beck[2], Juan Pablo Suárez[3], Alfredo Martínez[4]

[1]Universities of Marburg and [2]Bayreuth, Germany – Coordinator and Deputy Coordinator of the DFG-PAK Research Consortium

[3]Universidad Técnica Particular de Loja, [4]University of Cuenca, Ecuador – Coordinator and Deputy Coordinator of the SENESCYT Research Consortium

After the official end of the Research Consortium the coordinators describe how the research stations will operate from now on and how research is planned to be continued in a new Research Unit. The Consortium's researchers summarized recent findings in a booklet, the Ecuadorian counterparts are about to start five research projects, international collaboration is extended, and the non-academic partner Nature and Culture International (NCI) celebrated its round anniversary.

This is our temporarily last Tabebuia Bulletin. Our "official" three-years period of the Platform project has ended by October 2016. The ETAPA research station in Cuenca is already cancelled, but the NCI stations Estación Científica San Francisco (ECSF) and Laipuna are still open until the end of the year, and our station managers Jörg Zeilinger and Felix Matt are on duty as well.

Research Unit in Preparation

We are intensively working on a follow up program (Research Unit ReSp*EC*t - Environmental changes in biodiversity hotspot ecosystems of South **EC**uador: **ReSp**onse and feedback eff**ECt**s) where the first preproposal was unfortunately refused by the DFG expert board (Fachkollegium, FK) recently, concomitant with the invitation to submit an improved version with a significant change in the consortium to document a certain change in the research focus as a main point raised by the FK.

Management of Prolonged Projects

At the same time, six projects mainly from the knowledge transfer subprogram C were allowed to apply for a prolongation (**Table 1**). The applications were almost completely approved in October 2016 by German Research Foundation (Deutsche Forschungsgemeinschaft, DFG). All other projects have meanwhile applied for a cost-neutral prolongation so that the platform program as such can be extended from the German site until September 2017.

There was only one main setback. Due to procedural reasons at DFG, we were not allowed to form a central money pool in Marburg, which means that we officially do not have a central coordination anymore.

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Table 1: Extended subprojects of the German DFG Consortium

Project ID	Subprogram	Principal Investigator
A1	A	Jürgen Homeier
B3	D	Reinhard Mosandl et al.
C2	C	Nina Farwig et al.
C5	C	Erwin Beck
C6	C	Jörg Bendix
C7	C	Lutz Breuer

However, every sub-project got approved an amount for "infrastructure" costs which has to be individually balanced mostly with NCI. We are currently working on a template for individual invoices, which are in discussion with NCI and the universities of the prolonged subprojects. If everything works fine with the administrations, NCI has the possibility with the money of the six projects to keep ECSF and Laipuna open, of course, with reduced service. We have to stress at this point that all other projects have to pay potential stays in 2017 individually to NCI at their rates. Also our station managers will be available at site from now until the end of the prolongation phase, which is 30 September 2017.

Knowledge Transfer Booklet

The reviewers of the prolongation panel particularly commended our knowledge transfer activities. Hence, a main duty in the remaining time is to finalize our deliverables in the knowledge transfer sector. Thanks to the tireless effort of Franz X. Bogner and the head of the Transfer Working Group of the platform, Erwin Beck, our first deliverable, the knowledge transfer booklet "Biodiversity Hotspot" (**Figure 1**), came into the world in September 2016 [1]. We hope that everybody will enjoy not only the scientific content but also the unique layout characterized by "emotional" photographs. Hardcopies will be available soon, printed by NCI and Technical University of Loja (UTPL) in Loja. The digital version is available via the Data Warehouse [1]. A Spanish translation particularly addressing our stakeholders in Ecuador is in work.

High Ranking Papers

Besides our successful work in knowledge transfer so far, the reviewers of the Research Unit called for a better publication record from the platform, particularly regarding joint high ranked papers. Fortunately, with the second Knoke et al. paper in *Nature Communications* in 2016 [2] (which was not yet published at the application stage), we made a big step in the expected direction. While further initiatives from our consortium are highly appreciated, we should also be aware that our research is internationally visible so that our data (and thus Principal Investigators, PIs) were recently entered in joint high ranked papers focussing the global scale [3, 4].

Since the last issue of our Tabebuia Bulletin, the time was busy as always. On a coordination trip in March-April this year, the coordinator got aware of the problematic financial situation in Ecuador and its ramifications for universities and public entities. This topic was always present in all talks with our colleagues from the universities University of Cuenca (UC), UTPL and National University of Loja (UNL) and our vis-

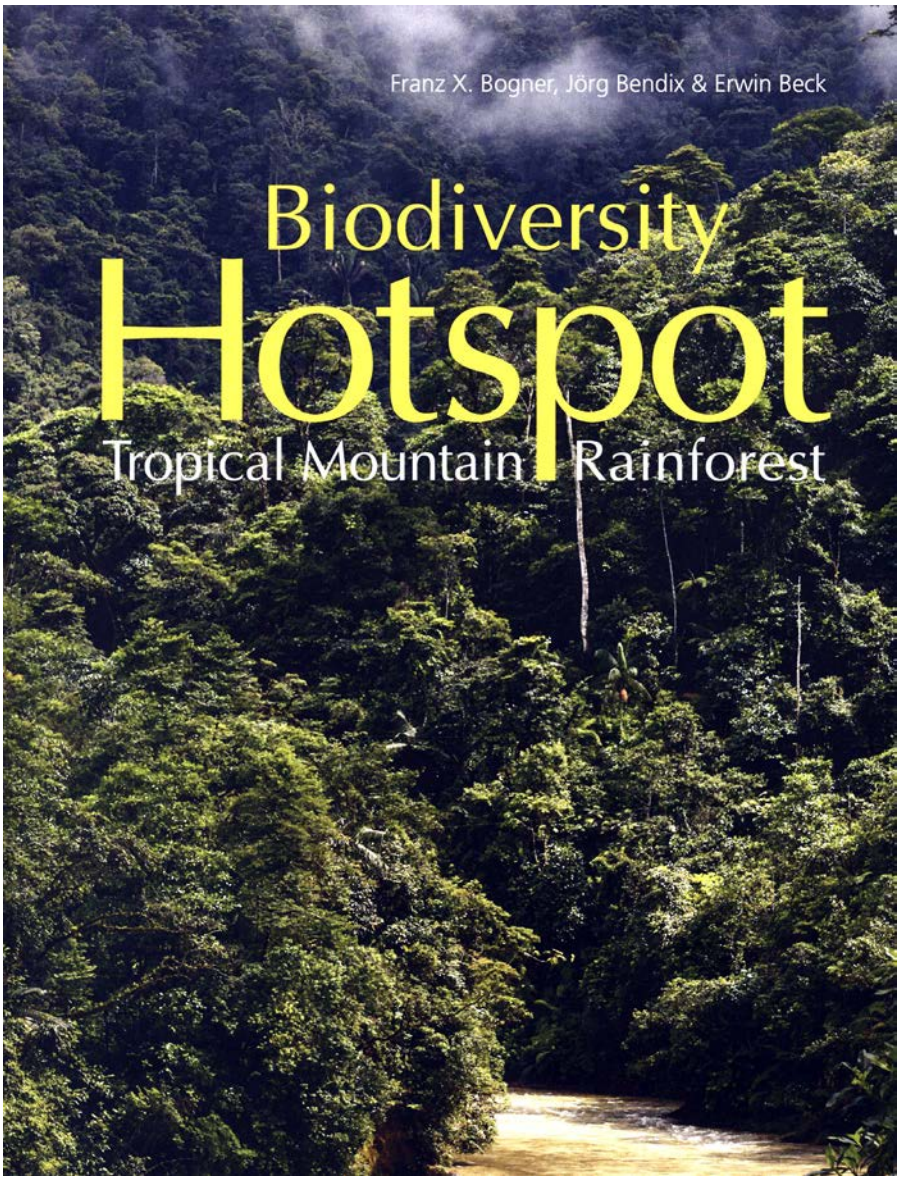

Figure 1: Cover of the knowledge-transfer booklet [1]. Photo: Franz X. Bogner

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Table 2: Projects of the Ecuadorian SENESCYT Research Consortium

Working package 1: Monitoring Biodiversity and Ecosystem Functions	**Investigators**	**Institutions**
EC 1.2 Use of bioacoustics to develop innovative indicators of diversity in communities of amphibians and bats along altitude and disturbance gradients	David Siddons[1], Andrea Jara[2], Carlos Nivelo[1] and Juan Carlos Sanchez[1]	[1]Universidad del Azuay, Cuenca (UDA) [2]Universidad Técnica Particular de Loja (UTPL)
EC 1.4 Network topology of epiphytic orchid-mycobiont and epiphytic orchid-phorophyte interactions	Juan Pablo Suárez, Lorena Riofrío and Carlos Naranjo	Universidad Técnica Particular de Loja (UTPL)
EC 1.5 Spatial-temporal responses of bird and bat communities to altitudes and disturbance in three different habitats	Carlos Iván Espinosa[1], Boris Tinoco[2], Andrea Jara[1]	[1]Universidad Técnica Particular de Loja (UTPL) [2]Universidad del Azuay, Cuenca (UDA)
EC 1.6 Morpho-functional adaptations along a climatic stress gradient and its influence on plant community assembly	Elizabeth Gusmán M., Diego Vélez M. and Carlos Iván Espinosa	Universidad Técnica Particular de Loja (UTPL)
Working package 2: Water and Element Fluxes	**Investigators**	**Institution**
EC 2.1 Development of functional hydrological indicators for evaluation the impact of global change on Andean ecosystems	Patricio Crespo	Universidad de Cuenca (UC)

ited counterparts NCI, and the government of the province Loja (GPL). In addition, the high uncertainty about our group's potential future research activities and related problems were omnipresent in the discussions.

Research by Ecuadorian Counterparts

Particularly in the light of the complex financial situation, we were very glad that finally the Ecuadorian National Secretariat for Higher Education, Science and Technology (SENESCYT), the UC, the UTPL and Universidad of Azuay (UDA) came to an agreement, which allows the start of the Ecuadorian part of the platform program. That situation created a delay for the start of the research projects because it was necessary to search first a new legal way to administrate and to finance them.

The new legal way implicated a change of the structure of the SENESCYT Research Consortium. It has to be administrated by UC and no longer for the ETAPA EP. The function of the UC is to follow-up projects execution, administration of funds, provide equipment and materials and to support the private universities with the execution of their research projects.

This important change also involves the necessity of a coordinator to organize all these activities at UC. The rector appointed Dr. Alfredo Martínez as coordinator (e-mail: alfredo.martinez@ucuenca.edu.ec).

A schedule of activities and deadlines for the transfer of financial funds from ETAPA EP to the University of Cuenca were initiated to insure the start of the research projects. At this moment, the funds are under the administration of the University of Cuenca. The necessary agreements with SENESCYT have been signed by all participating universities.

Five research projects will be developed by this SENESCYT research consortium within the next three years (**Table 2**).

International Collaborations

We also were intensifying our ties with the Peru transect coordinated by the University of Oxford (http://www.andesconservation.org/; Yadvinder Malhi) with a joint talk of Jürgen Homeier and the coordinator, Jörg Bendix (**Figure 2**, [5]), and further discussions on potential cooperation in Oxford in July 2016. Several topics were identified where joint data evaluation seems to be possible.

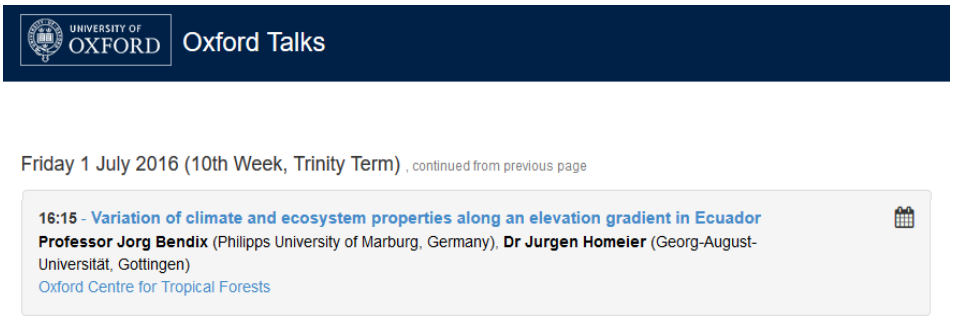

Figure 2: Oxford Talk: Variation of climate and ecosystem properties along an elevation gradient in Ecuador by Professor Jörg Bendix and Dr Jürgen Homeier from the German Research Consortium

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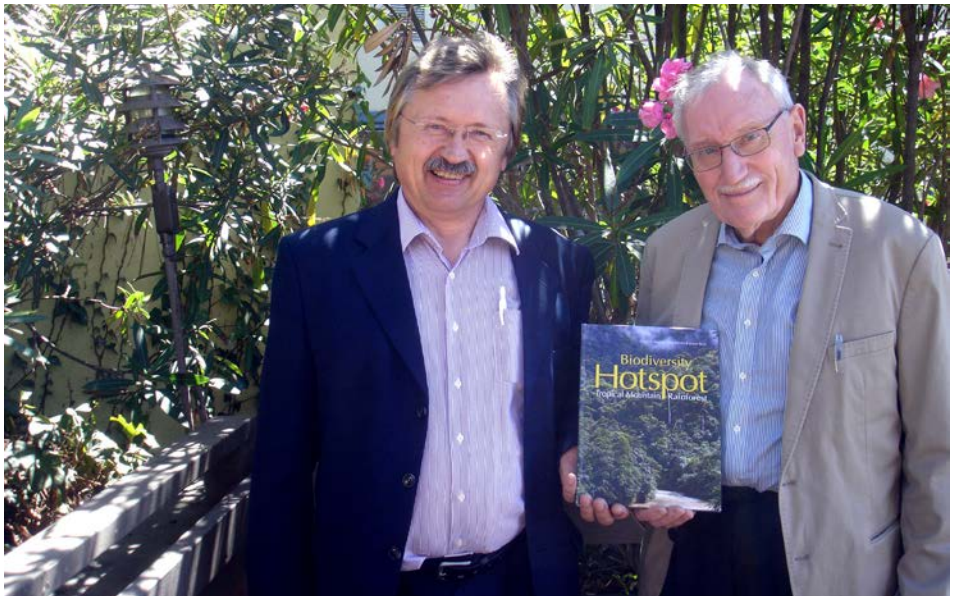

Figure 3: Franz Bogner and Erwin Beck presenting the book "Biodiversity Hotspot" at the NCI Office in Del Mar, California. The editors wish to take the opportunity to cordially thank all contributors to the book for providing manuscripts and impressive photographs and for their patience with the editors' numerous comments and requests. Photo: Rainer Bussmann

Figure 2: Ivan Gayler (left) and Nick Ervin appreciating the booklet "Biodiversity Hotspot" at the Head-Office of NCI in Del Mar, California. Photo: Erwin Beck

One outcome of this meeting is our joint session scheduled for the next conference of the *European Conference of Tropical Ecology* taking place in Brussels in February 2017 (see Event Calendar in this issue). In this session entitled "Complete Altitudinal Rainforest Transects in the tropics" (conveners and chairs: M. Leponce, J. Homeier, Y. Malhi, P. Klimes, J. Bendix, V. Novotny), we will not only compare the Ecuador and Peru transect but also further transects in Malaysia (Mt. Kinabalu) and elsewhere.

NCI Anniversary

A highlight of this year was NCI's celebration of the 20th anniversary in San Diego where Erwin Beck and Franz X. Bogner attended the main event. After nearly a year of writing, revising, editing, and layouting our book "Biodiversity Hotspot – Tropical Mountain Rainforest" (Bogner, Bendix, Beck eds., 150 pp) could be presented as a birthday gift to NCI by Franz Bogner and Erwin Beck who participated in the celebration of NCI's 20ies anniversary in Del Mar in South California where the head office of NCI is situated (**Figures 3, 4**). The celebration on 15 September was an evening's reception which was attended by approximately 100 congratulators, mostly actual and prospective donors of NCI. Embedded in a series of speeches Erwin Beck delivered the congratulations and best wishes of the German group of researchers, showing with a few anecdotes and slides the history of the German-Ecuadorian collaboration as powerfully supported by NCI and financed by the German Research Foundation DFG since almost 18 years. At the end of the celebration ceremony Ivan Gayler was honoured with the E.O. Wilson award for his untiring efforts for nature protection through NCI. In the following morning Franz Bogner presented details of the book to the staff of NCI and Erwin Beck gave a comprehensive lecture on major achievements of the German projects which was well received. The message that six of the current projects got an extension of a year, which arrived just the same day by e-mail, was picked up with great relief. A one day's tour to the autumnal Sonora desert with Nick Ervin and Ivan Gayler rounded off the visit to California. NCI will have another birthday celebration in Ecuador (Quito) on 29 November.

Data Management and Future

From the administration site we have to ask once more all participants to upload/update their data sets and publications to the Data Warehouse, which is essential for our follow-up activities. In an interim solution, Simone Strobl (former C5), Jörg Zeilinger and Brenner Silva (former C6) are employed as Data Base Managers. They will handle all data issues until December 2017. Beyond, there is no more central data management, but Maik Dobbermann

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from the coordinator's group will keep the Data Warehouse running. The German Federation for Biological Data (GFBio, www.gfbio.org) has meanwhile asked for a transfer of the old FOR402/816 data to the GFBio repository. We are currently discussing technical details. More comprehensive information about administrative issues will be given at the member assembly along our next Status Symposium scheduled for 1-2 December 2016.

Final Remarks

This is the end of our last Coordinators' Corner! And the temporarily last Tabebuia Bulletin in your hands, which again convinces by its great professional quality. The latter is owed to only one person, our Executive and Managing Editor, Dr. Esther Schwarz-Weig (www.Sci-Stories.com). We are deeply indebted for her excellent work. She accompanied us since 14 years in our Ecuadorian adventure with her very high professionality, reliability and, most important, her patience (e.g. with delayed contributions by the coordinators). Esther, thank you very much also on behalf of all the scientists of running and past programs, it was a great pleasure to work with you! Of course, we hope that this is just a temporary break so that we will be able to continue our fruitful collaboration within a new Research Unit ReSp*EC*t in 2018.

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Booklet

Biodiversity Hotspot: Tropical Mountain Rainforest

Contents

Event Calendar

International Symposium of the Monitoring and Research Platform South Ecuador

The Research Consortium presents and discusses recent findings on its next Status Symposium, which is scheduled to take place in Ecuador at the Universidad Técnica Particular de Loja (UTPL), Centro de convenciones, on December 1 and 2, 2016. One day will cover Spanish and the other will cover English talks. Attendence is free and electronic certificates can be ordered.

Details: http://www.bergregenwald.de/news.do?newsid=176

European Conference of Tropical Ecology

The annual scientific meeting of the Society for Tropical Ecology (German: Gesellschaft für Tropenökologie, gtö) will be organized on the campus "Etterbeek" from the Vrije Universiteit Brussel, Belgium, from Monday 6 to Friday 10 February 2017. The overarching topic will be "(re)connecting tropical biodiversity in space and time". The conference aims to connect researchers at all levels of their career and from all disciplines relevant to tropical ecology. Oral and/or poster presentations can be submitted until October 31, 2016 via the website: http://www.gtoe-conference.de/

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Science News - Short Communications

Carbon Stocks in Pine Plantations on Páramo Sites

Carlos Quiroz Dahik[1,2], Patricio Crespo[1], Nikolay Aguirre[3], Patrick Hildebrandt[2], Bernd Stimm[2], Reinhard Mosandl[2], Michael Weber[2]
[1]Universidad de Cuenca, Ecuador
[2]Technical University of Munich, Germany – Members of the DFG-PAK Research Consortium
[3]Universidad Nacional de Loja, Ecuador

Here we show, that carbon stocks under pine plantations decrease considerably on higher elevations.

Pine plantations have been established on páramo sites in Ecuador within the framework of Clean Development Mechanism (CDM) and several related projects (**Figure 1**). However, negative impacts on e.g. biodiversity, hydrology regulation or soil characteristics have been claimed and the performance regarding carbon sequestration is not clear. As a part of **project B3** (funded by DFG, ETAPA and University of Cuenca) we assessed carbon stocks in aboveground and belowground biomass and soil organic carbon in pine plantations, which later on will be compared to carbon stocks of natural páramo vegetation.

Figure 1: Pine plantation on páramo site (3700 m). Photo: Marion Schmid

Materials and Methods

45 randomly distributed sample plots have been established within pine plantations on 9 different sites at 3 elevations in the province of Azuay (3300 m, 3500 m, and 3700 m a.s.l.); the mean age of the plantations was 16, 17, and 15 years, respectively. Forest inventories on sample areas of 24 m x 24 m (576 m²) have been conducted in order to determine tree density, diameter, total height and crown height. One randomly selected tree per plantation was cut in order to determine biomass of stems, branches and needles (**Figure 2**). Ground vegetation has been collected on subplots of 1 m², oven-dried and weighted (**Figure 3**). Coarse roots (> 5 mm) have been dug out for two opposite quarters of each cut tree and subsamples have been used for determining dry weights. Biomass of fine roots (< 5 mm) was calculated by proportions in volumetric soil samples. For calculation of carbon contents, we used a general share of 50% for all biomass compartments [1].

Figure 2: Tree harvest for analysis of aboveground biomass. Photo: Kathrin Schreiber

Soil organic carbon (SOC) stocks were estimated based on undisturbed volumetric soil samples (100 cm³) at 10 cm, 25 cm and 40 cm depth from 3 different soil profiles on all sample plots. Soil samples have been oven-dried and sieved in order to separate stones and roots. The dry mass of soils was measured for all samples and the SOC content was quantified by dry combustion using an EA 3000 elementary analyser.

Results

Carbon stocks in aboveground biomass are decreasing considerably with higher elevations. Especially at 3700 m the stocks are low (average: 21 Mg/ha) in comparison

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to the stocks at 3500 m (average: 43 Mg/ha) and 3300 m (average: 55 Mg/ha). The same tendency was detected for carbon stocks in belowground biomass. However, the decrease is not that strong compared to aboveground biomass. The average of SOC on 3300 m is 100 Mg/ha whereas the stocks on higher elevations are a quarter less (3500 m: 77 Mg/ha; 3700 m: 76 Mg/ha). The general tendency of decreasing values for higher elevations is sustained for total carbon stocks. However, the difference is slightly stronger between 3300 m (average: 163 Mg/ha) and 3500 m (average: 127 Mg/ha), which is mainly caused by the difference in SOC stocks between both elevation levels (**Figure 4**; average at 3700 m: 101 Mg/ha).

Figure 3: Analysis of ground vegetation biomass samples. Photo: Amanda Suqui

Conclusions

SOC stocks contribute considerably to total carbon stocks in pine plantations on páramo sites and the contribution of biomass is relatively low. Decreasing stocks on higher elevations are as expected; however, the differences in stocks are quite high on a relatively small range of elevation. A comparison with the carbon stocks of natural páramo vegetation is currently being conducted in order to assess the effects of pine plantations.

Reference

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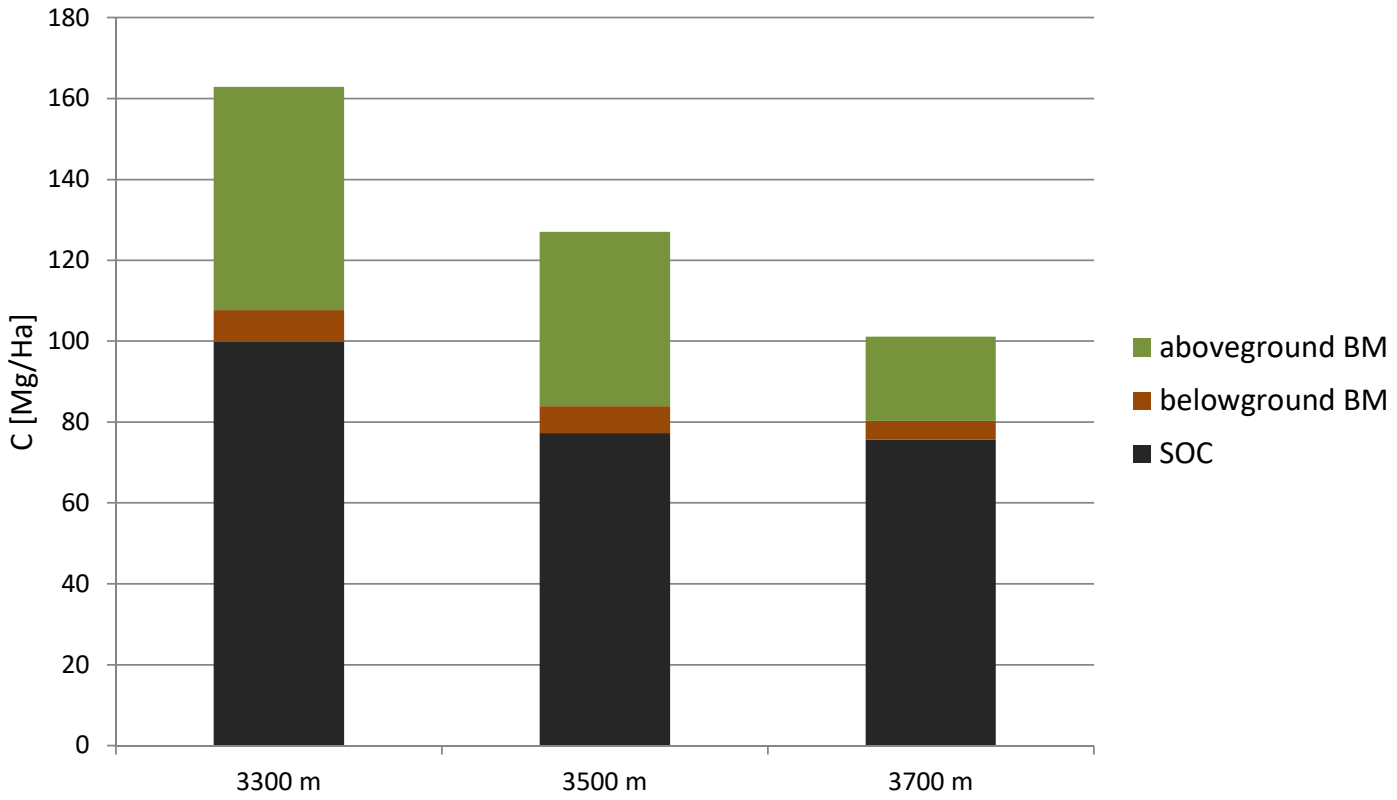

Figure 4: Average carbon stocks of aboveground and belowground biomass and soil organic carbon (SOC) at different elevations in the paramo. Graph: Patrick Hildebrandt

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Ectomycorrhizal Fungi of *Pinus patula* Plantations from Páramo Sites in Ecuador

Ingeborg Haug[1], Janine Spreuer[1], Carlos Quiroz Dahik[2,3], Patrick Hildebrandt[3]
[1]University of Tübingen, Germany – Members of the DFG-PAK Research Consortium
[2]Universidad de Cuenca, Ecuador
[3]University of München, Germany – Members of the DFG-PAK Research Consortium

The ectomycorrhizal community of pine plantations in páramo regions near Cuenca is dominated by one fungus, *Thelephora terrestris*.

Plantations of *Pinus patula* are regularly found in the páramo of the Ecuadorian Andes between 3000 m and 4000 m a.s.l. These habitats do not provide adequate fungal partners for ectomycorrhizal pine plants, because the páramo is dominated by arbuscular mycorrhizal plants. Thus **project C4** among others addresses the question, with which fungi the pines are associated [1].

Material and Methods

Samples were taken in October 2015 at *Pinus patula* plantations in Nero (3250 m a.s.l.), Tutupali (3500 m) and Soldados (3750 m, **Figures 1, 2**), all near Cuenca. We sampled and dried all ectomycorrhizas that were morphologically distinguishable. For each morphotype, we isolated DNA. We identified the involved fungi by sequencing and doing a BLAST search against sequences in the nucleotide database NCBI.

Results

The fine root system of *Pinus patula* was well developed in the plantations with many vital ectomycorrhizal tips growing between dead needles (**Figure 3**). There were three, morphologically distinguishable types: **a.** Light brown mycorrhizas with white tips and separate bifurcations along the long-root (**Figure 3**), **b.** greyish

Figure 1: *Pinus patula* plantation in the paramo ecosystem. Photo: Ingeborg Haug

Figure 2: *Pinus patula* plantation in Soldados (3750 m). Photo: Ingeborg Haug

Figure 3: Fine root system of *Pinus patula* in the organic layer, with ectomycorrhizas of *Thelephora terrestris.* Photo: Ingeborg Haug

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to whitish mycorrhizas with many bifurcations closely together forming a tubercle (**Figure 4**), and **c.** black mycorrhizas with many emanating hyphae (**Figure 5**). The fungal partner of the light brown mycorrhizas was identified as *Thelephora terrestris* and less often to be *Inocybe jacobi* and *Sebacina* sp. The fungus associated with the tubercles was *Suillus luteus*. Identification of the fungus involved in the black mycorrhiza type was not possible because DNA amplification was unsuccessful.

The ectomycorrhizal community of pine plantations in Soldados and Nero were very similar sharing four out of five fungi. In pine plantations in Tutupali, though, only *Thelephora terrestris* was present (**Table 1**).

Discussion

The low diversity of ectomycorrhizal fungi we found and the community composition is in accordance with findings from other investigations about fungi in pine plantations across South America [2, 3]. *Thelephora terrestris* has a widespread distribution and is often used in nurseries to improve seedling development. *Thelephora terrestris* is a species, which copes with many soil types and this explains the dominance of *Thelephora terrestris* at different sites. *Suillus luteus* is a bolete fungus (**Figure 6**) and native to Eurasia. It is a fungus that has been introduced into many other areas and is especially abundant in pine plantations.

Conclusion

Our study shows no correlation between altitude and mycorrhizal community composition. Further studies are needed to disentangle the factors influencing the composition of ectomycorrhizal fungi and the impact each of these fungi have on the nutrition of pines.

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Table 1: Abundance of ectomycorrhizal fungi in Nero 3250 m, Tutupali 3500 m and Soldados 3750 m

Ectomycorrhizal fungus	occurrence in Nero	occurrence in Tutupali	occurrence in Soldados
Thelephora terrestris	high	high	high
Suillus luteus	rare	absent	medium
Inocybe jacobi	rare	absent	rare
Sebacina sp.	absent	absent	rare
Black fungus	rare	absent	medium
Number of ecto-mycorrhizal fungi	**4**	**1**	**5**

Figure 4: Tubercle-like ectomycorrhizas of *Pinus patula* – *Suillus luteus*. Photo: Ingeborg Haug.

Figure 6: Mushroom of *Suillus luteus*. Photo: Ingeborg Haug

Figure 5: Black ectomycorrhiza of *Pinus patula*, the dark color indicates that this could be the ascomycete *Cenoccocum* sp. Photo: Ingeborg Haug

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First Quantitative Plant-Frugivore Network of Podocarpus National Park

Marta Quitián[1,2], Vinicio Santillán[1,2], Agustín Carrasco[3], Matthias Schleuning[1], Katrin Böhning-Gaese[1,2] and Eike Lena Neuschulz[1]

[1]Senckenberg Biodiversity and Climate Research Centre Frankfurt, Germany – Members of the DFG-PAK Research Consortium
[2]Goethe-Universität Frankfurt, Germany – Members of the DFG-PAK Research Consortium
[3]Universidad del Azuay, Cuenca, Ecuador – Members of the DFG-PAK Research Consortium

Over two years, we studied birds and plant-frugivore interactions in a region that hosts one of the most diverse bird communities on earth: the tropical Andes. Here we here report on our activities and illustrate the great diversity we encountered.

Methods

From 2014 to 2015, **project C3** monitored the bird community of Podocarpus National Park in southern Ecuador (**Figure 1**). A total of 18 plots, covering three elevations (1000 m, 2000 m, 3000 m a.s.l.) and two habitat types (natural and fragmented forest within and around the park) were continuously studied in both wet and dry season. Besides conducting standardized point counts of the entire bird community, we focused on the interactions among frugivorous birds and fruiting plants.

Figure 1: Over two years Marta Quitián and Vinicio Santillán monitored bird diversity and plant-frugivore interactions in Podocarpus National Park. Photo: Eike Lena Neuschulz

Results

In 216 hours of bird point counts, we recorded 4323 individuals of 241 species across all study sites, reflecting the incredibly rich bird diversity of Podocarpus National Park. Out of the 241 species, 49 were classified as having fruits as their main diet. The results of our in-depth sampling of plant-frugivore interactions revealed an even higher number of bird species feeding of fleshy-fruited plants. In 1800 hours of network-observations, we recorded 134 bird species feeding on the fruits of 115 plants that were connected in a complex network of 5467 interactions (**Figure 2**, next page). The most important frugivores belonged to the group of tanagers (*Tangara* spec.) and bush tanagers (*Chlorospingus* spec.). Plants of the genus *Miconia* belonging to the glory bush family, and the genus *Cecropia* belonging to the nettle family were the most commonly consumed fruiting trees by birds.

Conclusion

Our results suggest that these important plants, attracting many frugivorous bird species, should be considered in forest restoration efforts to support the natural regeneration of disturbed forest habitats in the area of Podocarpus National Park.

Acknowledgements

We thank Jürgen Homeier for his enormous help in plant identification. Patricio Estrella helped in the field. We are also thankful to our local counterparts Edwin Zárate and Carlos Iván Espinosa, as well as to Jörg Zeilinger and Felix Matt for structural support.

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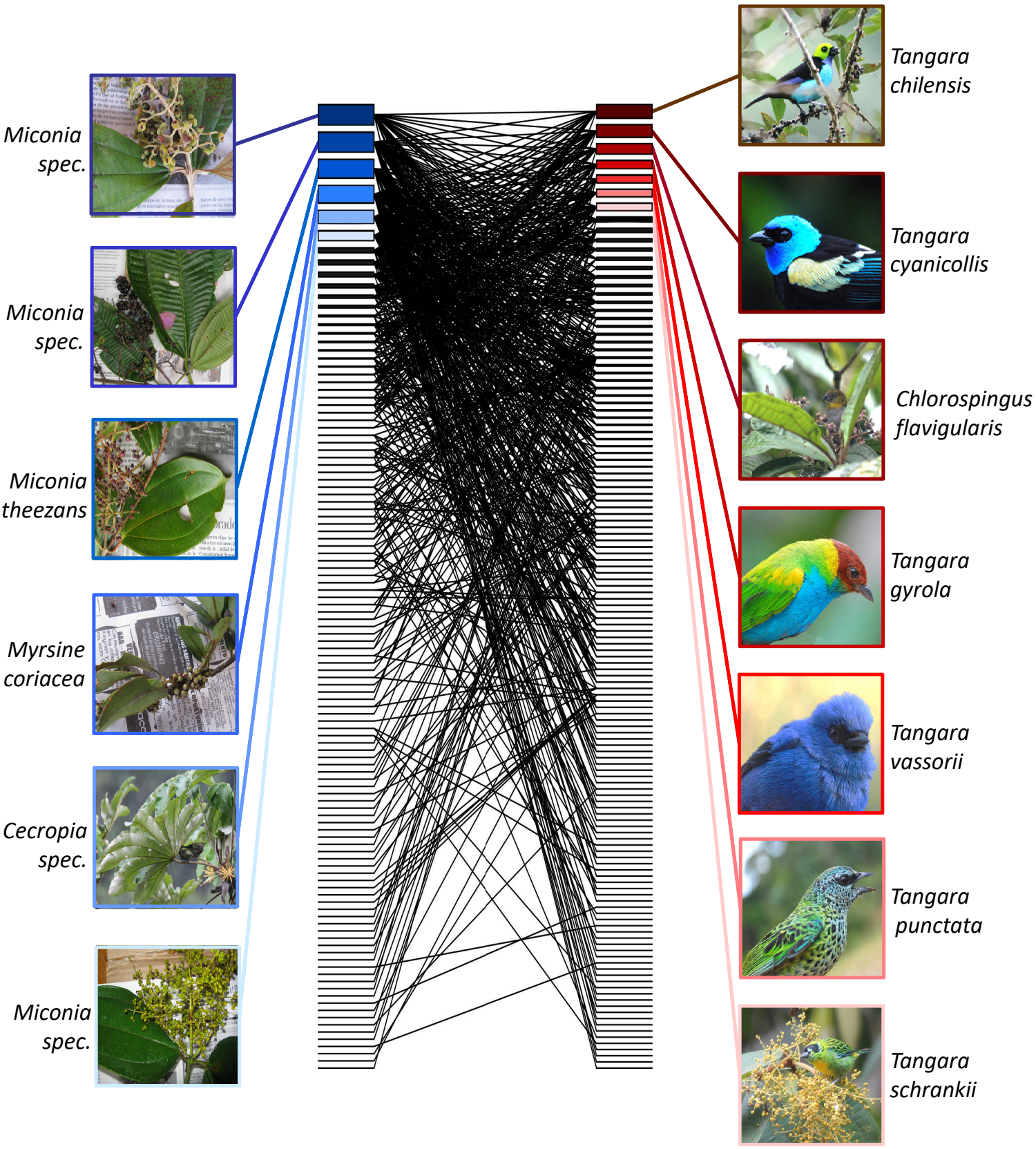

Figure 2: Quantitative plant-frugivore network of Podocarpus National Park. Frugivorous bird species are represented by bars on top, fruiting plant species by bars on bottom. Frugivores (red colors) and fruiting plants (blue colors) with the highest number of interactions in the network are highlighted in color and correspond to the pictures. Photos: Agustín Carrasco, Vinicio Santillán and Marta Quitián. Graph: Eike Lena Neuschulz

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Functional Monitoring of Biodiversity and Ecosystem Processes along Land-Use and Elevation Gradients

Christine Wallis[1], Yvonne Tiede[1], Jan Schlautmann[1], Gunnar Brehm[2], David A. Donoso[3,4], Konrad Fiedler[5], Jürgen Homeier[6], Detlev Paulsch[7], Dirk Süßenbach[8], Roland Brandl[1], Nina Farwig[1], Jörg Bendix[1]

[1]Philipps-University Marburg, Germany – Members of the DFG-PAK Research Consortium
[2]Inst. für Spezielle Zoologie und Evolutionsbiologie mit Phyletischem Museum, D-07743 Jena, Germany
[3]Facultad de Ciencias Agropecuarias, Universidad de Cuenca, Cuenca, Ecuador
[4]Museo de Colecciones Biológicas (MUTPL), Universidad Técnica Particular de Loja, Loja, Ecuador
[5]Tropical Ecology and Animal Biodiversity, University of Vienna, AT-1030 Wien, Austria
[6]Georg-August-Universität Göttingen, Germany – Member of the DFG-PAK Research Consortium
[7]Gesellschaft für angewandte Ökologie und Umweltplanung mbH, D-69190 Walldorf, Germany
[8]Federal Environment Agency, D-06844 Dessau-Roßlau, Germany

We report our latest outcomes from our project studies that aim to develop a functional integrative monitoring system for biodiversity and ecosystem processes within natural and degraded mountain rainforests. We compared the predictability of species richness and turnover of trees, moths, ants and birds using remote sensing data. Furthermore, we found ants to be a suitable indicator for climatic changes and the ecosystem process predation.

Our **project C2** aims at investigating patterns of diversity of trees, ants and birds and how associated processes in particular herbivory and predation are affected by elevation and forest degradation. As it is time consuming to quantify the status of biodiversity and ecological processes within an ecosystem we aim to develop a simple indicator system for ecosystem monitoring across large areas (**Figure 1**). We expect that we can predict variables describing the status of biodiversity as well as certain processes by measures of spectral and structural diversity derived from remote sensing as for instance herbivory-induced vegetation changes can result detectable changes in net primary production and leaf pigment status.

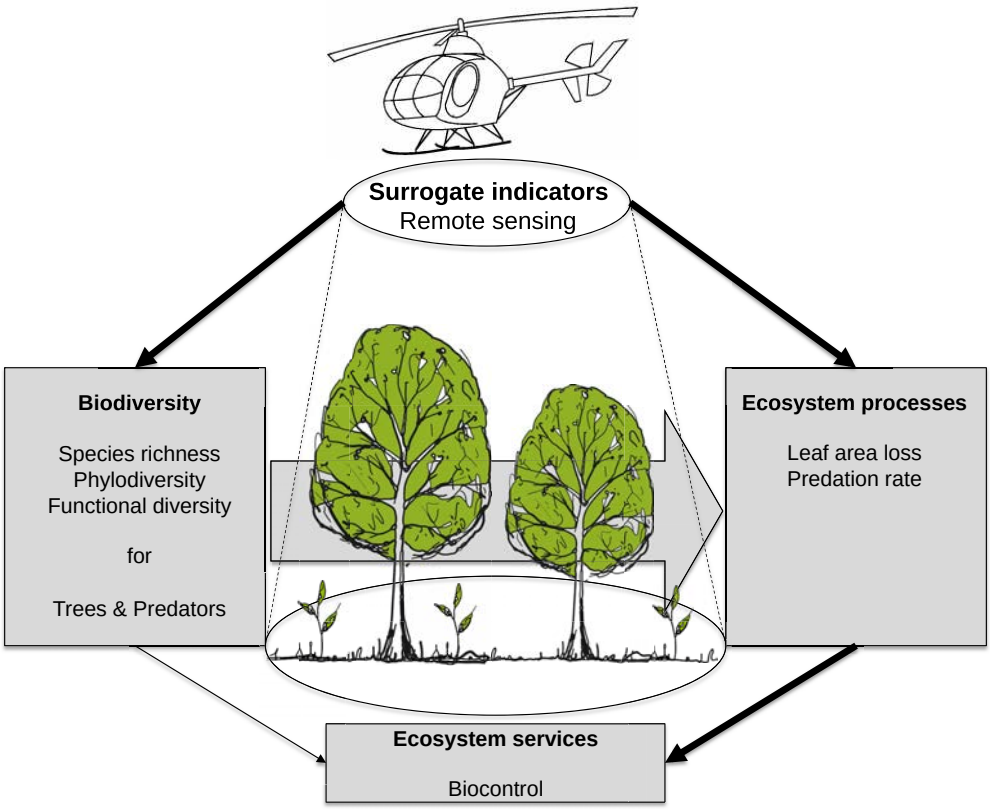

Figure 1: Schematic diversity monitoring system. Habitat indicators derived from remote sensing can be used to model different measures of biodiversity and ecosystem processes, which are in turn linked to ecosystem services. This allows monitoring of changes in biodiversity and ecosystem functioning. The thickness of the arrows indicates the expected strength of the relationships. Graph: Nina Farwig

Predictability of species richness and turnover

In our modeling approach we combined field-based inventories of trees, ants, moths and birds with topography and high-resolution orthophotos sampled in tropical mountain rainforests. Based on vegetation indices derived from multispectral orthophotos we calculated textural images to derive spatially explicit indicators (for the image textural approach refer to Wallis & Tiede [1]). These topographical and textural indicators were associated with the biochemical diversity of vegetation, e.g. the C/N ratio of leaves in understory plants (**Figure 2**). To compare diversity models of the seven investigated taxa, we calculated species richness and two numerical measures of species turnover (quantified by ordinations of non-metric multidimensional scaling; NMDS) and used them as

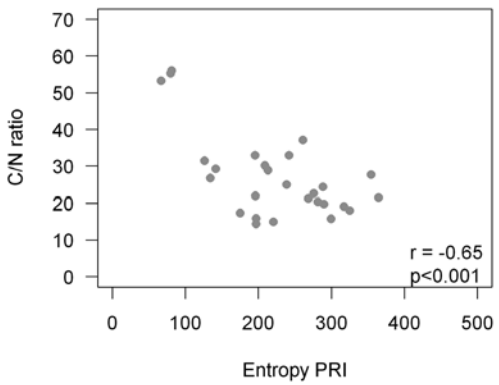

Figure 2: Relationship between one of the derived textural habitat indicators (Entropy PRI) and C/N ratio in leaves of understory plants. Graph: Christine Wallis

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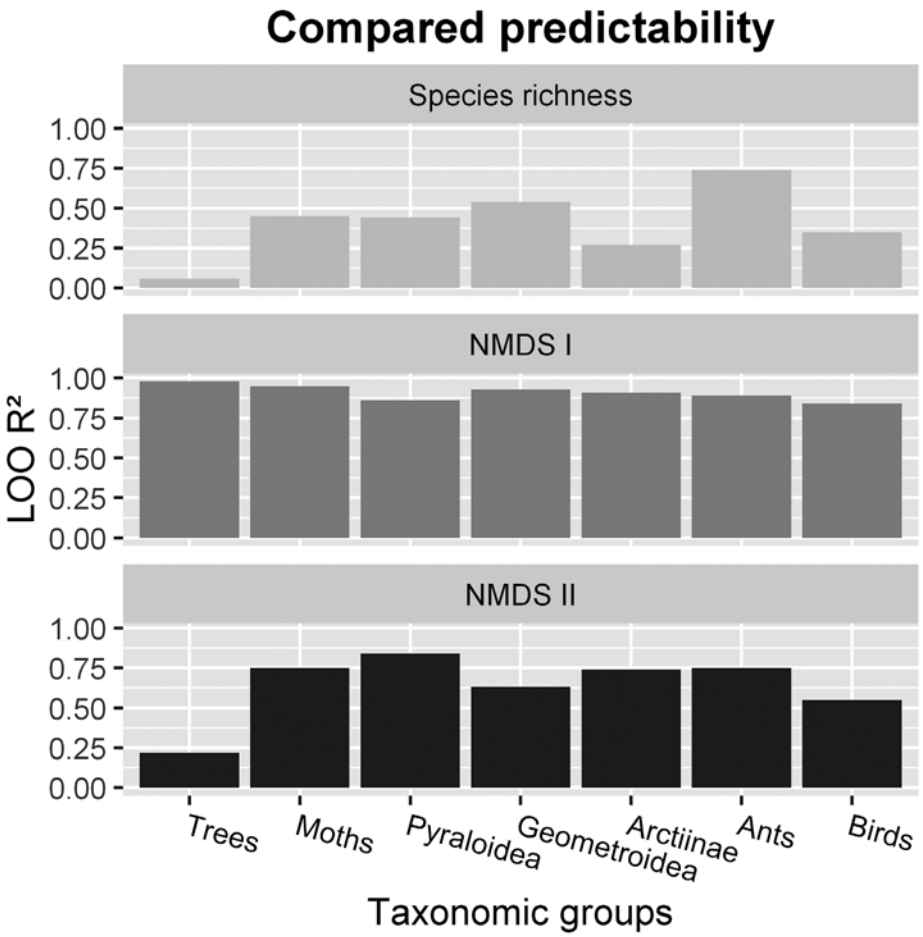

Figure 3: Compared predictive power of leave-one-out validated (LOO) regression models for species richness and species turnover. Models were fitted by habitat indicators derived from multi-spectral orthophotos and topography. Species turnover was assessed by non-metric multidimensional scaling (NMDS) of Bray-Curtis dissimilarities. The first two dimensions were extracted and subsequently used in the regression analysis as response variables for species turnover. Graph: Christine Wallis

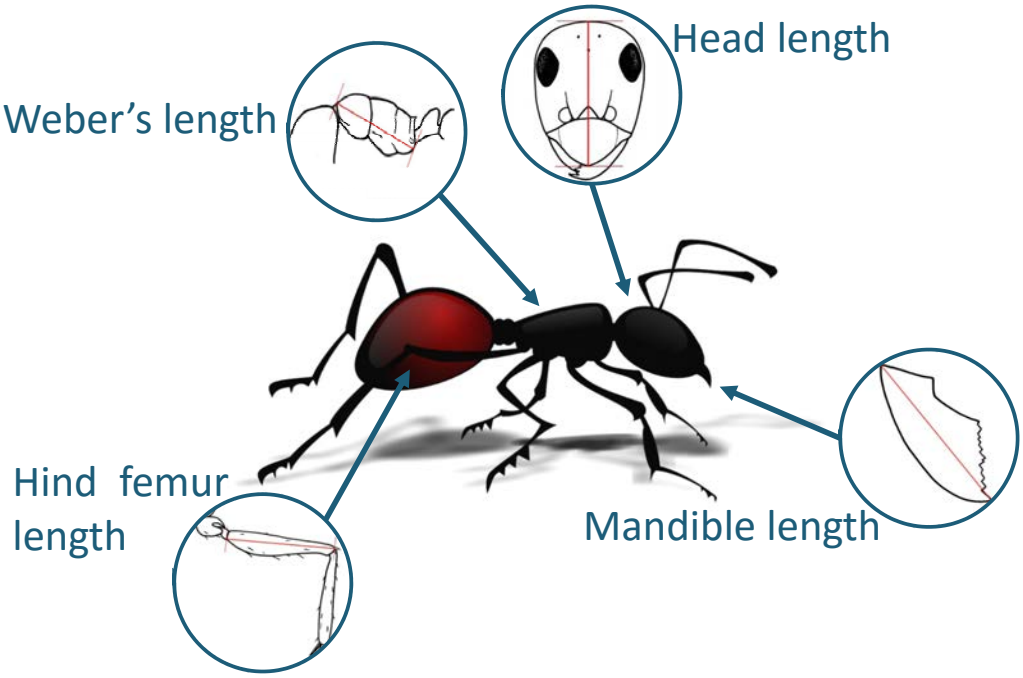

Figure 4: We used four predation-related ant traits to calculate their functional richness: Weber's length, head length, hind femur length and mandible length. Image ant: public domain, Creative Commons CC0. Graph: Yvonne Tiede

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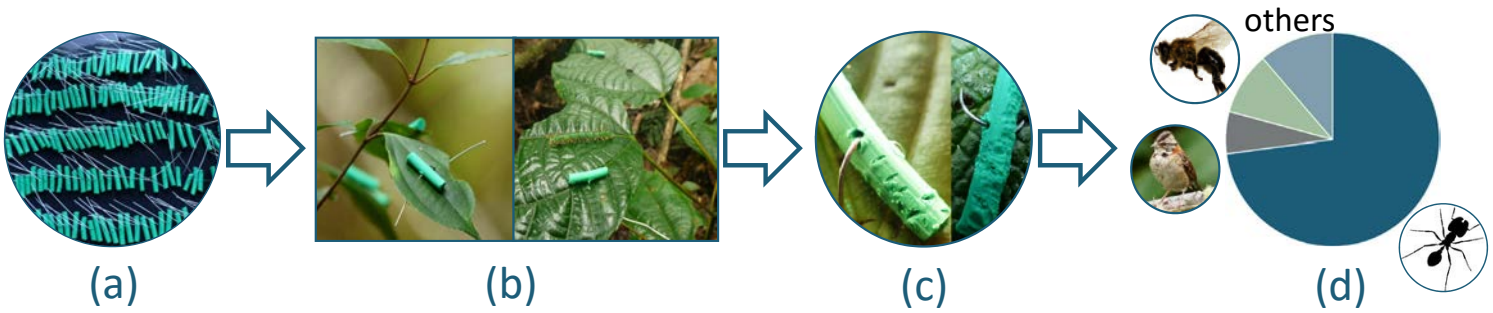

Figure 5: We prepared 16.200 artificial caterpillars out of Plasticine (**a**), attached them to plants and left them for five days in the field (**b**). Predators left their bite marks on the surface (**c**). Most bite marks originated from ants (73 %), followed by others (12 %), wasps / bees (9.5 %), and birds (6.3 %, **d**). Graph: Yvonne Tiede

response variable in separate partial least-square regression models. The compared predictability of diversity measures was assessed by the leave-one-out validated R^2. Our results showed that the predictive power was higher for species turnover among all taxa (**Figure 3**). Secondly, we found varying predictability of species richness among taxa. From these results we suggest that not all taxa are suitable for an area-wide monitoring by assessing multi-spectral remote sensing data. Species richness models of certain taxa such as geometrid moths or ants as well as models of species turnover showed higher reliability and are thus well-suited for a remote sensing based indicator system of biodiversity.

Ants as bio-indicator for climatic changes and predation

We tried to disentangle the causal relationships between the abiotic factors temperature, wet and dry season and forest degradation on the biotic factors abundance and functional richness of ants and their consequences for the ecosystem process predation. We used simple but meaningful measures to quantify the abundance (baiting approach) and functional richness (four morphological traits, which are related to predation; **Figure 4**) of ants and a rapid assessment tool (artificial caterpillars; **Figure 5**) for the ecosystem process predation. Our results showed that the abundance of ants is a suitable measure to indicate changes in temperatures as well as to quantify the process of predation on herbivorous arthropods in our study system (**Figure 6**).

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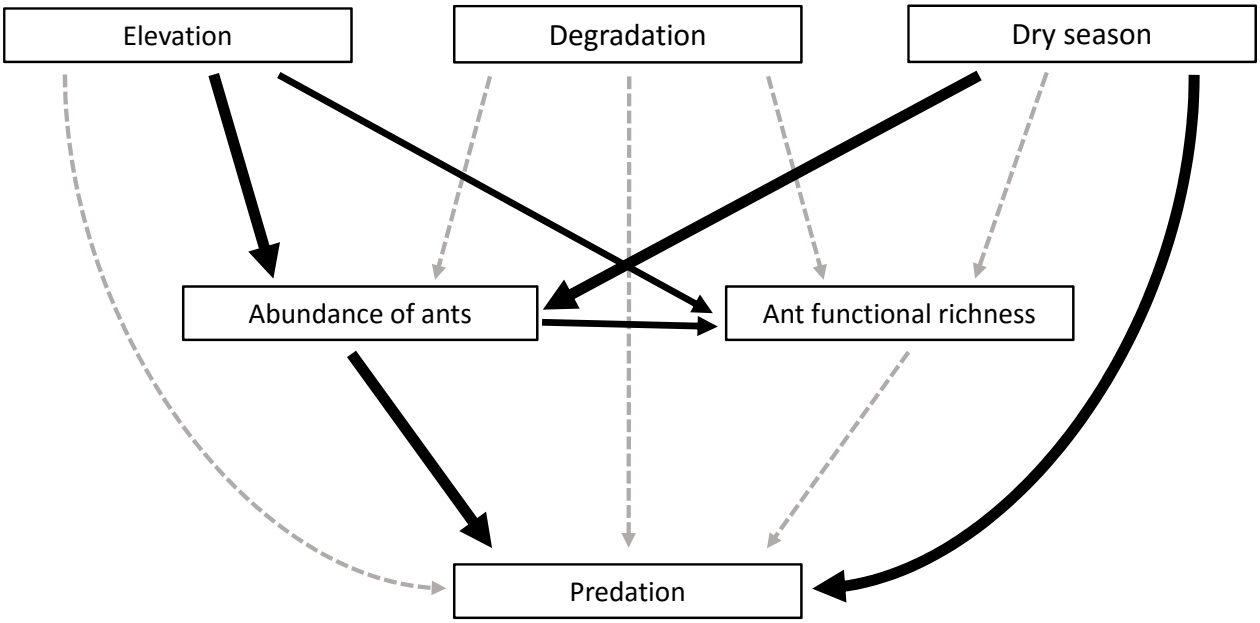

Figure 6: A structural path-model summarizes the results of the study of ants as bio-indicator. The thickness of black arrows indicate the strength of the relationship, dashed grey arrows represent non-significant relationships. The abundance of ants but not their functional richness can be used as indicator for climatic changes (elevation and season were used as proxy) and the ecosystem process predation, but not for forest degradation. Graph: Yvonne Tiede

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Diurnal Oscillation of Leaf Water Status of Trees in the Reserva Biológica San Francisco

Simone Strobl[1], Brenner Silva[2], Jörg Bendix[2], Erwin Beck[1]
[1]University of Bayreuth, Germany – members of the DFG-PAK Research Consortium
[2]University of Marburg, Germany – members of the DFG-PAK Research Consortium

With a new, non-invasive method, we investigated the diurnal course of the leaf turgor to complement the variables for understanding water relations of trees in the Reserva Biológica San Francisco (RBSF).

Turgor pressure of leaves is an excellent indicator of a tree's water status. The classical measurement uses the Scholander pressure chamber at predawn (fully saturated) and at noon (stressed by transpiration). Unfortunately, this method is destructive, time-consuming and can only be performed once per leaf. A new method has recently been developed for controlling irrigation in crop cultures measuring turgor by applying a counter-pressure to the leaves. In the RBSF, these leaf patch clamp pressure probes (ZIM-probes [1], are now used together with other physiological parameters of the trees to interpret their water relations in **project C5**.

Method

ZIM probes (YARA ZIM Plant Technology GmbH, Henningsdorf, Germany) measure relative changes in the turgor pressure of leaves. The leaf is clamped between two magnetic pressure sensors (**Figure 1**), the clamping pressure is held constant during the measurements and is opposed to the turgor pressure of the leaves. Measurements were performed in 10 minutes intervals over 5 consecutive days on 8 trees (*Vismia tomentosa, Spirotheca rosea, Lauraceae* sp., *Beilschmidia tovarensis, Ocotea aciphylla, Miconia* sp., *Matayba inelegans* and *Tapirira guianensis*) in the RBSF forest, together with simultaneous measurements of sap flow, leaf transpiration and the microclimate in the crowns of the trees.

Results

Turgor pressure of the leaves is decreasing during the day due to transpiration but is increasing again during the night, when there is enough water available to the tree's roots. As the clamping pressure of the ZIM-probes is opposed to the turgor pressure, values vary with water loss of the leaves and regain of the turgor. **Figure 2** shows a diurnal course of leaf transpiration (E), sap flow (SF), clamping pressure and vapor pressure deficit (VPD) of *Tapirira guianensis* on November 6, 2015. On that day, leaf transpiration and turgor loss started early in the morning, peaking at noon. Transpi-

Figure 1: Turgor measurement with a ZIM probe on a *Matayba inelegans* leaf. Photo: Simone Strobl

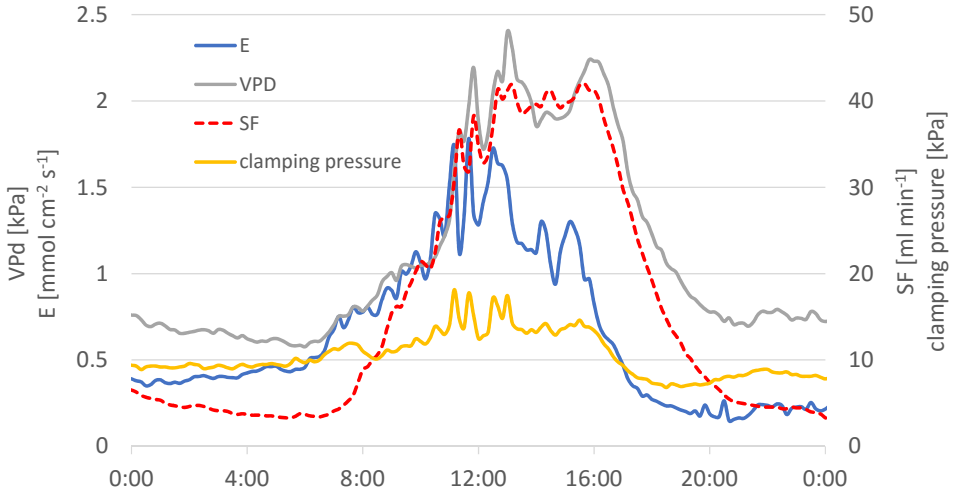

Figure 2: Daily course of leaf transpiration (E), sap flow (SF), clamping pressure and vapor pressure deficit (VPD) of *T. guianensis* on November 6, 2015. Graph: Simone Strobl

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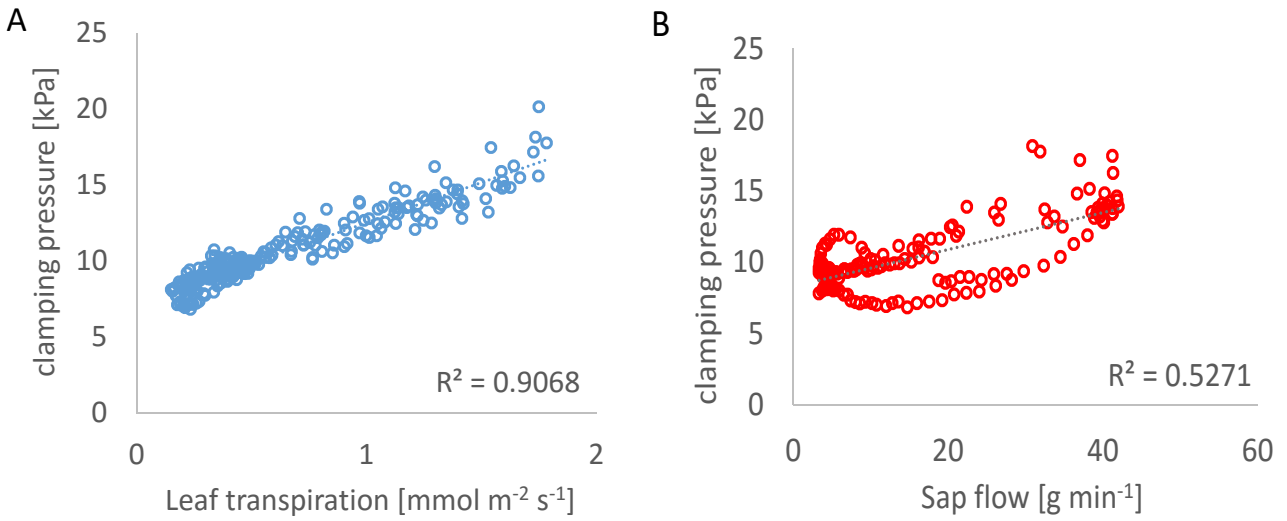

Figure 3: Relationship between (**A**) clamping pressure and leaf transpiration and (**B**) clamping pressure and sap flow of *T. guianensis* on November 6, 2015. Graphs: Simone Strobl

ration and clamping pressure decreased in the afternoon, potentially because of short-term water stress of the leaves, which is also indicated by significantly high correlation between the two parameters (**Figure 3A**). Ongoing sap flow in the afternoon when transpiration was already decreasing might serve two processes, transpiration (by other sectors of the crown) and refilling the internal water store of the tree. The hysteresis in the relationship between turgor and sap flow indicates the effects of more than one factor in the regulation of sap flow, one of the factors being most likely turgor (R^2 = 0.53, **Figure 3B**).

The eight investigated trees showed different strategies concerning the water status of the leaves: some had a small diurnal oscillation of leaf turgor, such as *Tapirira guianensis* (**Figure 4A**), while others showed a high amplitude, for example *Beilschmidia tovarensis* (**Figure 4B**). As leaf turgor is an indicator for the water status of the whole plant, the differences could be attributed to trees with a water saving strategy or to trees which are no water-savers at all. As potential indicator trees for climate change, trees with a high amplitude (**Figure 4C**, Box) would be suitable, exhibiting the water saving strategy.

Calibration of the ZIM-Probes for measuring not only turgor but also the actual water potential seem to be possible and will be the next step in our research.

Reference

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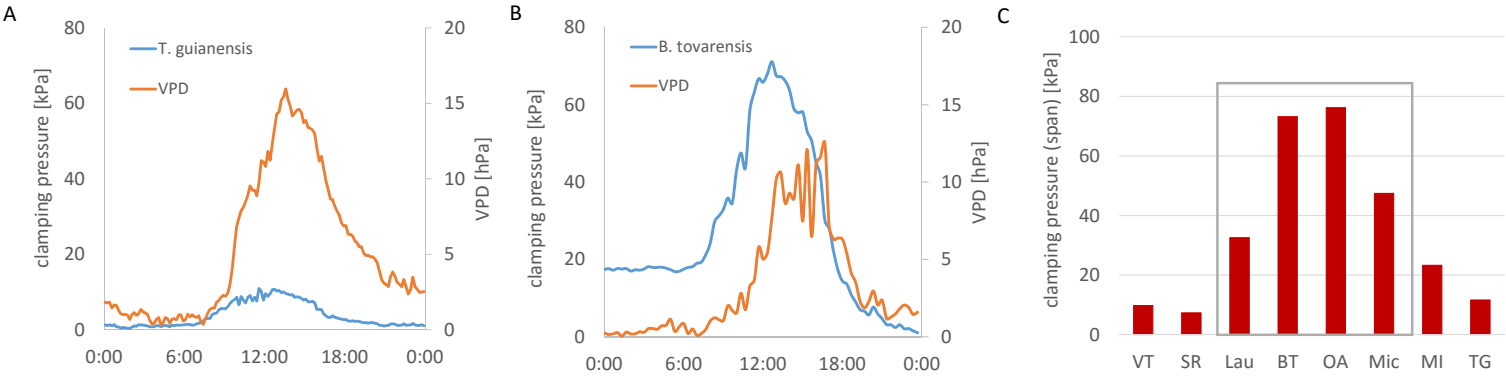

Figure 4: Daily course of the clamping pressure and vapor pressure deficit (VPD) of (**A**) *B. tovarensis*, (**B**) *T. guianensis* and (**C**) highest values of clamping pressure of all investigated trees (VT: *V. tomentosa*, SR: *S. rosea*, Lau: Lauraceae sp., BT: *B. tovarensis*, OA: *O. aciphylla*, Mic: *Miconia* sp., MI: *M. inelegans*, TG: *T. guianensis*, grey box: potential indicator trees). Graphs: Simone Strobl

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Development of Area-Wide Functional Indicators Using Remotely Sensed Data

Brenner Silva[1], Simone Strobl[2], P. Alava-Nunes[1], G. Carillo-Rojas[1,3], Erwin Beck[2], Jörg Bendix[1]
[1]University of Marburg, Germany – members of the DFG-PAK Research Consortium
[2]University of Bayreuth, Germany – members of the DFG-PAK Research Consortium
[3]University of Cuenca, Ecuador – member of the DFG-PAK Research Consortium

Evapotranspiration and productivity can serve as area-wide indicators in high-spatial resolution in the tropical mountain forest ecosystems.

Project C6 focuses on indicators suitable to area-wide monitoring of water relations and phylodiversity (**with C2**). Field and meteorological data are combined with remote sensing to obtain indicators at crown and landscape levels which can now reveal effects of climate change and land use.

Current State of Measurement Setup

The method of combined flux measurements at leaf and landscape scales has been published using observations at a pasture site [1]. The results revealed a significant (r^2 = 0.74) link between leaf transpiration (T) and surface evapotranspiration (ET). At the forest site, the laser scintillometer has been operating since March 2014. We can now quantify the mountain forest ET, which typically follows weather conditions along the year (**Figure 1**). In the forest, the complex and dense canopy interacts with the ruggedness of the surface. However a significant link (r^2 =0.65) has also been observed between leaf transpiration and surface evapotranspiration (see [2]). Last, eddy covariance instrumentation has been installed at the towers to complement scintillometer observations with water and carbon fluxes at the landscape level.

Remote Sensing Products

Tower observations are used to calibrate remote sensing data within the observed footprint, which reveals influences of the terrain, wind and other meteorological conditions. For now, our observations were shown to represent the evergreen lower mountain forest between 1900 and 2000 m a.s.l. with limited influence of the topography (**Figure 2**, next page).

Following that, area-wide evapotranspiration (ET) and gross primary productivity (GPP) were calculated for November 2014 at the basin of the San Francisco River (**Figure 3**). The ET map was calculated using the enhanced vegetation index and monthly averaged vapor pressure deficit and the GPP map required radiation, air temperature, and relative humidity.

We observed that especially secondary vegetation (patches of forest and pasture) shows the highest ET and GPP values, similar to that observed for areas of tall trees in the ravines. Using thermal sensors at the regional level, ET maps were constructed close to the Parque Nacional Cajas [3] with good agreement at monthly and annual steps (deviation < 17%).

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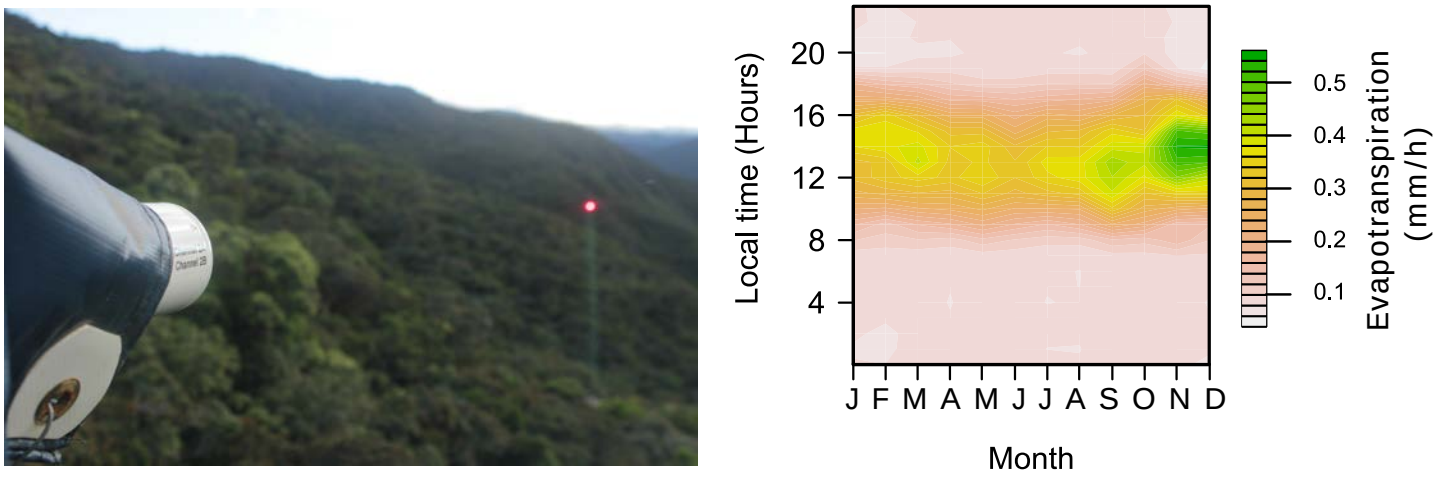

Figure 1: Scintillometer operating at Estación Científica San Francisco (left) and evapotranspiration along the year (November 2014 - November 2015). Photo and Graph: Brenner Silva

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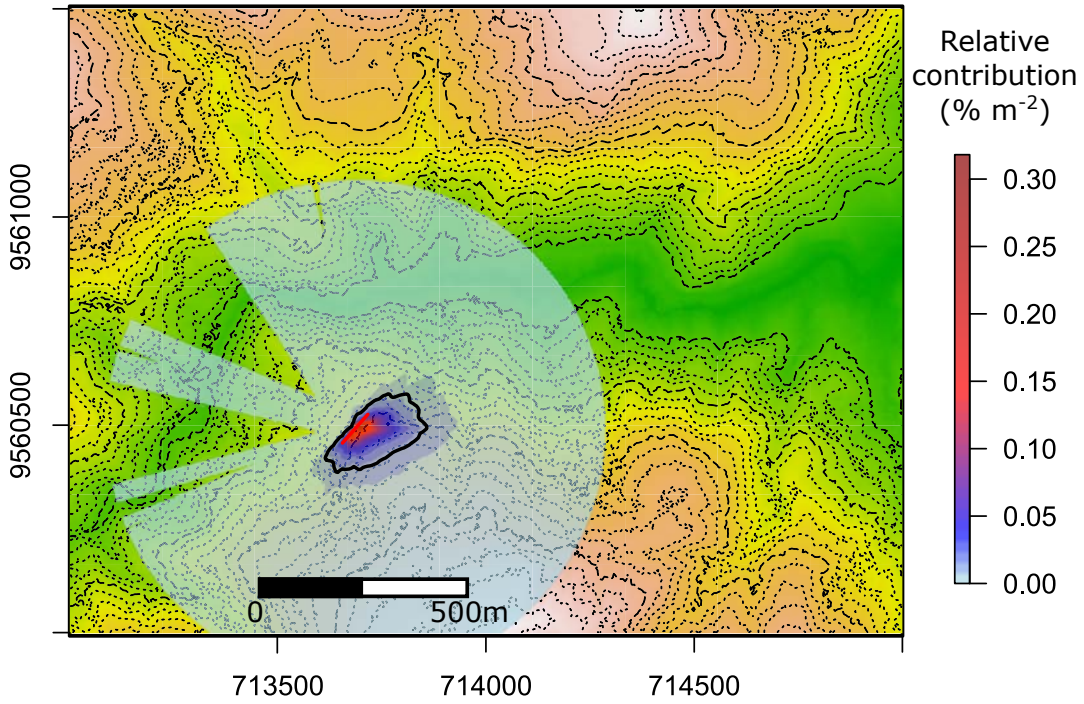

Figure 2: Footprint analysis shows the relative contribution (color key) to the measurements of each point in the terrain, where the area with > 0.01 % per m² of contribution is delineated in black. Graph: Brenner Silva

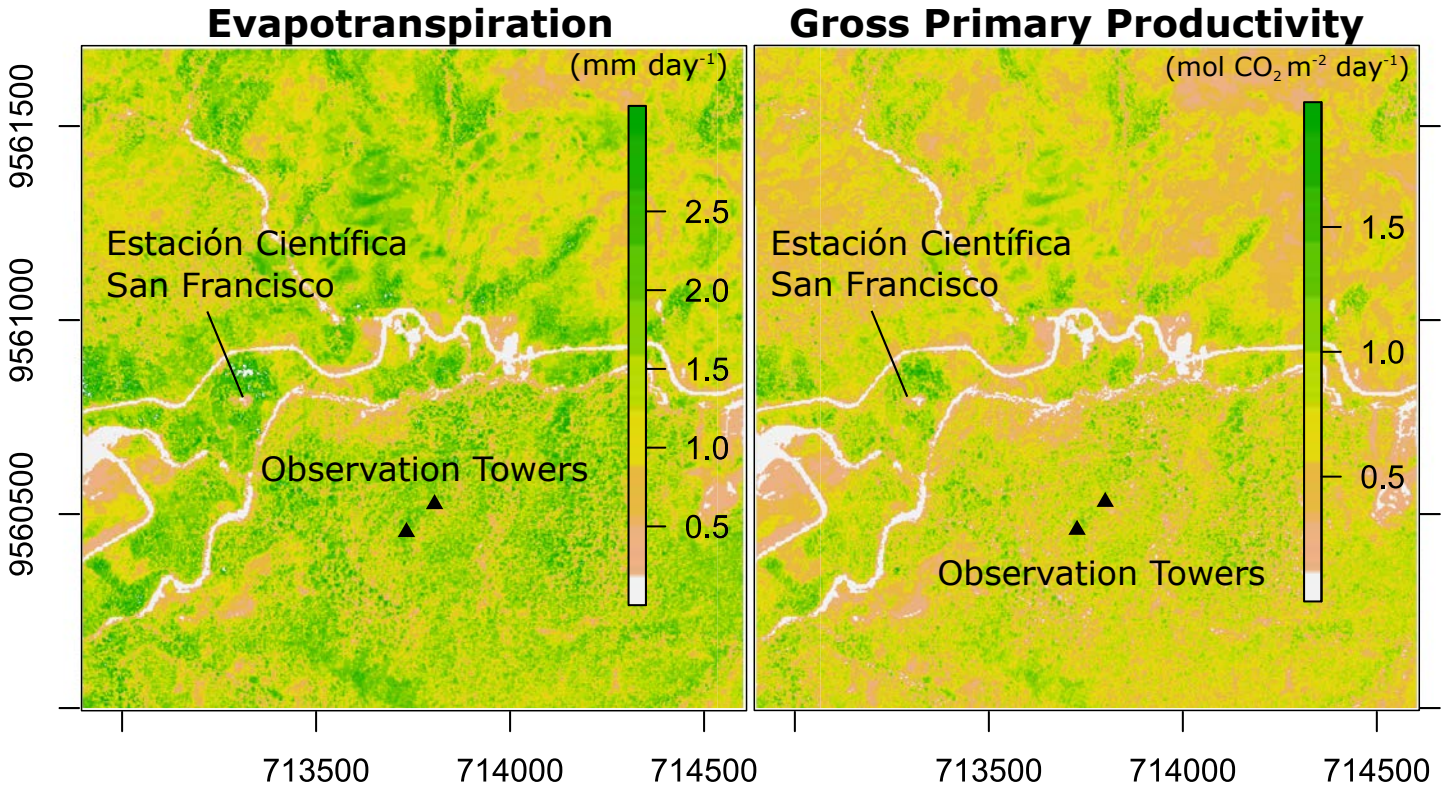

Figure 3: Evapotranspiration map and gross primary productivity estimated for an average day of November 2014. Graphs: Brenner Silva

doi: 10.5678/lcrs/pak823-825.cit.1510

Publications

Besides the mentioned high ranking papers (see Coordinators' Corner, p. 2) and Knoke et al. (2014) *Nature Communications* Doi: 10.1038/ncomms6612 the Research Consortium published 9 books, 100 book chapters and more than 370 peer reviewed papers in scientific journals covering the various disciplines involved. Although not all are integrated into the Data Warehouse jet, many can already be retrieved and searched for via: http://www.bergregenwald.de/publications.do. Search for publication type "books", "chaperts", or "Article" for peer reviewed papers in scientific journals, respectively.

Bachelor, Master and PhD Theses from the Research Consortium

All 27 Diploma, 34 Bachelor, 33 Master, 38 PhD and 10 other theses, that were conducted so far during the research phases can be retrieved from the data warehouse via: http://www.bergregenwald.de/publications.do (search for the respective publication type).

Theses since the last Tabebuia Bulletin (2015 and 2016, alphabetically sorted)

Ahlers J (2016): Variabilität der Feinstreuquantität und -qualität sowie die Auswirkungen einer kontinuierlichen N und P Düngung entlang eines Höhengradienten im tropischen Bergregenwald Südecuadors. University of Goettingen, bachelor thesis

Bachmann SC (2016): Untersuchungen zur räumlichen Varianz der Isotopenverhältnisse im Holz von *Cedrela montana* in Bergregenwäldern Südecuadors. Institute of Geography, University Erlangen-Nürnberg, bachelor thesis

Barros Sulca DC (2015): A land-use allocation model for Ecuador using site-specific land-use restrictions. Institute of Forest Management, Technische Universität München, master thesis

Cabrera García MP (2016): Determinación de la fenología foliar mediante la interpretación de fotografías hemisféricas en la Reserva Natural Laipuna, Cantón Macará Universidad Nacional de Loja, thesis

Gietmann L (2016): Identifikation und Analyse lokaler und saisonaler Einflussfaktoren auf die Nährstofffrachten eines ecuadorianischen Hochgebirgsökosystems. University of Giessen - Institute of Landscape Ecology and Resources Management, bachelor thesis

Greiner L (2016): Texture images as tool for predicting bird feeding guilds in a tropical montane rainforest. Philipps-Universität Marburg, Department of Conservation Ecology, master thesis

Groth T (2015): Effects of fragmentation on forest structure and tree size distribution in tropical montane forests in southern Ecuador. University of Goettingen, bachelor thesis

Helfrich IH (2015): Influence of altitude on tree structural parameters of five tree species in a tropical dry forest of Southern Ecuador. Universität Göttingen, bachelor thesis

Henz S (2016): Zeitreihenanalyse von Nitratkonzentrationen des Rio San Francisco in Ecuador. University of Giessen, Institute of Landscape Ecology and Resources Management, master thesis

Liedtke R (2016): Mobile and Soil Bonded Phosphomonoesterase Activity of the Organic Layer along an Altitudinal Gradient in South Ecuador. University of Tuebingen, bachelor thesis

Lintzel E (2015): Establishment of a three-locus barcoding in the hotspot of a tropical mountain rainforest in Ecuador within the family Lauraceae for taxa re-identification. University of Marburg, Faculty of Biology, Conservation Biology, bachelor thesis

Lopez G (2015): Effects of experimental nutrient additions on root architecture of tropical montane forest trees in South Ecuador. University of Goettingen, master thesis

Mattes J (2016): Seasonal variation in nutrient use of ants in natural and disturbed montane rainforests in Southern Ecuador. Philipps University of Marburg, Faculty of Biology, master thesis

Münch E (2015): Baseline P storage and availability in soil in forest ecosystems in South Ecuador. University of Tübingen, bachelor thesis

Niepoth A (2015): Remote sensing based measures of tree diversity in the Southern Ecuadorian Andes. Humboldt-Universität zu Berlin, Geographisches Institut, master thesis

Pérez Postigo I (2015): Potential of Remotely Sensed Image Textures for Predicting Herbivory in the Ecuadorian Andes. Fachbereich Philipps-Universität Marburg, Geographie, master thesis

Pucha Cofrep DA (2016): Environmental signals in radial growth, stable isotope variations and nutrient concentration of trees from different forest ecosystems in southern Ecuador. Institute of Geography, University Erlangen-Nürnberg. PhD thesis

Rehmus A (2015): Aluminum toxicity in a tropical montane forest ecosystem in southern Ecuador. University of Berne, PhD thesis

Riahi, M. (2016): Three-locus barcoding of trees in an Ecuadorian mountain rain forest. University of Marburg, Faculty of Biology, Conservation Biology, bachelor thesis

Rodrigo R (2015): Forest structure, species composition and tree sap flux of a disturbed tropical dry forest in South Ecuador. Georg-August-Universität Göttingen, master thesis

Schlautmann J (2016): Predator richness, elevation and rainfall seasonality: direct and indirect effects on artificial caterpillar predation. University of Marburg, master thesis

Schmid M (2015): Afforestation with *Pinus patula* in the Andean highlands of Ecuador: forest inventory and biomass of single trees. Technische Universität München, master thesis

Spöri E (2015): Phosphatase activity in soil of an Ecuadorian tropical montane rainforest. University of Tuebingen, bachelor thesis

Spreuer J (2016): Ektomykorrhizapilze in Kiefernplantagen im Páramo von Ecuador. Universität Tübingen, bachelor thesis

Timbe E (2015): Water flow dynamics assessment for a tropical montane forest basin by means of spatially differentiated multi-criteria. University of Giessen, Institute of Landscape Ecology and Resources Management, PhD thesis

Utiger C (2015): Temporal variation of the element concentrations and fluxes in rainfall and throughfall of a tropical montane rain forest in southern Ecuador. University of Berne, master thesis

Zimmermann S (2016): Die Regenerationsentwicklung im tumbesischen Trockenwald. Institute of Silviculture, Technische Universität München, bachelor thesis

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People and Staff

Photo: Dario Cruz

Darío Javier Cruz received his PhD from the Faculty of Biological Sciences of Johann Wolfgang Goethe-University Frankfurt am Main, Germany.

On April 28, 2016 **Darío Javier Cruz Sarmiento** successfully completed his doctoral studies. His PhD thesis, entitled "*Tulasnella* spp. as saprotrophic and mycorrhizal fungi of tropical orchids: morphology, molecular taxonomy, and ecology", was supervised by Dr. Juan Pablo Suárez from the Universidad Técnica Particular de Loja, Ecuador, Prof. Dr. Meike Piepenbring from the Johann Wolfgang Goethe-University Frankfurt am Main, Germany, as well as from Prof. Dr. Franz Oberwinkler and Dr. Ingrid Kottke, both from Eberhard-Karls-University Tübingen, Germany.

Ingrid Kottke

Photo: private

Steffen Guth is a Master student in Geoecology at the Institute of Geography and Geoecology of the Karlsruhe Institute of Technology (KIT, Germany) and has begun his master thesis in the Soil Science Group of Wolfgang Wilcke in October 2016. He will conduct field work in the Reserva Biológica San Francisco on the plots of the nutrient manipulation experiment (NUMEX) and of the long term ecosystem study (LTES Q2) within **Project A6/X2**. He will explore the change of the ^{13}C isotope signal in dissolved organic carbon (DOC) of ecosystem solutions in response to nutrient availability and investigate the hypothesis that N, P, N+P and Ca additions accelerate the turnover of dissolved organic matter in the tropical mountain rain forest of South Ecuador.

Andre Velescu

About Us

Monitoring and Research Platform | South Ecuador

The Platform for Biodiversity and Ecosystem Monitoring and Research in South Ecuador (MRp|SE) is a German-Ecuadorian joint venture of interdisciplinary research and knowledge transfer. Investigating three ecosystems in South Ecuador, the teams aim to understand impacts of global change (mainly atmospheric nutrient deposition related to land use changes) on processes, functions and services of the megadiverse ecosystems of the Andean mountain rainforest, the dry forest and the Páramo. Regarding knowledge transfer the program aims on implementing and further testing options for sustainable land use. At the same time, research has been started towards a novel functional monitoring system indicating impacts of environmental changes on ecosystem functions in the sense of an early warning system. The prototype indicator system under development shall be implemented on a broad scale in cooperation with non-university partners for use by relevant stakeholders in policy and development planning. In the Tabebuia Bulletin scientists and partners inform about their progress and latest research results. It is named after the Tabebuia tree which generates charismatic yellow blossoms and is home to the Neotropics.

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In research funding, the Platform marks a new and advanced step of cooperation as all involved organizations are funding joint German-Ecuadorian projects for the first time in parallel and on a larger scale. The MRp|SE was inaugurated in Cuenca on 16 October 2013 based on more than 16 years of intensive research into biodiversity and ecology of the South Ecuadorian Andes. In 1997, a small group of German researchers funded by the DFG began to investigate the biodiversity-rich mountain rain forests. From 2001 the first DFG Research Unit (FOR 402) operated with a significantly larger consortium. A second Research Unit (FOR 816) continued from 2007 to 2013.

Over the years, cooperation with Ecuadorian partners has gradually been intensified including the Universidad Técnica Particular de Loja, the Universidad Nacional de Loja, the Universidad del Azuay, the Universidad de Cuenca, the Pontificia Universidad Católica de Quito, the foundation Nature and Culture International (NCI), the city enterprise of Cuenca (ETAPA EP), the regional water fund FORAGUA, and the environmental department of the city of Zamora. Two more knowledge transfer projects funded by DFG are closely linked to the Platform: The program "Nuevos Bosques para Ecuador" and "Radar Net Sur" which are cooperating with the government of the province Loja (GPL) and private land owners.

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Editorial Board

Credits and Contact

DFG PAK 823-825 Research Consortium
More information about the Research Consortium: www.tropicalmountainforest.org

Coordinator of the German Group
Prof. Dr. Jörg Bendix, Fachbereich Geographie der Philipps-Universität Marburg, Deutschhausstraße 10, D-35032 Marburg, Germany, phone: ++49 (0)6421-2824266. e-mail: bendix@staff.uni-marburg.de

Coordinating Office
Mrs. Birgit Kühne-Bialozyt, Fachbereich Geographie der Philipps-Universität Marburg, Deutschhausstraße 10, D-35032 Marburg, Germany, phone ++49 (0)6421- 2826543, e-mail: kuehnebi@staff.uni-marburg.de

Coordinator of the Ecuadorian Group
Dr. Juan Pablo Suárez, Universidad Técnica Particular de Loja, Departamento de Ciencias Naturales, San Cayetano Alto s/n, C. P. 1101608 Loja, Ecuador, phone: 593-7-2570275 e-mail: jpsuarez@utpl.edu.ec

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Executive and Managing Editor
Dr. Esther Schwarz-Weig (esw), 95490 Mistelgau, Germany. phone: ++49 (0)9206-993579 www.Sci-Stories.com, e-mail: esw@sci-stories.com

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