



Research in the dry forest yields first results (left). Caterpillars are a model for the dummies used in the predation assessments (middle) - read more inside. Example of the many plants in the forests around the research stations. Photos: Felix Matt (2). Jana Schön

In this Issue

In this Issue	1
Coordinators' Corner	1
Science News - Short Communications ...	5
Season, water and carbon fluxes in the dry forest	5
HUMBOL-TD – Proof of concept	8
Vertical C isotope distribution in soils, N mineralization under forest / pasture....	11
Modelling topography and biodiversity	14
Tree above- and belowground traits in the dry forest.....	16
Topographic influence on stable isotope ratios in tree rings	18
Seeds in the dry forest	22
Arthropod communities, herbivory, and predation.....	24
Data Warehouse News.....	27
Event Report: Open Day	30
Event: Symposium at gtoe2023	31
UTPL News: Structure and biomass of dry and rain forests	32
UC News: Towards rainfall nowcasting ..	33
Miscellaneous: New tree discovered	35
NCI News: New amphibians and new protected areas around the ECSF	36
People and Staff.....	37
About Us.....	39
Editorial Board.....	40
Credits and Contact.....	40

Coordinators' Corner

Successful launch of the second phase of RESPECT research

Nina Farwig¹, Jörg Bendix¹, Baltazar Calvas¹, and Felix Matt¹

¹University of Marburg, Germany, spokesperson, deputy spokesperson and local coordinators of the RESPECT RU

Despite the considerable additional workload caused by the pandemic, the organizational tasks for the start of the second phase of our RESPECT Research Unit could be carried out so that research in the dry forest could get underway.

After a successful evaluation of the second phase of RESPECT, the first general meeting was held in an online format, at which all the preliminary steps for establishing the joint plots and infrastructure in the dry forest were decided. In addition to recruiting personnel for some projects, suitable areas for the core plot establishment in both the dry forest and replacement ecosystem were selected and Subproject B1 (see **Figure 1**, next page) realized the tagging and identification of the tree communities so that the joint field campaign could start

in the first quarter of 2022. Based on this data, Jürgen Homeier selected the tree species for the joint field campaign.

Even though the ongoing COVID-19 pandemic led to additional work in the planning of the field campaign in early 2022, the Subprojects A1 and A2 were able to establish the climate-hydro stations on all process plots and the joint sampling and measurements of the selected tree species of A1, B1 and B4 was carried out with great success (**Figure 2**). In addition, the



Figure 2: Soon after their delivery the parts of the new climate-hydro station were transported to the final sites on the selected plots. Photos: Felix Matt

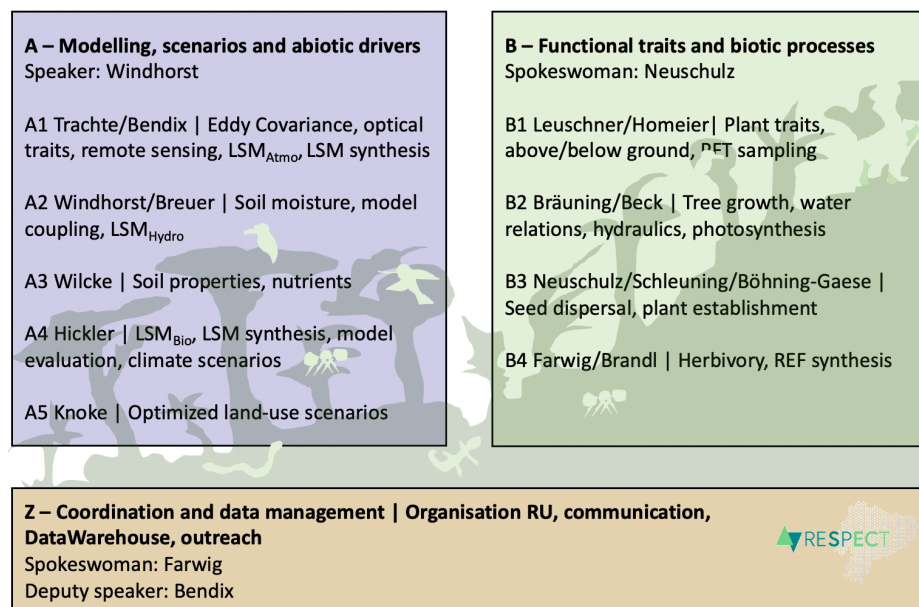


Figure 1: Structure of the DFG-funded RESPECT Research Unit (FOR2730) and Contributions of the nine subprojects. LSM = Land Surface Model, REF = Response Effect Framework, Graph: FOR2730

sampling and experiments on the biotic interactions of Subprojects B3 and B4 and the monitoring of seeds and leaf litter also started **Figure 3**).

Within the framework of the various meetings with our cooperation partners at Universidad Particular de Loja (UTPL) and Universidad Nacional de Loja (UNL), co-

operation agreements have been renewed (**Figure 4**), joint activities were organised within the framework of associated projects (**Figure 4**) and the novel master's program Biodiversity and Climate Change at UNL. Within this master's program at UNL the deputy speaker Jörg Bendix already gave an introductory lecture on climate change and a lecture by Thomas Knoke (Subproject A5) was given at UTPL (**Figure 5**). Further joint seminars with our partners are scheduled for 2022 and 2023.

In meetings with the Foundation Nature Culture International (NCI) in Loja and Laipuna the great cooperation and the support of NCI, especially with regard to infrastructure at the Laipuna station, was emphasised. Likewise, in a meeting with the Instituto Nacional de Biodiversidad (INABIO) long-term storage of data and samples were discussed.

Following the joint field campaign, an open day was organised to promote the project's methods and objectives in the area around the field station. This was a very success-



Figure 3: The plots and trees were selected for field measurements near the Laipuna station (left) by tree expert Jürgen Homeier who was accompanied by Annemarie Wurz and Jana Schön in the field. The sites for the replacement systems were also selected. Photos: Felix Matt



Figure 4: Cooperation between RESPECT Research Unit and its partners (f.l.t.r): RESPECT's speaker Professor Dr. Nina Farwig underwrites the renewed convention between the Universidad Nacional de Loja (UNL) represented by its director, Professor Nikolay Aguirre, PhD, and our Research Unit. Master student Camilo Gonzalez from UNL and Annemarie Wurz (PostDoc Marburg University) are resting after finishing data collection in the dry forest Laipuna Reserve. Photos: Felix Matt and Annemarie Wurz

Figure 5: Cooperation between RESPECT Research Unit and its partners (f.l.t.r): Climate scientist Professor Dr. Jörg Bendix and forest scientists Professor Dr. Thomas Knoke gave oral presentations at our partners, the Universidad Nacional de Loja (UNL) and Universidad Particular de Loja (UTPL), respectively. Both presentations can be downloaded from the RESPECT website under <https://uni-marburg.de/2W5LE7> and http://vhrz669.hrz.uni-marburg.de/tmf_respect/downloadpublication.do?id=7540.

ful day that strengthened the cooperation between the local community in Laipuna, infrastructure provider NCI and our RESPECT Research Unit (Figure 6, see also article on page 30).

Within the second digital members assembly the overall progress of RESPECT was reported and discussed. This also included the progress of the data warehouse for which GeoEngine is contracted in order to harvest dataset from other databases and link those to a currently developed raster system (see also on page 27).

RESPECT was present at the annual meeting of the Society for Tropical Ecology (gtö) in Montpellier, France. Here the team of speakers organized as symposium in which the published framework [1] and a wide range of results from the first phase were presented.

Since the beginning of August Baltazar Calvas joined the coordination team. He is resident in Loja and mostly in charge of the organisation of the cars, drivers, transport and food supply also involved in the organisation of the Infrastructure at ECSF and

Laipuna Station. Staff members who have been with us for a while already know Baltazar. He was involved in the coordination of the transfer project “Nuevos Bosques para Ecuador” in the years between 2012 and 2015.

The database and writing workshop which was scheduled as a first joint in person event in October 2022 had to be transformed into an online event due to COVID. Still, very interesting synthesis ideas were discussed and two manuscripts were further advanced in small groups.



Figure 5: Impressions from the open day around and inside Laipuna’s research station, where members of our RESPECT Research Unit introduced research questions and measurements they are conducting in the dry forest. Photos: Felix Matt



Figure 7: Cover of the new Seed Guide. Courtesy of INABIO

RESPECT has already achieved several successes. Importantly, PhD student Diana Acosta-Rojas from Subproject B3 has succeeded to publish a Field guide of animal-dispersed plants: fruits and seeds in and around Podocarpus National Park both in English and Spanish (**Figure 7**). We can also congratulate Johanna Orellana (**Figure 8**), who received the doctoral award of the University of Marburg in an associated project with RESPECT's deputy speaker Jörg Bendix. Furthermore, a book about the dry forest is in preparation, which will be edited by Erwin Beck (Subproject B2) and Franz Bogner and published in English and Spanish.

Outlook

Altogether, we are looking very much forward to the first scientific Status Symposium at Universidad Técnica Particular de Loja (UTPL) in March 2023, that will strengthen our long-standing cooperation with our Southern Ecuadorian University partners, INABIO and NCI.

This issue of our Tabebuia Bulletin will already provide a first taste of the substantial scientific progress and introduce new project members and associated projects.

Last but not least, we are grateful to our executive editor, Esther Schwarz-Weig, for her continuous support in the production of the first Tabebuia Bulletin this year.

With that, we look forward to the collaboration and promising insights that lie ahead.

References

[1] Bendix, J., Aguire, N., Beck, E., Bräuning, A., Brandl, R., Breuer, L., Böhning-Gaese, K., et al. (2021): A research framework for projecting ecosystem change in highly diverse tropical mountain ecosystems. *Oecologia* **195** (3), 589–600. DOI: 10.1007/s00442-021-04852-8

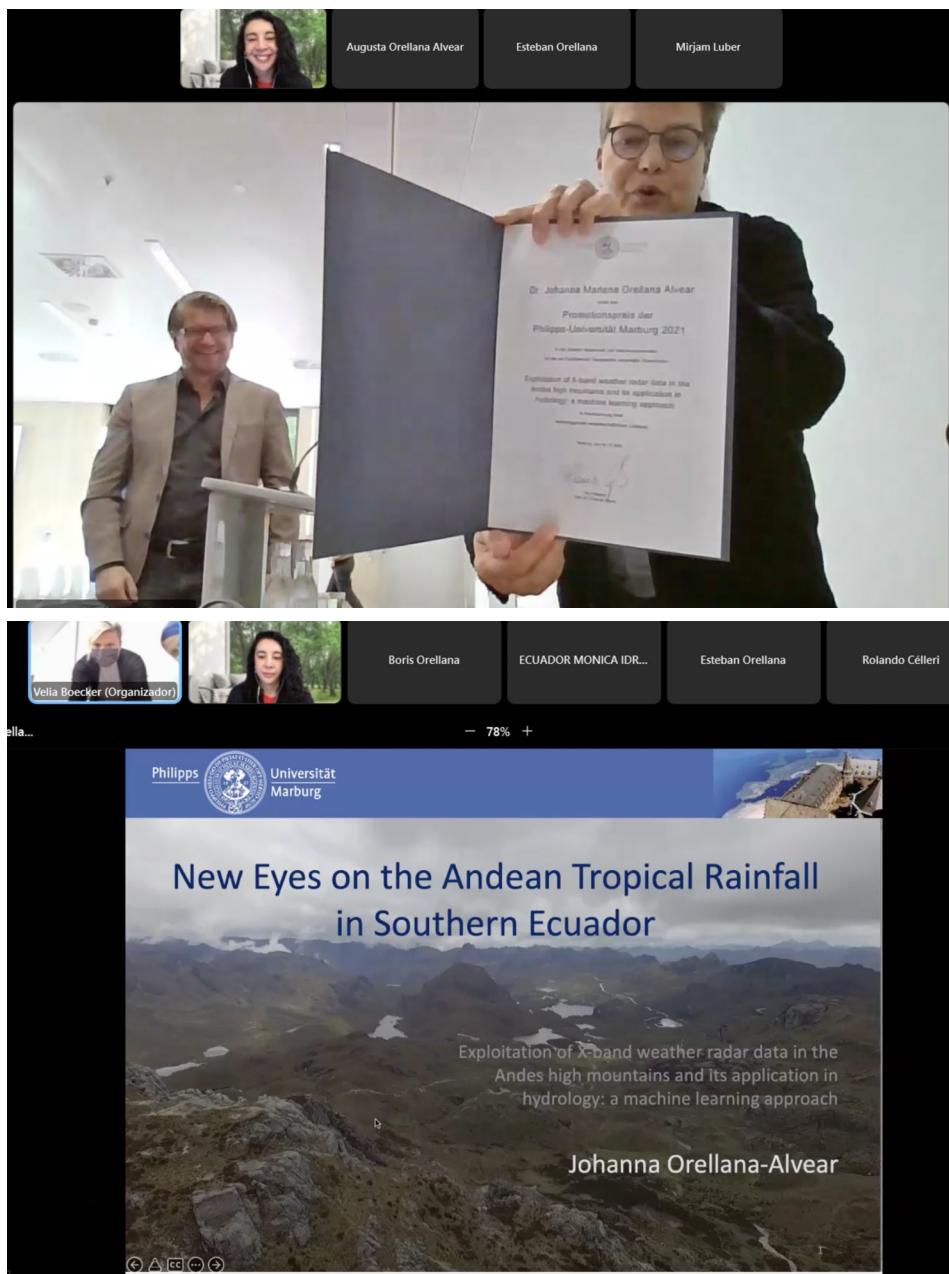


Figure 8: Award ceremony in which Johanna Orellana-Alvear received her PhD title from the University of Marburg in an online meeting due to the COVID19 pandemic. **Top:** Prof. Dr. Sabine Pankuweit, Vice President for equal opportunities and career development, is presenting the certificate. Prof. Dr. Peter Chiffard (left), second reviewer, held the laudatory speech since first reviewer Prof. Dr. Jörg Bendix was at the UN Climate Change Conference 2022 (COP27) in Egypt at this day. **Bottom:** Johanna Orellana-Alvear's presentation on the occasion of the online event. Screenshots: Johanna Orellana-Alvear

Science News - Short Communications

Seasonal signals in water and carbon fluxes over the Laipuna mountain dry forest

Charuta Murkute¹, Franz Pucha Cofrep^{1,2}, Volker Raffelsbauer¹, Sebastian Scholz¹, Oliver Limberger³, Jörg Bendix³, and Katja Trachte¹

¹Brandenburg University of Technology Cottbus-Senftenberg, Germany, member of the RESPECT RU

²Universidad Técnica Particular de Loja, Ecuador, Counterpart of the RESPECT Research Unit

³University of Marburg, Germany, member of the RESPECT RU

A new eddy covariance measurement system has been installed over forest canopy in the mountain dry forest area. The measured carbon and water fluxes reveal a distinct seasonal signal with feedback effects at the soil-vegetation-atmosphere interface.

At the mountain dry forest (MDF) site of the Reserva Laipuna a new eddy-covariance (ECov) measurement system has been installed during the last field campaign in March 2022. The ECov system was set up above the canopy on the tower on the core plot at 670 m a.s.l. shown in **Figure 1** (left panel). It is equipped with an open-path infrared gas analyzer for atmospheric H₂O/CO₂ fluxes and a 3D sonic anemo-

meter to capture the turbulent fluxes (IRGASON), a net-radiometer for short-wave and long-wave radiation, a rain gauge, temperature / relative humidity probe, soil temperature / moisture, and a heat flux plate. In October 2022, the ECov pasture station in the Reserva Biosfera San Francisco (RBSF) was moved to Laipuna and re-installed on the pasture site in the valley at about 550 m a.s.l. (**Figure 1** right panel),

while the ECov over forest in the mountain rain forest (MRF) in the RBSF remains. That allows for analyses of the two target functions water and carbon fluxes, as well as microclimatological conditions along (i) a land-use gradient in the MDF and (ii) a zonal climate gradient across MRF and MDF.

Figure 2 shows first results of the daily rainfall amount and the response of the

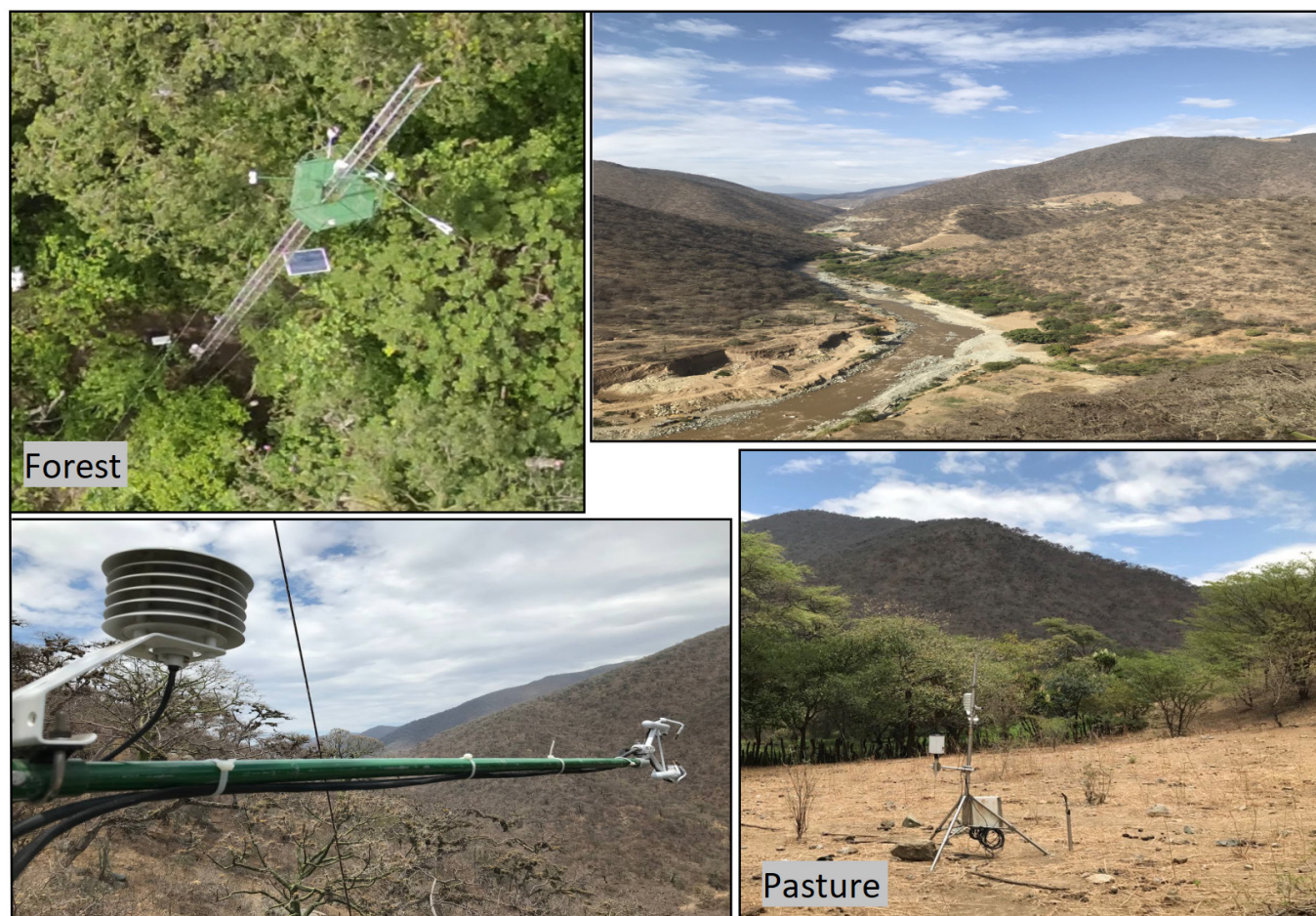


Figure 1: Overview map of the locations of the installed eddy covariance systems (ECov) in the mountain dry forest (MDF) in the Reserva Laipuna. Photos: Sebastian Scholz

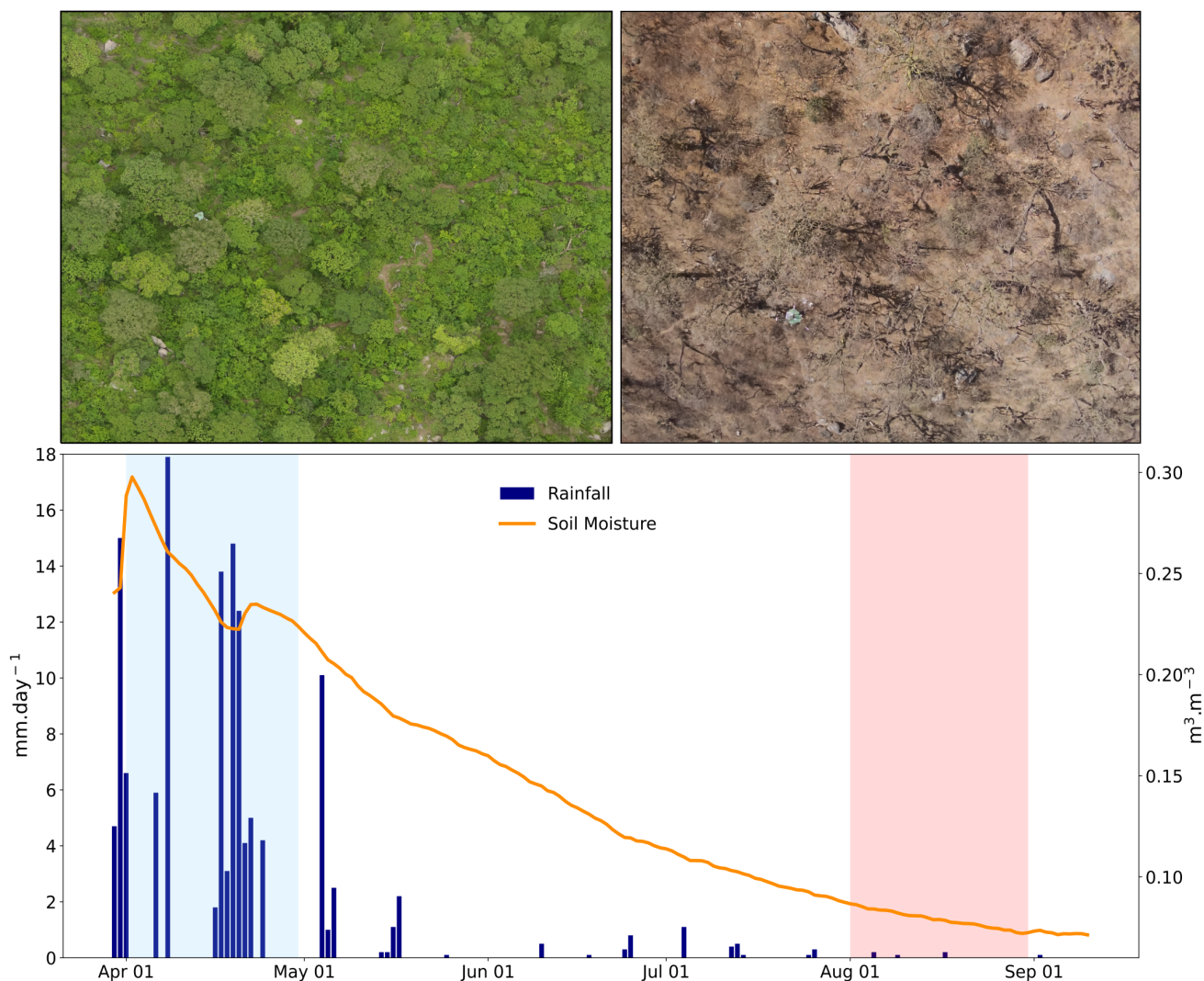


Figure 2: Rainfall [mm day⁻¹] and soil moisture [m³ m⁻³] at the MDF study site “Reserva Laipuna”. The wet month April is shaded blue and the dry August is indicated in red. (upper panel). Drone images taken in wet (left) and dry (right) season. Graphs: Charuta Murkute, Drone images: Sebastian Scholz

soil moisture in MDF highlighting the separation between rain and dry season and a transition to scarce rainfall events from May. This is accompanied by a continuous decrease of the soil moisture content in 20 m from close to 0.30 m³ m⁻³ in April / May (blue shade) down to almost zero in August / September (red shade).

Comparing both periods using the mean diurnal cycle of the density of H₂O [g m⁻³] and CO₂ [mg m⁻³] over the canopy within the planetary boundary layer (PBL) as well as the surface energy budget demonstrates the feedback effects in the soil-vegetation-atmosphere continuum (**Figure 3**). Distinct differences between April (wet) and August (dry) are obvious. The CO₂ density amplitude is much stronger in the wet month with

a minimum during midday of 390 mg m⁻³ representing carbon uptake by the vegetation and a maximum during night time of 425 mg m⁻³, indicating vegetation respiration. In the dry month changes between day time / night time hours are reduced from 370 mg m⁻³ to 363 mg m⁻³. The same is true for the water flux, which shows an opposite behaviour to the carbon flux, with a maximum (minimum) during daytime (night time) and a clear reduction from April to August. The corresponding surface energy fluxes confirm this behaviour. In the wet month, the latent (LE) and sensible (H) heat fluxes are comparable, while in the dry month H is clearly dominant due to the lack of soil moisture and foliage as a source for evapotranspiration.

Future analyses will focus on the quantification of the carbon dynamic in the soil-vegetation-atmosphere continuum by partitioning net-ecosystem exchange (NEE) into its components gross primary productivity (GPP) and ecosystem respiration (R_{eco}), following the definition $NEE = R_{eco} - GPP$ [1]. Results will be compared with the MRF site to investigate effects of the zonal climate gradient [2, 3]. Additionally, soil carbon efflux will be used to determine the proportion of soil and vegetation carbon sink function.

References

[1] Reichstein, M., Stoy, P. C., Desai, A. R., Lasslop, G., Richardson, A. D. (2012): Partitioning of net fluxes. In: Aubinet, M., Vesala, T., Papale, D.

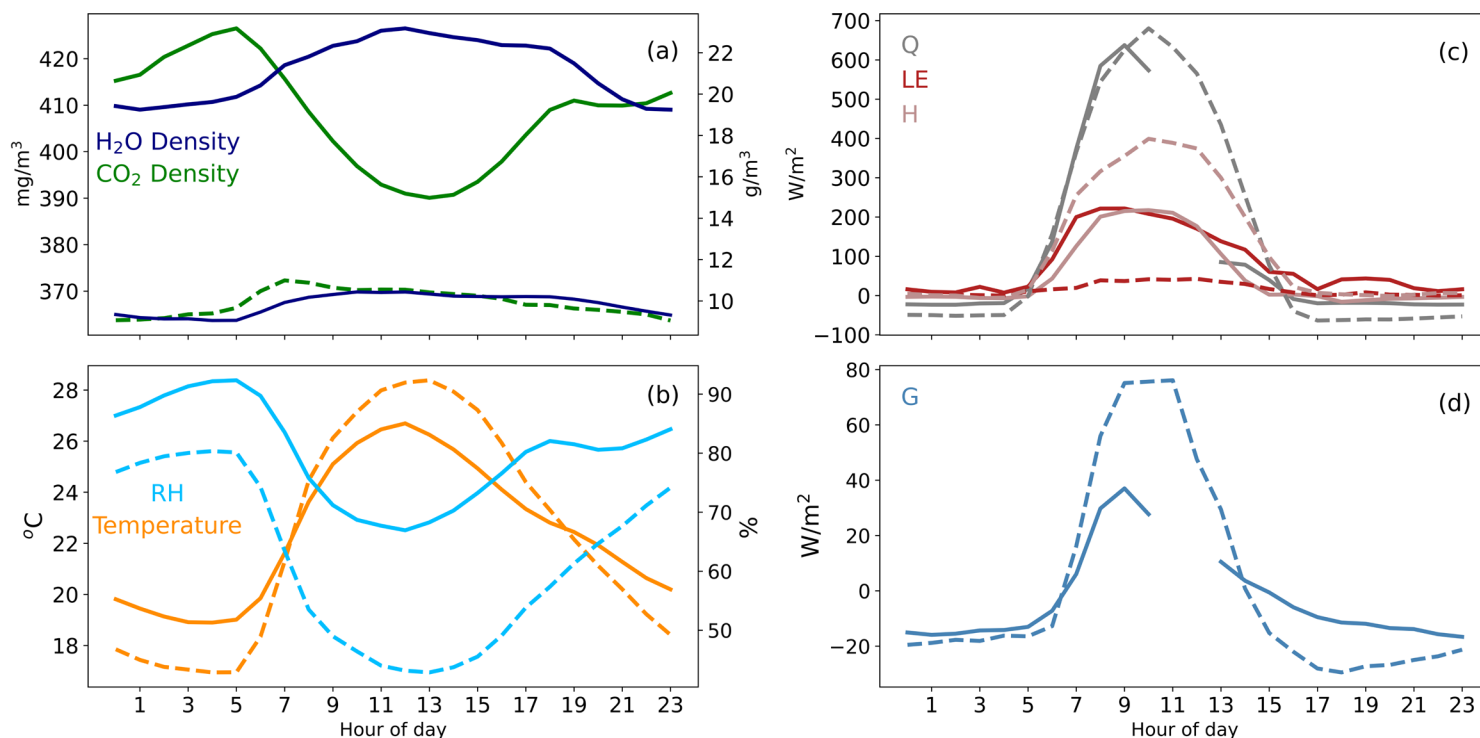


Figure 3: Figure 3: Mean diurnal cycle of (a) CO₂ density [mg m⁻³] and H₂O density [g m⁻³], (b) air temperature [°C] and Relative Humidity (RH [%]), (c) net-radiation (Q [W m⁻²]), latent heat flux (LE [W m⁻²]) and sensible heat flux (H [W m⁻²]), and (d) ground heat flux (G [W m⁻²]) for a wet period considering April month with highest precipitation of 89mm month⁻¹ (solid lines) and a dry period considering August month (dashed lines). Missing Q and G data due to overheating issues. Graphs: Charuta Murkute

(eds) *Eddy Covariance*. Springer Atmospheric Sciences. Springer, Dordrecht. pp. 263-289

[2] Trachte K., Pucha Cofrep, F., Limberger O., Carillo-Rojas, G., Bendix, J. (2020): Determination of fetch areas for comparing ET and NEE over natural forest and anthropogenic replacement systems in the RBSF area. *Tabebuia Bulletin* 7, 5-6. DOI: 10.5678/lcrs/for2730.cit.1817

[3] Trachte K., Pucha Cofrep, F., Limberger O., Carillo-Rojas, G., Bendix, J. (2020): Partitioning of NEE fluxes into carbon uptake and ecosystem respiration for the anthropogenic replacement system in the RBSF area. *Tabebuia Bulletin* 8, 8-9. DOI: 10.5678/lcrs/for2730.cit.1857

HUMBOL-TD – Proof of concept and next steps

David Windhorst¹, Oliver Limberger², Mateus Dantas de Paula³, Lutz Breuer¹, Thomas Hickler³, and Jörg Bendix²

¹Justus-Liebig University Giessen, Germany, member of the RESPECT RU

²University of Marburg, Germany, member of the RESPECT RU

³Senckenberg Biodiversity and Climate Research Center (SBIK-F), Frankfurt - Germany, members of the RESPECT RU

In a first proof-of-concept scenario, we compare the newly developed HUMBOL-DT model to field data and show first results on the benefits of the model.

State of installation and data collection

The Land Surface Model (LSM) HUMBOL-TD (Hydroatmo Unified Model of Biotic interactions Organic Matter and Local Trait Diversity) has been developed within the RESPECT Research Unit to study in detail how ecosystem biomass production and water fluxes are affected by climate and land-use changes through alterations in response and effect traits. The concept and theoretical background of HUMBOL-TD have been presented in last issue of the Tabebuia Bulletin [1] and in Bendix et al. [2].

In this contribution our **sub-project A2** presents the results of a basic proof-of-concept scenario, which we recently used to assess the performance and credibility

Table 1: Variance explanation (R^2) and root mean squared error (RMSE) for latent and sensible heat flux simulated by the sub model LSM_{Atmo} ranging from standalone runs of LSM_{Atmo} to runs of the fully coupled HUMBOL-TD model with all three sub models (LSM_{Atmo} , LSM_{Hydro} and LSM_{Bio}).

Run	Latent Heat flux [W/m^2]		Sensible Heat flux [W/m^2]	
	R^2	RMSE	R^2	RMSE
LSM_{Atmo}	0.68	22.31	0.86	26.30
$LSM_{Atmo} + LSM_{Bio}$	0.70	19.70	0.86	31.30
$LSM_{Atmo} + LSM_{Hydro}$	0.72	15.21	0.89	31.38
HUMBOL-TD	0.78	14.98	0.89	34.42

of the results generated by the model. In this proof-of-concept scenario, HUMBOL-TD has to reflect the water, energy and biomass fluxes of the pasture core plot located at the Estación Científica San Francisco (ECSF, 2,000 m a.s.l.) between October 2019 and September 2020. To highlight the benefits of HUMBOL-TD, we compare

the results of the fully coupled model to standalone, but also bi-directional coupled versions of the three individual sub models: (I) LSM_{Atmo} based on the atmospheric component from Community Land Model (CLM, Lawrence et al. [3]; sub-project A1), (II) LSM_{Hydro} based on the hydrological component from Catchment Modelling

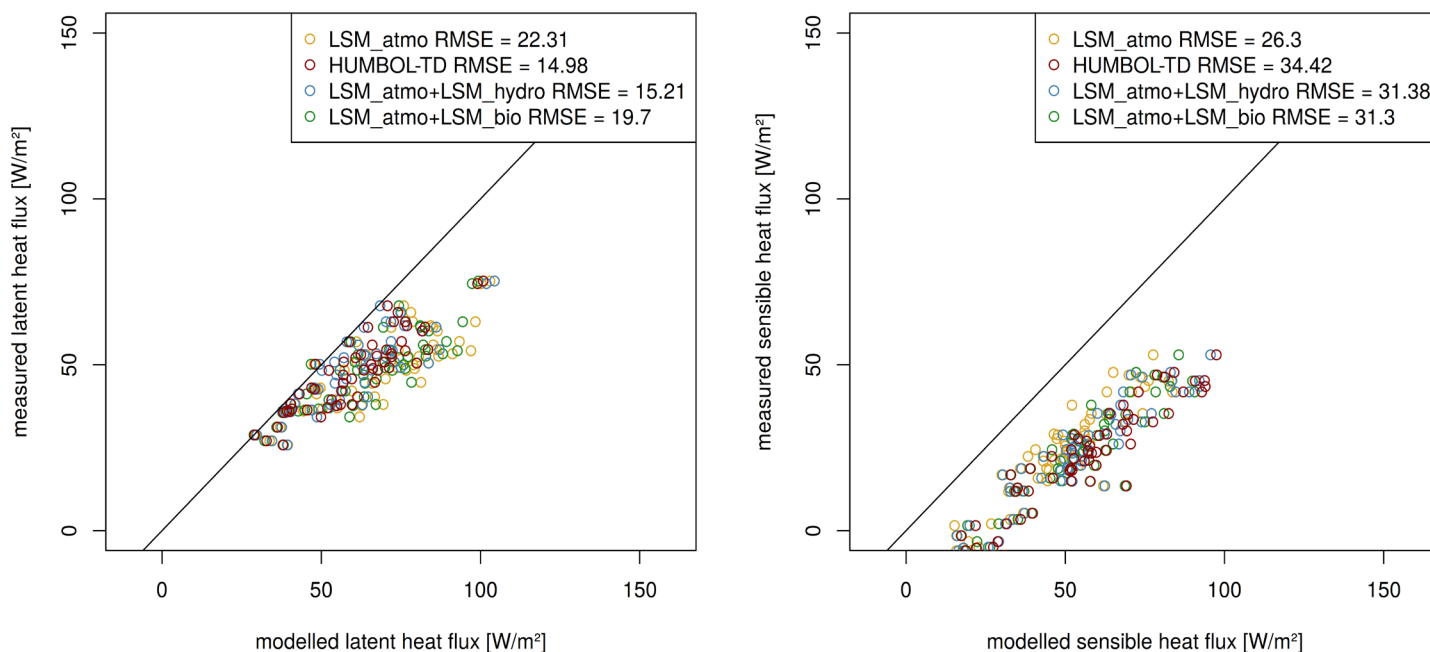


Figure 1: Modeled vs. measured latent (left) and sensible (right) heat flux. ECov data are delivered by Subproject A1, Katja Trachte. Graphs: Oliver Limberger

Table 2: Water balance and Nash–Sutcliffe efficiency (NSE) for soil moisture simulated by the sub model LSM_{Hydro} ranging from standalone runs of LSM_{Atmo} to runs of the fully coupled HUMBOL-TD model with all three sub models (LSM_{Atmo} , LSM_{Hydro} , and LSM_{Bio}). ET = Evapotranspiration

Run	Rainfall [mm]	Through-fall [mm]	ET [mm]	Ground water recharge [mm]	Storage change [mm]	NSE
LSM_{Hydro}	1,603	1,324	-261	-1,507	136	0.82
$LSM_{Hydro} + LSM_{Atmo}$	1,603	1,520	-610	-1,084	143	0.95
$LSM_{Hydro} + LSM_{Bio}$	1,603	1,324	-261	-1,507	136	0.82
HUMBOL-TD	1,603	1,502	-595	-1,080	142	0.95

Framework (CMF, Kraft et al. [4]; sub-project A2), and

(III) LSM_{Bio} based on the biological component from LPJ-GUESS (Lund-Potsdam-Jena General Ecosystem Simulator, Smith et al. [5]; sub-project A4).

Validation of latent and sensible heat flux simulated by the LSM_{Atmo} and its combinations within the HUMBOL-TD coupling framework was conducted using eddy covariance measurements of latent and sensible heat fluxes (sub-project A1, Katja Trachte).

The results of LSM_{Atmo} showed that the variances of 24 h average fluxes are well explained, both by the stand-alone model version as well as by the coupled framework. The variance in sensible heat flux thereby was always better explained than the variance in latent heat flux. In terms of variance explained, the HUMBOL-TD model showed the best performance, followed by the $LSM_{Atmo} + LSM_{Hydro}$, $LSM_{Atmo} + LSM_{Bio}$ and the standalone LSM_{Atmo} runs (Table 1). The variance explained of sensible heat did only differ between models integrating LSM_{Hydro} ($R^2 = 0.89$) and those using the LSM_{Atmo} hydrology ($R^2 = 0.86$). It is thus shown, that improved hydrological process descriptions contribute to improvements in variances explained of both, latent and sensible heat fluxes. The variance explained of the measured latent heat flux by LSM_{Atmo} profited particularly from dynamic vegetation state variables.

As visible in the validation plots (Figure 1), all model combinations overestimated latent and sensible heat flux as measured by the ECov system. The overestimation was only slight in case of latent heat but pronounced for the sensible heat flux. Generally, an overestimation of the heat fluxes by the model can

most likely be attributed to an imbalance between the sum of latent and sensible heat measured by the eddy covariance system and the measured net radiation flux (data not shown). While the prediction error of the latent heat flux decreased with increasing variance explanation, the error in the sensible heat flux showed an increase for the fully coupled model even though the variance explanation was better compared to $LSM_{Atmo} + LSM_{Bio}$, $LSM_{Atmo} + LSM_{Hydro}$ and LSM_{Atmo} .

Compared to the standalone version of LSM_{Hydro} , the improved representation of evapotranspiration (ET), using the closed energy approach from LSM_{Atmo} , yielded a higher performance (Nash–Sutcliffe efficiency (NSE) 0.82 vs. 0.95) and more realistic values (261 mm vs. 610 mm; see Table 2). Due to the limited biomass change in the established pasture plot, the daily update of the vegetation parameters (i.e. leaf area index, LAI) within LSM_{Atmo} by LSM_{Bio} in the fully coupled HUMBOL-TD model caused no change in model performance (NSE 0.95), and only minor changes in the overall water balance (ET decreases from 610 mm to 595 mm).

Net primary production (NPP) results of LSM_{Bio} did not differ significantly between the coupled and standalone model runs. The reason for this was that NPP allocation in the proof-of-concept scenario is limited by photosynthesis (i.e., v_{max}) and nutrient availability (i.e., nitrogen). As a result, even doubling the potential evapotranspiration (ET_{pot}) computed by LSM_{Atmo} did not cause any further increase in NPP. Under different conditions (e.g. under dryer conditions or higher nutrient availability) any change in ET_{pot} is likely to increase the NPP.

Overall, HUMBOL-TD allows to utilize the strengths of each sub model, outperform-

ing the standalone versions of the three individual components and yielding a more realistic representation of the ecosystem. In the next steps HUMBOL-TD will be used to simulate the biomass production, water- and energy-fluxes for all core plots. Further adaptations to HUMBOL-TD are currently being implemented (e.g., lateral flow representation and performance optimization) to allow its application on landscape scale for two designated research areas with contrasting climatic and land use conditions: (I) the mountain rain forest (MRF; 1,646 km² of the Rio Zamora catchment) and (II) the mountain dry forest (MDF, 2,345 km² of the Rio Catamayo catchment, Figure 2).

References

- [1] Windhorst Limberger, Dantas de Paula, Breuer, Hickler and Bendix (2020): The HUMBOL-TD model. DFG Research Unit FOR2730, University of Marburg, Marburg, Germany. *Tabebuia Bulletin* 8, 4-5. DOI: 10.5678/lcrs/for2730.cit.1857
- [2] Bendix, J., Aguire, N., Beck, E., Bräuning, A., Brandl, R., Breuer, L., Böhning-Gaese, K., et al. (2021): A research framework for projecting ecosystem change in highly diverse tropical mountain ecosystems. *Oecologia* 195 (3), 589–600. DOI: 10.1007/s00442-021-04852-8
- [3] Lawrence, D. M., Oleson, K. W., Flanner, M. G., Thornton, P. E., Swenson, S. C., Lawrence, P. J., Zeng, X., et al. (2011): Parameterization improvements and functional and structural advances in Version 4 of the Community Land Model. *J. Adv. Model. Earth Syst.* 3 (1), M03001. DOI: 10.1029/2011MS00045
- [4] Kraft, P., Vaché, K. B., Frede, H.-G. & Breuer, L. (2011): CMF: A Hydrological Programming Language Extension For Integrated Catchment Models. *Environmental Modelling & Software* 26 (6), 828–830. DOI: 10.1016/j.envsoft.2010.12.009
- [5] Smith, B., Wårlind, D., Arneth, A., Hickler, T., Leadley, P., Siltberg, J. & Zaehle, S. (2014): Implications of incorporating N cycling and N limitations on primary production in an individual-based dynamic vegetation model. *Biogeosciences* 11 (7), 2027–2054. DOI: 10.5194/bg-11-2027-2014

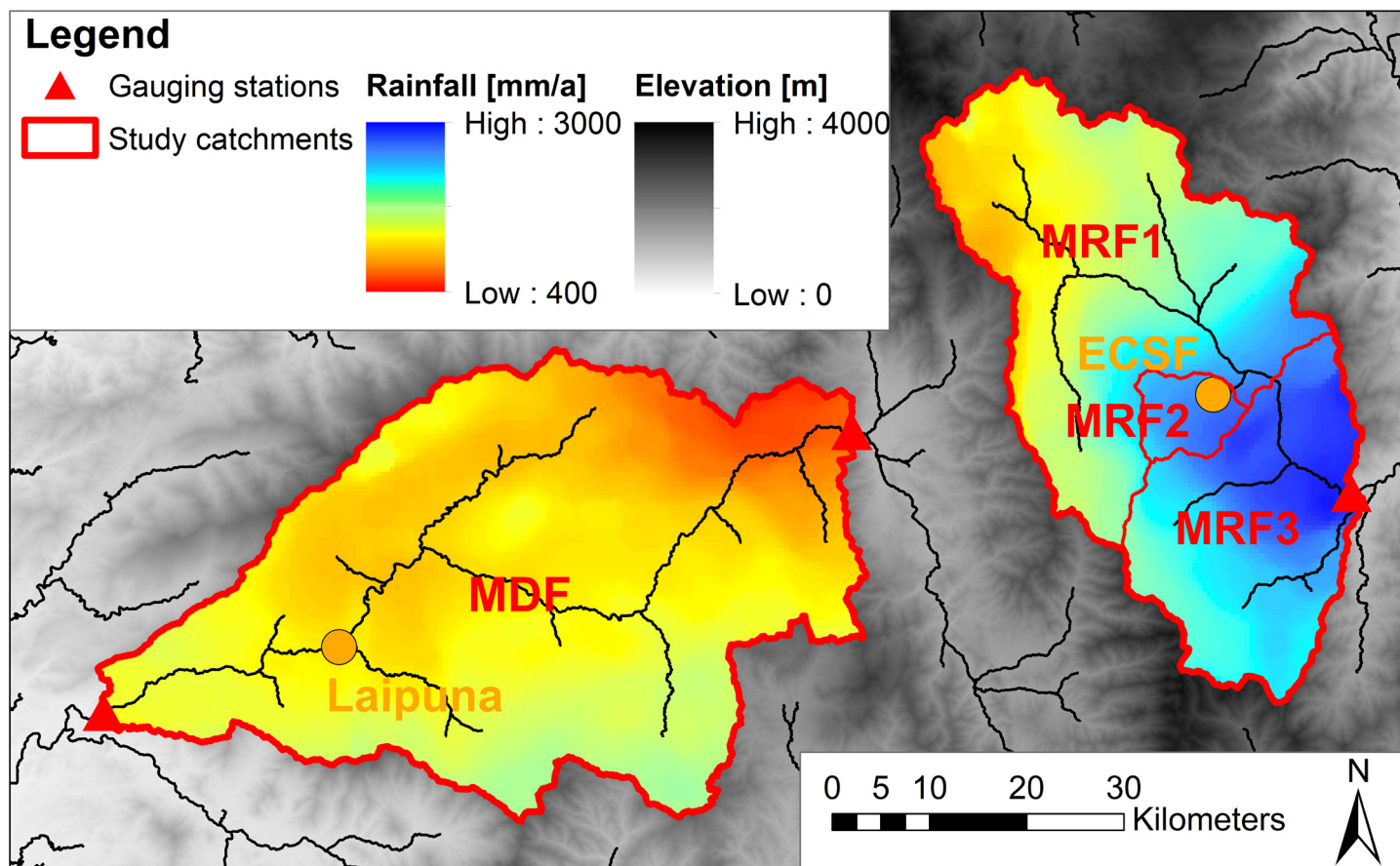


Figure 2: Research areas for the mountain rain forest (MRF) and mountain dry forest (MDF). Graph: Oliver Limberger

Vertical distribution of the carbon isotope ratios in soils to predict nitrogen mineralization rates under forest and pasture along an elevational gradient in South Ecuador

Tobias Fabian¹, Andre Velescu¹, Carlos Iván Espinosa², and Wolfgang Wilcke¹

¹Karlsruhe Institute of Technology, Germany, member of the RESPECT RU

²Universidad Tecnica Particular de Loja (UTPL), Ecuador, member of the RESPECT RU

In the soils of the tropical montane ecosystem in south Ecuador, nitrogen (N) mineralization varies with elevation and land use. We aimed to find a proxy for the prediction of N mineralization rates. Net N mineralization can be successfully predicted with the help of the slope of the regression line of carbon isotope ratios ($\delta^{13}\text{C}$ values) values on soil depth under forest with its C_3 trees, but not in soils under pastures with C_4 grasses. C_3 and C_4 are different fotosynthesis pathways that result in distinctly different $\delta^{13}\text{C}$ of the biomass. Moreover, the N mineralization was much lower in soils developed from the nutrient-poor acidic granodiorite than in those developed from phyllite and meta-sandstone.

In the Ecuadorian tropical montane forests, primary production is often limited by the N availability in soil, which is influenced by climate and land use. Understanding the response of net N mineralization to climate and land use is important to predict the effect of environmental change on the biodiversity of tropical montane forests, which is known to be negatively impacted by increasing N availability [1]. Slow mineralization or microbial immobilization may limit the availability of N although organic N stocks in soils are high. During the previous research phase, we had shown that N availability in soils was generally low and not directly related with elevation or land use [2].

To determine the role of climate and land use for N mineralization in the mineral topsoil, which is one of the variables needed for the modeling efforts of the Research Unit, **Subproject A3** conducted field incubations of soil-filled PVC cylinders (10 cm length, 90 cm³ volume) in forest and pasture soils during 31 days on all core plots of the Research Unit. We made use of the threefold replicated, full factorial design with both land use types – natural forest and pasture – and all three research areas on the humid side of the cordillera along the elevation gradient from 1000 – 3000 m a.s.l. Moreover, we sampled one additional site at 1000 m a.s.l. on granodiorite. The incubation cylinders were buried in the upper 10 cm of the mineral soil. To reach this, we removed a core of the organic layer which was filled back on top of the incubation cylinders after the installation. To avoid N leaching losses, the cylinders were closed at the bottom and the top and only allowed for horizontal water and element fluxes through thin lateral slits. We measured start and end concentrations

of NH_4^+ and NO_3^- in 1 M KCl extracts to determine net ammonification and nitrification rates, the sum of which is called N mineralization rate.

In the absence of changes in the C source, the $\delta^{13}\text{C}$ values of soil organic matter integrate the C isotope fractionation by microbial organic matter turnover of a longer time period. Therefore, the slope of the regression line of the $\delta^{13}\text{C}$ values on mineral soil depth (which we sampled in 10-cm increments down to 1 m) was proposed to serve as a proxy for N mineralization rates [3]. Thus, this slope could replace the soil incubations which are more labor- and time-intensive than measuring $\delta^{13}\text{C}$ values of soil samples collected once and can moreover be influenced by seasonal fluctuations.

At the natural forest sites, soils are mainly Dystric Cambisols which developed from granodiorite (1000 m a.s.l.) or phyllites and meta-sandstones (1000-3000 m a.s.l.) [4]. We observed a considerable variation in the slopes of the regression lines of the $\delta^{13}\text{C}$ values on soil depth under forest (**Figure 1**). The expected increase in $\delta^{13}\text{C}$ values with depth was only observed in the upper ca. 50 cm of the soil profiles, because the mineral soil seemed to be layered, possibly as a consequence of historic landslides.

In contrast to the natural forest, the highest $\delta^{13}\text{C}$ value in the pasture soils was observed in the upper 10 cm of the mineral soil (**Figure 2**). This can be explained by the mixing of C_4 biomass with a high $\delta^{13}\text{C}$ value (11 to 13 ‰) originating from the cultivated African grasses (i.e., *Setaria sphacelata* Stapf & C.E.Hubb. ex M.B.Moss) into the soil after the conversion to pasture. Because this in-

put reverses the usual relationship between $\delta^{13}\text{C}$ values and soil depth, our proxy approach to predict N mineralization rates from the vertical distribution of $\delta^{13}\text{C}$ values cannot be used on the pasture sites.

Although the climate is wetter and cooler at higher elevations, mean N mineralization in the mineral soil on the forest sites significantly increased with elevation (**Figure 3**). On pastures, N mineralization was not significantly related with elevation. Highest N mineralization rates at 2000 m a.s.l. could be explained by the most intensive farming at this elevation.

We observed a close relationship between the slope of the regression line of the $\delta^{13}\text{C}$ values on soil depth and the measured net N mineralization rates under natural forest (**Figure 4**). This indicated that our short-term incubation indeed reflected the long-term mineralization regime so that the unexpected increase in N mineralization with increasing elevation was a realistic finding. The N mineralization in the mineral soil on the granodiorites at 1000 m a.s.l. was much lower than at 2000 and 3000 m a.s.l. but also closely linked with the slope of the regression line of the $\delta^{13}\text{C}$ values on soil depth. This low N mineralization rate was again unexpected, because the higher mean annual temperature at 1000 m a.s.l. should accelerate organic matter turnover. Apparently, the lower nutrient availability and higher acidity of the topsoils on the three granodiorite plots at 1000 m a.s.l. than at the other two elevations overruled the climate effect. This conclusion is supported by the finding that the topsoil on meta-sandstone at 1000 m a.s.l., which belongs to the three core plots, showed the expected highest mineralization

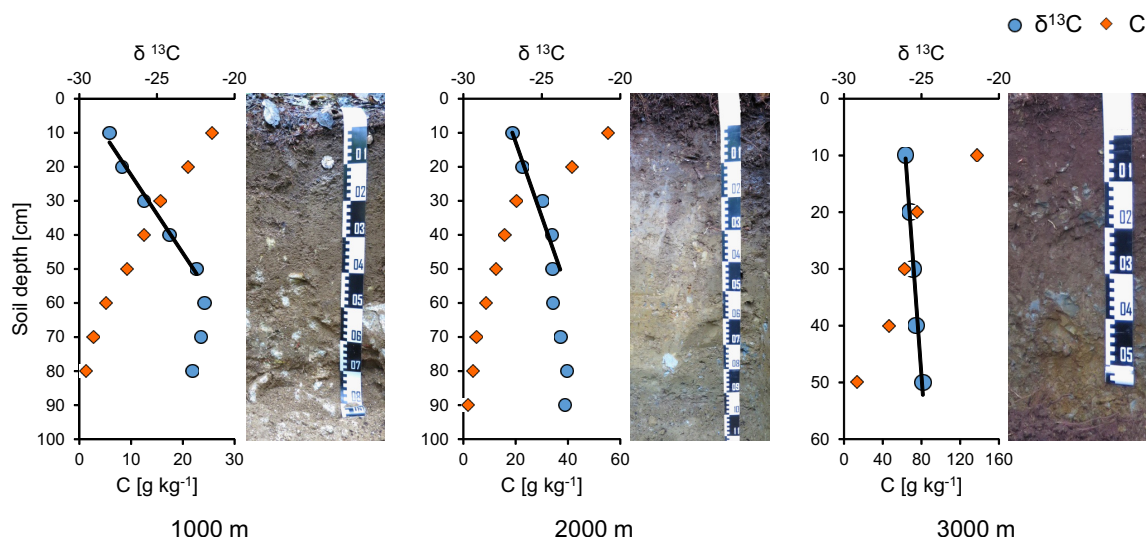


Figure 1: Typical distribution of the $\delta^{13}\text{C}$ values and of organic C concentrations in the soils of the natural forest sites at 1000 – 3000 m a.s.l. Photos and Graphs: Tobias Fabian

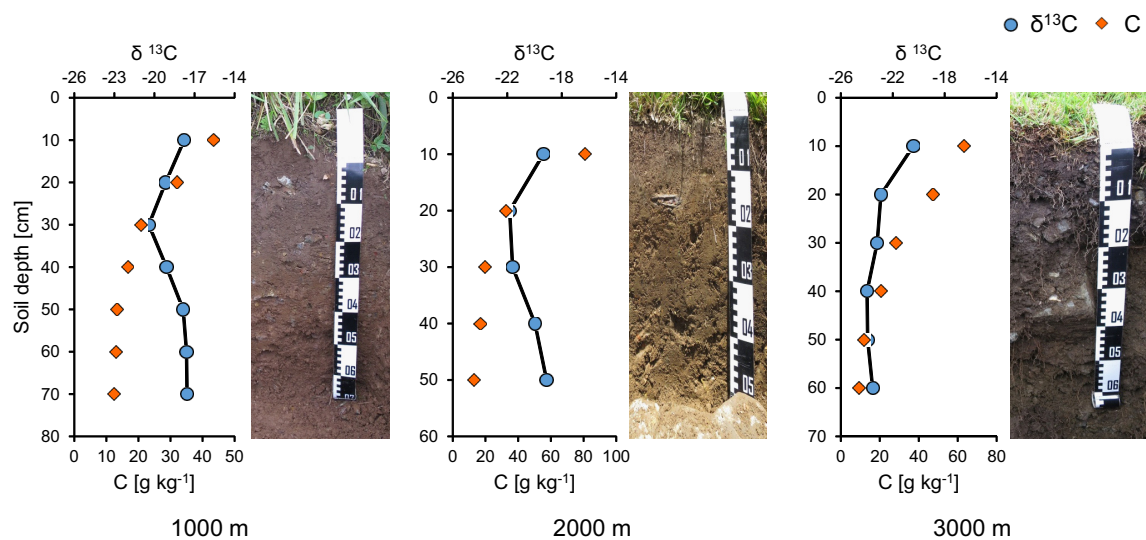


Figure 2: Typical distribution of the $\delta^{13}\text{C}$ values and of organic C concentrations in the soils of the pasture sites at 1000 – 3000 m a.s.l. Photos and Graphs: Tobias Fabian

rate of all sites (BOM3, **Figure 4**). We additionally speculate that the on average thicker organic layers with wide C/N ratios (ca. 15-30) on the core plots at 2000 m (30 cm) and 3000 m (12 cm) than at 1000 m (5 cm) might have favored the formation of a microbial community that is more adapted to reduced N availability.

We conclude that net N mineralization can be predicted with the slope of the regression line of $\delta^{13}\text{C}$ values on soil depth under forest but not under pasture. In the latter, the vertical distribution of the $\delta^{13}\text{C}$ values was changed because of the input of C_4 plant-derived organic matter from the planted ex-

otic grasses. Furthermore, the relationship between the slope of the regression line of $\delta^{13}\text{C}$ values on soil depth and N mineralization measured by in-situ incubation depended on the parent material. The topsoils developed from granodiorite showed a much lower N mineralization rate than those developed from phyllite and meta-sandstone.

References

[1] Sala, O.E., Chapin, F.S. III, Armesto, J.J., Berlow, E., Bloomfield, J., Dirzo, R., Huber-Sannwald, E., Huenneke, L.F., Jackson, R.B., Kinzig, A., Leemans, R., Lodge, D.M., Mooney, H.A., Oesterheld, M., Poff, N.L., Sykes, M.T., Walker, B., Walker, M., Wall, D.H. (2000): Global biodiversity scenarios for the year 2100.

Science **287**: 1770-1774. DOI: 10.1126/science.287.5459.1770

[2] Wilcke, W., Velescu, A. (2020): Response of soil nutrient supply in the tropical montane forest in south Ecuador to climate and land-use change along an elevation gradient from 1000 to 3000 m above sea level. DFG Research Unit FOR2730, University of Marburg, Marburg, Germany. *Tabebuia Bulletin* **8**: 13-15. DOI: 10.5678/lcrs/for2730.cit.1857

[3] Garten, C.T. (2006): Relationships among forest soil C isotopic composition, partitioning, and turnover times. *Canadian Journal of Forest Research* **36**: 2157-2167. DOI: 10.1139/x06-115

[4] Fabian, T., Velescu, A., Wilcke, W. (2019): Soil development on heterogeneous parent material under tropical montane forest in South Ecuador. DFG Research Unit FOR2730, University of Marburg, Marburg, Germany *Tabebuia Bulletin* **6**: 8. DOI: 10.5678/lcrs/for2730.cit.1736

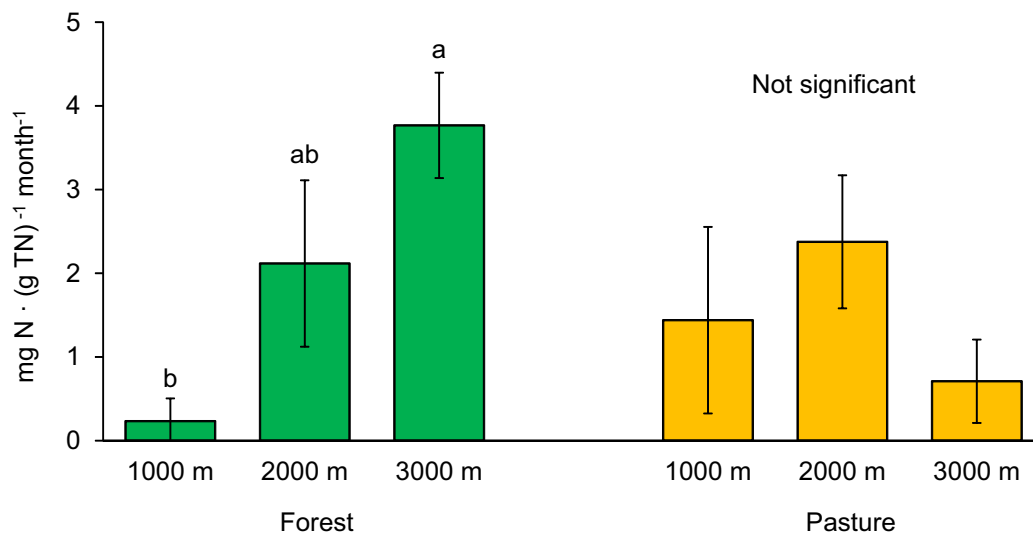


Figure 3: Total net N mineralization ($\text{NO}_3\text{-N} + \text{NH}_4\text{-N}$) on the forest and pasture plots at 1000, 2000 and 3000 m a.s.l. Error bars indicate standard error ($n = 3$). Different lower-case letters indicate significant differences according to Tukey's HSD post-hoc test ($p < 0.05$). Graph: Tobias Fabian

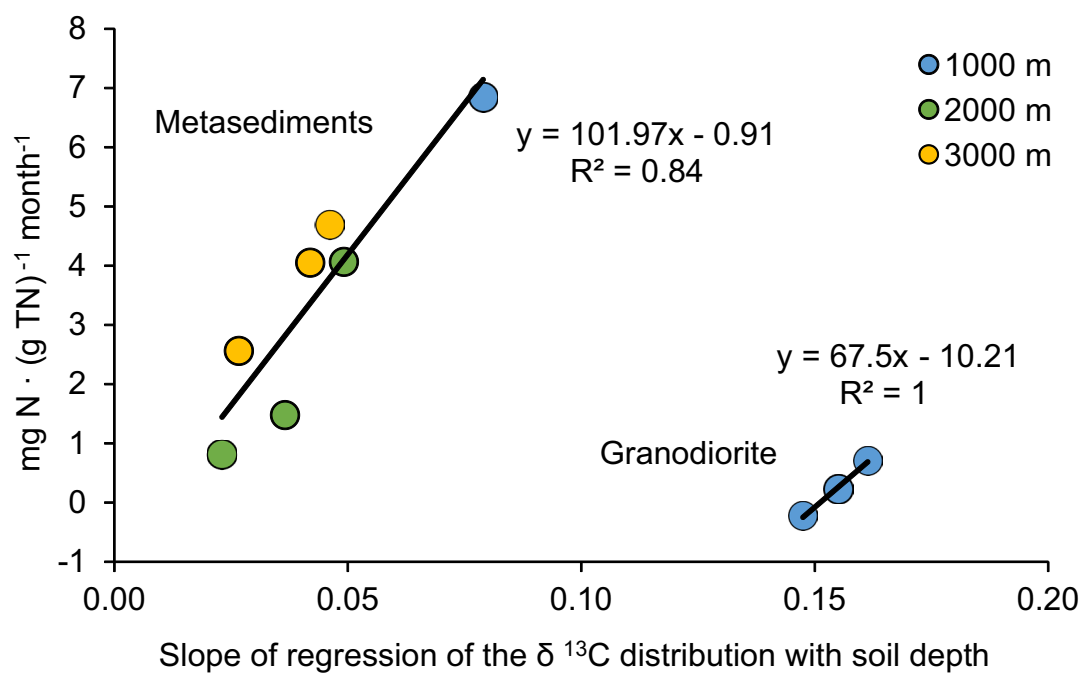


Figure 4: Relationship between net N mineralization ($\text{NO}_3\text{-N} + \text{NH}_4\text{-N}$) and the slope of the regression line of the $\delta^{13}\text{C}$ values on soil depth on the forest plots. Graph: Tobias Fabian

Modelling the relationship between topography and biodiversity – Current and future plant trait patterns

Mateus Dantas de Paula¹, Liam Langan¹, Jürgen Homeier², Wolfgang Wilcke³, and Thomas Hickler¹

¹SBIK-F - Senckenberg Biodiversity and Climate Research Center, Frankfurt - Germany, member of the RESPECT RU

²University of Goettingen, Germany, member of the RESPECT RU

³Karlsruhe Institute of Technology (KIT), Germany, member of the RESPECT RU

After developing a dynamic forest model with trait variability (LPJ-GUESS-NTD, the Lund-Potsdam-Jena General Ecosystem Simulator whereby NTD stands for nutrient-trait dynamics) with extensive input from the unique field data at our study sites from other RESPECT working groups, we now turn to model applications. Here we explored to what extent topography and changes in nitrogen deposition might influence nutrient flows and vegetation characteristics in the mountain forests. The model confirms the observation-based hypothesis that elevational nutrient redistribution can drive differences in community trait values, even though modelled differences between upper and lower slopes were smaller than observed. When we extrapolate historical nitrogen deposition increases into the future, model simulations suggest decreasing vegetation trait gradients until the year 2100. Such changes in plant trait diversity might threaten the unique biodiversity of the southern mountain rainforests of Ecuador.

The high plant diversity of tropical mountain forests (TMF) has inspired many concepts which suggest explanations for their driving factors [1]. Among these factors, nutrient limitation may play a crucial role. Along the large elevation gradient in the study area, nutrient availability is driven by temperature influence on litter decomposition, whereas on the local topographic scale, it is determined by fluxes of nitrogen from high upper slopes and lower areas [2]. This nutrient flux, which is dominated by N due to its high mobility [3], leads to marked differences in community composition and productivity between upper and lower slopes. Namely, more conservative plant strategies such as tougher leaves,

higher wood density and lower productivity dominate on higher topographic positions compared to lower areas [4]. Such local-scale topographic heterogeneity is regarded as one of the main drivers of biodiversity in TMF – which are however threatened by increasing nutrient deposition caused by fires and land use far away in the lowland Amazon basin [5]. This increased N deposition is expected to neutralize local site differences between slopes, which in turn may cause biological homogenization [6].

In order to test if our model is able to reproduce the topographical variation of TMF, we included surface flow of nitrogen between simulated patches of forest in our

LPJ-GUESS-NTD forest model. We thereby created upper and lower slopes for each of the three elevation sites, with greater or lower nutrient limitation of vegetation. The flux quantity was determined by runoff and measured concentrations of nitrate plus ammonia $\text{NO}_3 + \text{NH}_4$ for the study sites [7]. We then simulated upper and lower slope patches in each of the 1,000, 2,000, and 3,000 m elevation sites. The implementation of these fluxes led to the hypothesized results of higher nitrogen limitation of upper than lower slopes, however with less marked differences as observed in the field (Figure 1).

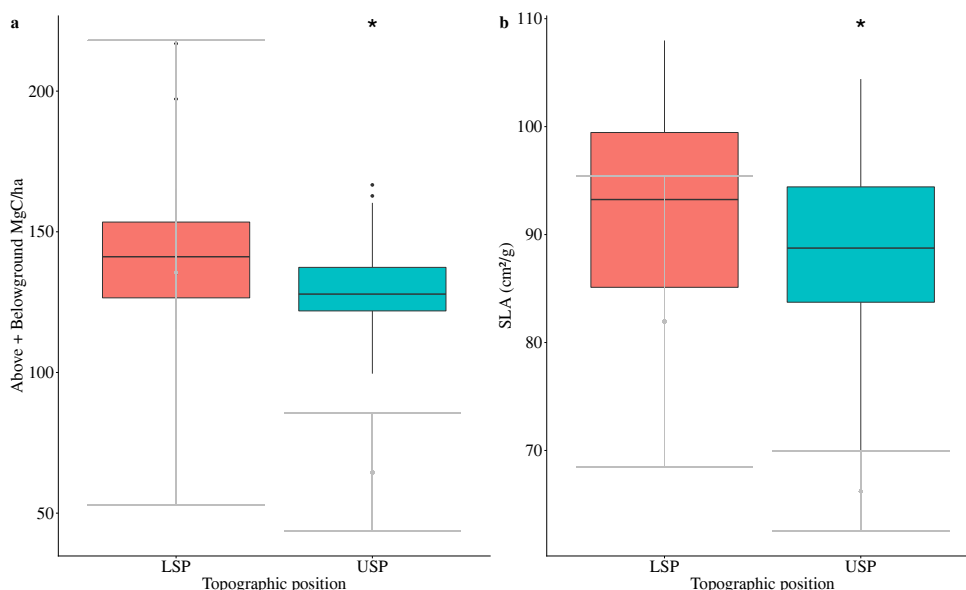


Figure 1: Simulated versus observed (gray error bars, with confidence intervals) biomass and specific leaf area (SLA) for the 2,000 meter elevation site, considering lower slopes (LSP) and upper slopes (USP). Asterisks indicate significant ($p < 0.05$) differences between simulated slopes (sample size = 30). Graph: Mateus Dantas de Paula

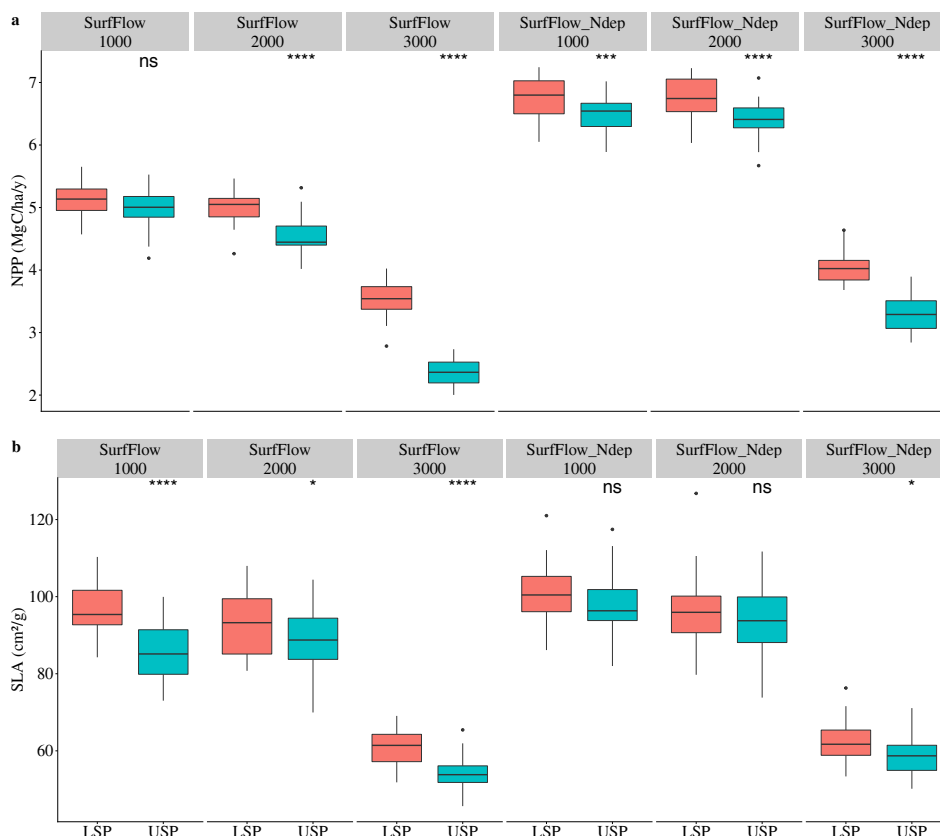


Figure 2: Differences between the control (SurfFlow) and increased nitrogen deposition (SurfFlow_Ndep) scenario for all elevation sites, considering lower slopes (LSP) and upper slopes (USP). Asterisks indicate significant ($p < 0.05$) differences between simulated slopes (sample size = 30). NPP: net primary production. SLA: specific leaf area. Graph: Mateus Dantas de Paula

Finally, we simulated a future scenario over the next 100 years, in which nitrogen deposition from the atmosphere increased at a rate of 0.5 kgN/ha/y, which seems a realistic rate as assessed by local measurements [8]. The resulting forest community had significantly higher productivity than a control scenario run under current environmental conditions, as well as a higher specific leaf area (Figure 2). This is in line with predictions from nutrient manipulation experiments [6], which suggest that species with acquisitive strategies will increase their relative fitness over species with more conservative strategies, possibly impacting TMF beta diversity patterns. We expect the new implementations on topography to also be invaluable for corresponding simulations in the tropical dry forest ecosystem, since heterogeneity in water availability due to topography may play a similar role in shaping ecosystem processes and biodiversity.

References

[1] Rahbek C, Borregaard MK, Colwell RK, Dalsgaard B, Holt BG, Morueta-Holme N, Nogues-Bravo D, Whittaker RJ, Fjeldsá J. (2019): Humboldt's enigma: What causes global patterns of mountain biodiversity? *Science* **365**: 1108–1113.

[2] Bendix J, Beck E, Bräuning A, Makeschin F, Mosandl R, Scheu S, Wilcke W. (2013): *Ecosystem Services, Biodiversity and Environmental Change in a Tropical Mountain Ecosystem of South Ecuador*. Berlin/Heidelberg: Springer.

[3] Wilcke W, Boy J, Goller R, Fleischbein K, Valarezo C, Zech W. (2011): Effect of topography on soil fertility and water flow in an Ecuadorian lower montane forest. In: Bruijnzeel LA, Scatena FN, Hamilton LS, (eds.) *Tropical Montane Cloud Forests: Science for Conservation and Management*. Cambridge: Cambridge University Press, 402–409.

[4] Werner FA, Homeier J (2015): Is tropical montane forest heterogeneity promoted by a resource-driven feedback cycle? Evidence from nutrient relations, herbivory and litter decomposition along a topographical gradient. *Functional Ecology* **29**: 430–440.

[5] Boy J, Rollenbeck R, Valarezo C, Wilcke W. (2008): Amazonian biomass burning-derived acid and nutrient deposition in the north Andean

montane forest of Ecuador. *Global Biogeochemical Cycles* **22**: 1–16.

[6] Homeier J, Hertel D, Camenzind T, Cumbicus NL, Maraun M, Martinson GO, Poma LN, Rillig MC, Sandmann D, Scheu S, et al. (2012): Tropical Andean Forests Are Highly Susceptible to Nutrient Inputs—Rapid Effects of Experimental N and P Addition to an Ecuadorian Montane Forest. *PLoS ONE* **7**: e47128.

[7] Boy J, Valarezo C, Wilcke W. (2008): Water flow paths in soil control element exports in an Andean tropical montane forest. *European Journal of Soil Science* **59**: 1209–1227.

[8] Wilcke W, Leimer S, Peters T, Emck P, Rollenbeck R, Trachte K, Valarezo C, Bendix J. 2013. The nitrogen cycle of tropical montane forest in Ecuador turns inorganic under environmental change. *Global Biogeochemical Cycles* **27**: 1194–1204.

Linking tree above- and belowground traits in seasonal dry tropical forest

Jürgen Homeier^{1,2}, Laura Würzberg², Karina Gonzalez³, Jorge Gonzaga³, and Christoph Leuschner²

¹University of Applied Sciences and Arts (HAWK) Göttingen, Germany, member of the RESPECT RU

²University of Göttingen, Germany, member of the RESPECT RU

³Maestría en biodiversidad y cambio climático, Universidad Nacional de Loja (UNL), Loja, Ecuador, members of UNL's MSc programme

Six new permanent forest plots were established in the Laipuna dry forest reserve. Following a species inventory, tree functional traits and root functioning are investigated.

Subproject B1 focuses on tree species composition and forest structure of the Laipuna dry forest reserve, and on the quantification of functional traits of dry forest tree species. Moreover, it strives to relate tree functional properties (from species to stand level) to their environment (soil properties, climate) and to forest functioning (biomass, productivity). Finally, we will compare tree

growth strategies along the studied environmental gradients (low to high elevations, moist forests to dry forests).

From October to November 2021, six new permanent forest plots were established in the Laipuna natural reserve, three at around 600 m and three at around 1200 m a.s.l..

The inventory of the 6 ha of tropical dry forest yielded 3027 tree stems (with diameters of ≥ 10 cm) from 52 different tree species. This number is quite low compared to the high tree diversity of the 9 permanent plots established in the premontane to upper montane forests of the Reserva Biológica San Francisco (RBSF) and Podocarpus National Park, which all harbour more than 70 tree species/ha.

Eleven tree species occur only on the drier plots at 600 m, and 28 species only on the moister plots at 1200 m, while the other 13 species are found at both elevations. *Bursera graveolens* (275 stems) *Eriotheca ruizii* (225), and *Ipomoea wolcottiana* (138) are the most common tree species at 600 m, *Handroanthus chrysanthus* (411), *Fulcaldea laurifolia* (328) and *Terminalia valverdae* (137) are the most common species at 1200 m. The most important tree families at 600 m are Malvaceae (284 stems), Burseraceae (275) and Convolvulaceae (138) and at 1200 m Bignoniaceae (411), Fabaceae (336) and Asteraceae (328).

As a next step, we will estimate above-ground biomass and carbon storage for the six forest plots (ongoing MSc thesis project Karina Gonzalez). A re-inventory of all plots to quantify tree growth and forest productivity is planned early in 2024.

Trait data recording started in March to May 2022 when during the first joint field campaign leaves and wood cores of 12

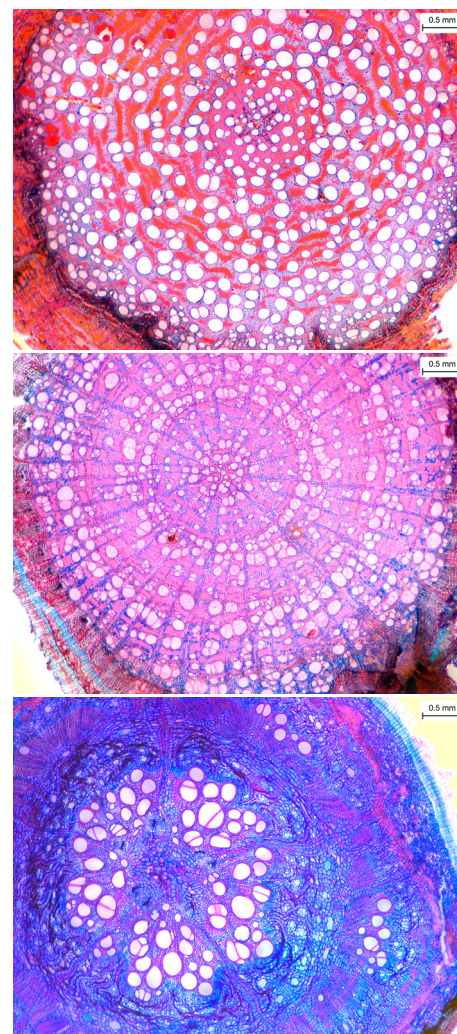


Figure 2: Coarse root cross-sections of three of the selected tree species (from top to bottom): *Vachellia macracantha* (Fabaceae, 1200 m), *Cordia lutea* (Boraginaceae, 600 m) and *Ipomoea wolcottiana* (Convolvulaceae, 600 m a.s.l.). Photos: Laura Würzberg

common tree species (**Figure 1**) per elevation level (with 8 replicates per species) have been sampled.

A special focus of Subproject B1 is on root properties and root dynamics of the dry for-



Figure 1: Flowers of some of the selected common tree species, which are studied in detail (from top to bottom): *Cordia lutea* (Boraginaceae, 600 m), *Morisonia petiolaris* (Capparaceae, 1200 m), and *Triplaris cumingiana* (Polygonaceae, 1200 m a.s.l.). Photos: Jürgen Homeier



Figure 3: Field team of Subproject B1 in the Laipuna dry forest reserve at the beginning of the dry season, end of May 2022. Photo: Jürgen Homeier

est tree species. The very short rainy season in 2022 resulted in low numbers of surviving fine roots in May, which were difficult to access, and we had to postpone most of our planned fine root studies to 2023. We are monitoring fine root seasonality with monthly topsoil samples in order to determine phases of fine root dieback and fine root biomass recovery (ongoing MSc thesis project Jorge Gonzaga).

For monitoring xylem sap flow, miniature sap flow gauges were mounted on the coarse roots (4–6 mm in diameter) of several tree species at 600 m and 1200 m a.s.l.. Coarse roots were collected from the same tree individuals that were sampled for aboveground traits. First coarse root cross-sections show the variation in root anatomy in the Laipuna dry forest tree species (**Figure 2**).

Comparing aboveground to belowground traits will show which combinations of leaf, stem and root properties are realised in the studied dry forest trees. Tree growth strategies will be linked to root water uptake, and to stand productivity along the studied environmental gradients (precipitation, elevation). The detailed information on tree functional composition compiled by Subproject B1 (**Figure 3**) will support predictions of species shifts in the respective tree communities caused by environmental change.

Geostatistical analyses reveal topographic influence on stable isotope ratios in tree rings

Adams Kyei Nyarko¹, Achim Bräuning¹, Jordy Andres Alvarado Chamba¹, Erwin Beck², and Darwin Alexander Pucha Cofrep³

¹Friedrich-Alexander-University Erlangen-Nuremberg, Germany, member of the RESPECT RU

²University of Bayreuth, Germany, member of the RESPECT RU

³Laboratorio de Dendrocronología y Anatomía de Maderas Tropicales, Carrera de Ingeniería Forestal, Universidad Nacional de Loja (UNL), Ecuador

Stable isotope chronologies from tree rings are widely used proxy records for detecting past environmental variability and the response of trees to ongoing climate change. We examined the correlation strength of isotope time series between twelve individuals of *Cedrela montana* from the Reserva Biológica San Francisco (RBSF) mountain rainforest and found that some trees show weaker common signals, but more individual isotope variations than others. We applied geostatistical modelling to identify topographic factors that strongly influence the isotope composition of tree rings. The most influential site factor was the Topographic Wetness Index, which integrates various site factors determining the water availability for trees as determined by local topography and position within a slope. Such kind of analysis can be helpful to develop a priori sampling strategies for tree-ring stable isotope studies to identify the most suitable tree individuals and to save time effort and laboratory costs.

Introduction

Dated time series of stable carbon and oxygen isotopes in annually formed tree rings provide valuable information about past environmental changes. This holds especially true for humid tropical environments, where tree-ring width series contain much weaker environmental signals than stable isotope chronologies [1]. However, despite of recent technical improvements [2], stable isotope analyses are still time consuming and costly. The use of so-called pooled isotope chronologies, where material from contemporaneous tree-rings of several tree individuals is mixed to produce a common isotopic signal saves time and effort. However, it is preferred to create isotope chronologies of averaged time series of individual trees to calculate the spread of values between different individuals and the strength of a common signal [3]. When comparing the isotope series of individual trees, it often becomes apparent that some trees share a stronger common isotope pattern than others. To prevent a dilution of the common signal in isotope chronologies, tree individuals showing highly individual isotope patterns that might be caused by local disturbance events or stand dynamics are often excluded from further analyses. Therefore, it would be useful to know the criteria that lead to individual isotope patterns in trees before collecting the wood samples in the field and undertaking the isotope analytical procedure. Topographical factors that strongly influence the water budget of trees are a crucial factors controlling the local microsite conditions [4].

In this study, we evaluated the similarities of stable isotope time series between different individuals of *Cedrela montana* in the RBSF forest. Then, we performed geostatistical analyses to identify topographical factors that might lead to the divergent isotope signals in individual trees. To that end, we applied the concept of “isoscapescapes” (isotopic landscapes; [5]) to test if topographic variables can explain deviations in isotope ratios.

Methods

Cedrela montana (Meliaceae) is a deciduous tree species [6] in the tropical mountain rainforest of the Reserva Biológica San Francisco (RBSF) which, according to its life form. Produces distinct annual tree rings [7]. We collected wood samples with increment borers of 5 mm diameter from twelve individual *C. montana* trees distributed in two quebradas (Q2 and Q5) of the RBSF within a narrow altitudinal range of 1970 – 2070 m, to avoid elevation effects on the stable isotope composition of the wood. Per tree, two increment cores were collected for measuring tree-ring width, synchronizing the growth patterns between two radii and assign a calendar date to each formed tree ring [7]. Then, annual tree ring material from one increment core was separated with a scalpel under a microscope, and alpha-cellulose was extracted from whole-wood samples using standard laboratory techniques [8]. Stable isotope values were measured at the Institute of

Geography of Friedrich-Alexander-University in Erlangen-Nürnberg (Germany) with an isotope ratio mass spectrometer (Delta V Advantage, Thermo Fisher) connected to a high temperature (1450 °C) pyrolysis reactor (HT Oxygen Analyzer). The analytical precision of isotope measurements was typically better than ± 0.25 ‰. To account for recent changes in the atmospheric ¹³C source value by anthropogenic fossil fuel burning, $\delta^{13}\text{C}$ isotope values were corrected (according to [9]).

We calculated correlation coefficients between all individual trees' stable isotope series and created three types of chronologies: beside a mean isotope chronology averaged from all trees, a group of four isotope curves showing high intercorrelations were averaged to a chronology termed “good”, whereas trees with lower intercorrelations were averaged to a chronology called “bad”. Statistics assessing chronology quality like the mean interseries correlation (R_{bar}) and Expressed Population Signal (EPS) were computed for the “good” and “bad” chronology, as well as for the chronology including all individuals. The calculation of EPS includes the number of series included in a chronology and their mean interseries correlation, an $\text{EPS} < 0.85$ is generally seen as trustful chronology [10].

The geostatistical analysis was based on the Digital Elevation Model (DEM) deposited in the RESPECT website with a resolu-

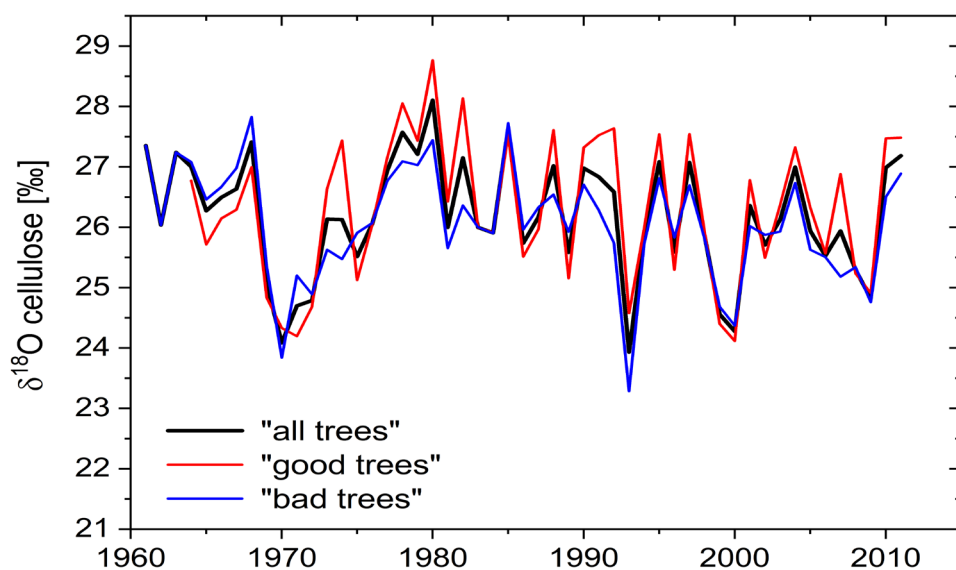


Figure 1: Comparison of three versions the $\delta^{18}\text{O}$ chronology of *Cedrela montana* in the RBSF mountain rainforest over the period 1962–2011, which is common to most trees. Chronology “all trees” is a mean of 12 tree individuals, “good trees” and “bad trees” represent means of subsamples of four trees showing highest and lowest mean correlation with the other trees.

Table 1: Sample number, mean interseries correlation (Rbar) and expressed population signal (EPS) from the three versions of $\delta^{18}\text{O}$ chronologies of *Cedrela montana*

	„good“ trees	„bad“ trees	all trees
sample no.	4	4	12
Rbar	0.577	0.392	0.495
EPS	0.85	0.72	0.92

Table 2: Correlation coefficients between different $\delta^{18}\text{O}$ chronologies of *Cedrela montana* (see Figure 1)

	„bad“ trees	all trees
„good“ trees	0.751	0.935
„bad“ trees		0.935

tion of 30 m. Using the Spatial analyst toolbox in ArcMap the topographic variables elevation, curvature, and slope were derived from DEM. In addition, we calculated the Topographic wetness index as $\text{TWI} = \ln(a / \tan \beta)$ (a is the local upslope area draining through a certain point per unit contour length, and $\tan \beta$ defines the local slope) using the Hydrology Analysis tools (Flow Direction/ Flow Accumulation) in ArcMap [11]. Ordinary multiple regression analysis was applied to generate models quantifying the relationships between the dependent (i.e., stable isotope series) and independent (i.e., topographic) variables [12]. To derive

isoscapes, we tested different interpolation methods, including kriging [13] and deterministic inverse distance weighting (IDW; [14]). To assess the most appropriate interpolating method, we calculated root mean square errors (RMSE) and standard error (SE) from the cross-validation (leave-one-out) of the respective approaches [15]. The final predictive model based on the formula $Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5$, where Y is the predicted value of the dependent variable, B_0 is the intercept, X_1 to X_5 are the distinct independent variables, and B_1 to B_5 are the estimated regression coefficients.

Results and Discussion

Chronology evaluation

Although all analyses were conducted for $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ signals in tree-ring cellulose, we focus here on $\delta^{18}\text{O}$. **Figure 1** shows the three versions of $\delta^{18}\text{O}$ chronologies for the investigated elevation range of the RBSF forest. The mean chronology calculated from 12 trees shows a moderate Rbar value, but due to the high replication the chronology has an EPS of 0.92, passing the recommended threshold for a robust chronology (**Table 1**). On the other hand, the chronology calculated from only four trees showing highest mean correlations would also pass the EPS threshold, whereas a chronology calculated from four trees qualified as “bad” would fail this criterion. Although all three chronologies were highly correlated with each other (**Table 2**), the “good” chronology showed a much higher interannual variability in $\delta^{18}\text{O}$ values than the “bad” chronology (**Figure 1**), underpinning its higher sensitivity to environmental signals. Hence, it is relevant to further analyze which site factors might affect the signal strength of individual trees.

Geospatial analysis of $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values

The distribution of isoscapes indicates the modelled probability of certain average isotope ratios in tree-ring cellulose (**Figure 2**). The spatial variability and distribution of individual tree-ring $\delta^{18}\text{O}$ values in the study area shows clusters and outliers of trees characterized by higher or lower mean isotope values. The final multi-regression models including all topographic variables explained 13 % and even 50 %, respectively, of the variances associated with the topographic variables in predicting the $\delta^{18}\text{O}$ isotope and $\delta^{13}\text{C}$ isotopes values, respectively.

In numbers, the final models quantify as follows:

$$\delta^{18}\text{O} \text{ (estimated)} = 15.023236 + 0.004451 \text{ (Elevation)} + 0.166350 \text{ (TWI)} + 0.014812 \text{ (Curvature Profile)} + 0.009949 \text{ (Curvature Plan)} + 0.061054 \text{ (Slope Angle)}$$

$$\delta^{13}\text{C} \text{ (estimated)} = -11.659995 + -0.008579 \text{ (Elevation)} + -0.164868 \text{ (TWI)} + 0.007276 \text{ (Curvature Profile)} + 0.103816 \text{ (Slope angle)} + 0.034681 \text{ (Curvature Plan)}$$

Table 3: Parameters of the final regression models for $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$. TWI = topographic wetness index

	Coefficient	Estimate	Std.Error	t value	significance
$\delta^{18}\text{O}$	(Intercept)	15.023236	3.388112	4.434	$p < 0.001$
	Slope Angle	0.061054	0.009901	6.166	$p < 0.001$
	Curvature Profile	0.014812	0.011249	1.317	0.1884
	TWI	0.166350	0.032199	5.166	$p < 0.001$
	Elevation	0.004451	0.001764	2.524	0.0119
	Curvature Plan	0.009949	0.005593	1.779	0.0758
$\delta^{13}\text{C}$	(Intercept)	-11.659995	3.250266	-3.587	$p < 0.001$
	Slope Angle	0.103816	0.010072	10.308	$p < 0.001$
	Curvature Profile	0.007276	0.013547	0.537	0.591493
	TWI	-0.164868	0.028991	-5.687	$p < 0.001$
	Elevation	-0.008579	0.001653	-5.188	$p < 0.001$
	Curvature Plan	0.034681	0.006196	5.597	$p < 0.001$

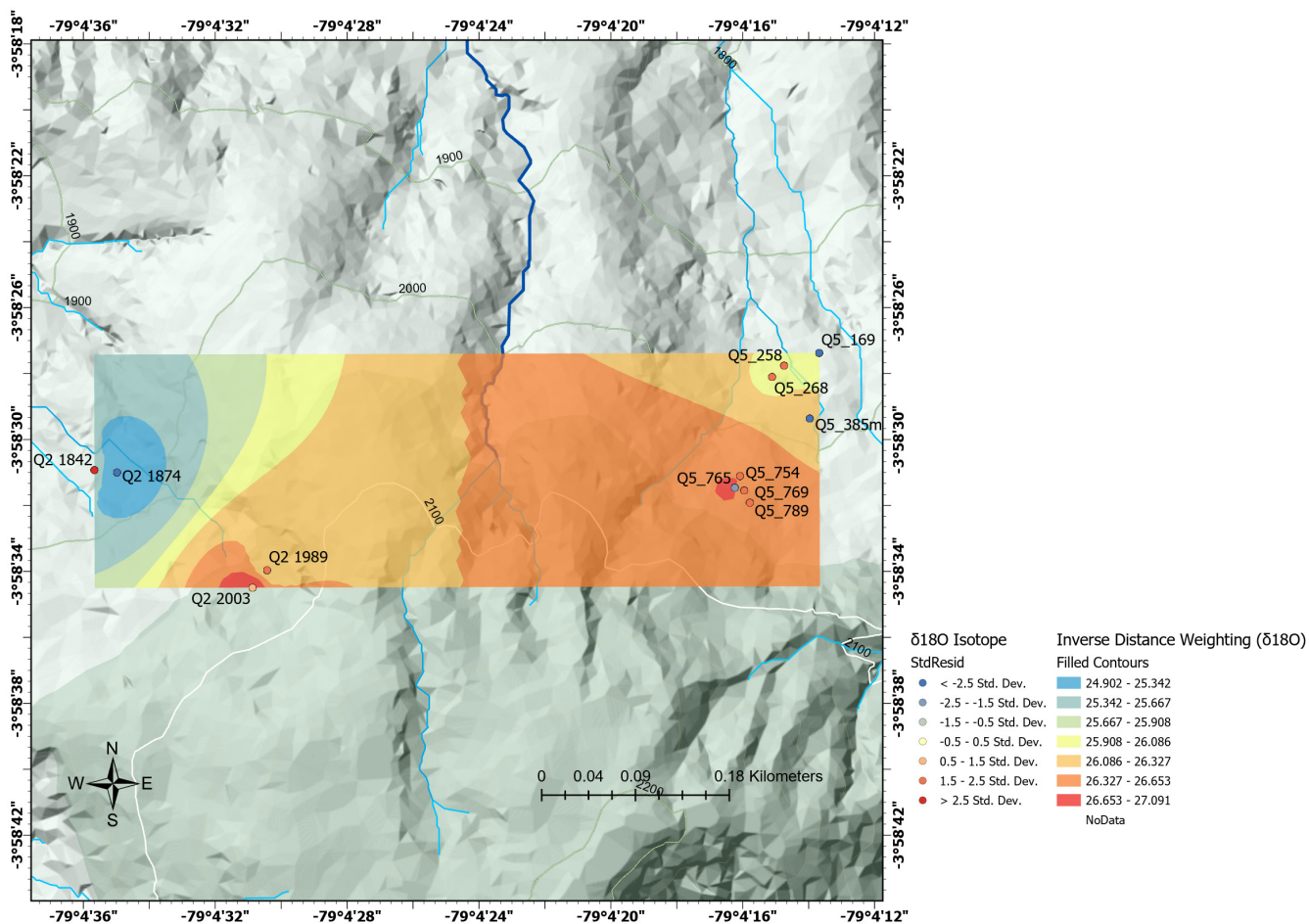


Figure 2: Map showing the OLS regression (stdresid) spatial distributions and the (deterministic method) IDW interpolated $\delta^{18}\text{O}$ (‰) prediction values and spatial distributions from *Cedrela montana* samples in the RBSF study region.

In both isotope signatures, the topography-dependent TWI turns out to be the most relevant factor influencing the isotopic composition of trees, showing the highest estimates in both regression models, followed by slope angle (**Table 3**).

Conclusions

The analyses of the individual tree-ring isotope series demonstrated that a well-selected small tree population of four to five trees may potentially provide enough common signal strength to develop a robust isotope chronology. Knowing “the right” trees may therefore help to facilitate sampling and reduce analytical efforts. However, there is no a priori indication which trees in the landscape contain a strong or weak isotope signal. Our results from geo-statistical analysis revealed a clear impact of topographic variables on stable isotope composition of individual trees. However, the spatial density of our samples and the spatial resolution of our DEM should still be improved to provide reliable estimates for single topographic variables or combinations thereof, which impact the stable isotope signals of trees. In a next step of the analysis, we plan to fill spatial gaps in our sample distribution, to update the tree-ring isotope chronologies to the year 2022, and to develop statistical models to quantify the impact of topographic conditions on the climatic signal in individual tree-ring isotope series.

References

- [1] Volland F, Pucha D, Bräuning A (2016): Hydro-climatic variability in Southern Ecuador from tree-ring oxygen isotopes. *Erdkunde* **70**: 69-82, DOI: 10.3112/erdkunde.2016.01.05
- [2] Rinne-Garmston KT, Helle G, Lehmann MM, Sahlstedt E, Schleucher J, Waterhouse JS (2022): Newer Developments in Tree-Ring Stable Isotope Methods. In: Siegwolf RTW, Brooks JR, Roden J, Saurer M (eds.): *Stable Isotopes in Tree Rings*. Pp 215-248. DOI: 10.1007/978-3-030-92698-4_7
- [3] Foroozan Z, Grieflinger J, Pourtahmasi K, Bräuning A (2019): Evaluation of different pooling methods to establish a multi-century $\delta^{18}\text{O}$ chronology for paleoclimate reconstruction. *Geosciences* **9**, 270, DOI: 10.3390/geosciences9060270
- [4] Fan B, Tao W, Qin G, Hopkins I, Zhang Y, Wang Q, Lin H, Guo L (2020): Soil micro-climate variation in relation to slope aspect, position, and curvature in a forested catchment. *Agric. and For. Meteorol.*, **290**, 107999. DOI: 10.1016/J.AGRFORMET.2020.107999
- [5] Bowen GJ (2010): Isoscapes. Spatial pattern in isotopic biogeochemistry. *Ann. Rev. Earth and Planetary Sciences* **38** (1), 161-187, DOI: 10.1146/annurev-earth-040809-152429
- [6] Bendix J, Homeier J, Cueva Ortiz E, Emck P, Breckle SW, Richter M, Beck E (2006): Seasonality of weather and tree phenology in a tropical evergreen mountain rain forest. *International J. Biometeorol.* **50**: 370-384
- [7] Bräuning A, Volland-Voigt F, Burchardt I, Ganzhi O, Nauss T, Peters T (2009): Climatic control of radial growth of *Cedrela montana* in a humid mountain rain forest in southern Ecuador. *Erdkunde* **63** (4): 337-345.
- [8] Wieloch T, Helle G, Heinrich I, Voigt M, Schyma P (2011): A novel device for batch-wise isolation of α -cellulose from small-amount whole-wood samples. *Dendrochronologia* **29**, 115–117, DOI: 10.1016/j.dendro.2010.08.008
- [9] Graven H, Allison CE, Etheridge DM, Hammer S, Keeling RF, Levin I, Meijer HAJ, Rubino M, Tans PP, Trudinger CM, Vaughn BH, White JWC (2017): Compiled records of carbon isotopes in atmospheric CO₂ for historical simulations in CMIP6. *Geosci. Model Dev.*, **10**, 4405–4417, DOI: 10.5194/gmd-10-4405-2017.
- [10] Wigley TML, Briffa KR, Jones PD (1984): On the Average Value of Correlated Time Series, with Applications in Dendroclimatology and Hydrometeorology. *J. Climate Appl. Meteor.* **23**, 201–213, DOI: 10.1175/1520-0450(1984)023<0201:OTAVOC>2.0.CO;2
- [11] Ray RL (2016): Moisture Stress Indicators in Giant Sequoia Groves in the Southern Sierra Nevada of California, USA. *Vadose Zone Journal*, **15** (10), DOI: 10.2136/vzj2016.03.0018
- [12] Guan H, Simmons C T, Love AJ (2009): Orographic controls on rain water isotope distribution in the Mount Lofty Ranges of South Australia. *Journal of Hydrology*, **374** (3–4), 255–264. DOI: 10.1016/J.JHYDROL.2009.06.018
- [13] Childs C (2004): Interpolating surfaces in ArcGIS spatial analyst. *ArcUser*, July-September, **3235** (569), 32–35
- [14] Maleika W (2020): Inverse distance weighting method optimization in the process of digital terrain model creation based on data collected from a multibeam echosounder. *Appl. Geomatics*, **12** (4), 397–407. DOI: 10.1007/S12518-020-00307-6/FIGURES/9
- [15] Robinson TP, Metternicht G (2006): Testing the performance of spatial interpolation techniques for mapping soil properties. *Computers and Electronics in Agric.*, **50** (2), 97–108. DOI: 10.1016/J.COMPAG.2005.07.003

Progress report: Working in the dry forest

Lea Kerwer¹, Andrea Vanessa Nieto Orellana¹, Matthias Schleuning¹, and Eike Lena Neuschulz¹

¹Senckenberg Biodiversity and Climate Research Centre (SBIK-F) Frankfurt, Germany, members of the RESPECT RU

Towards a story of regeneration success: from tree to seed - to disperser - to seedling and back to tree again!

The tropical dry forest is characterized by a strong seasonality that affects plant phenology and demography (Figure 1). The focus of **Subproject B3** is on the processes involved in plant regeneration of the dry forest of the Laipuna Reserve in South Ecuador. To this end, seed rain is recorded in connection with the fruiting phenology of local tree and shrub species. Together with the Subprojects B1 and B4, a total of 216 mesh traps were installed in the selected forest and agroforest plots at 600 m a.s.l and 1200 m a.s.l., respectively. Since July 2022, the content of the traps is collected every two weeks and all woody species on the plots are monthly inspected for fruiting individuals. Morphological fruit traits, such as size and weight are recorded from a statistically significant number of ripe fruits.

Dispersal types

First results show that most fruits and seed species contain structures for wind dispersal (e.g., a pappus or “wings”), but there are also several species that produce fleshy, animal dispersed fruits [1] (Figure 2).



- 1) Seed of *Ipomea wolcottiana* (wind dispersed)
- 2) Samara of liana sp.1, morphotype (wind dispersed)
- 3) Seed of *Cochlospermum vitifolium* (wind dispersed)
- 4) Capsules of *Cochlospermum vitifolium*
- 5) Pods of *Piscidia carthagenensis* (wind dispersed)
- 6) Mesh trap in the forest
- 7) Drupe of *Bursera graveolens* (animal dispersed)
- 8) Samara of *Terminalia valverdeae* (wind dispersed)
- 9) Open capsule of *Eriotheca ruizii* (wind dispersed)
- 10) Drupe and seed of *Geoffroea spinosa* (animal dispersed)
- 11) Samara of liana sp.2, Sapindaceae (wind dispersed)

Figure 2: Diversity of fruits and seeds collected in forest and pasture plots at both 600 m a.s.l. and 1200 m a.s.l. in Laipuna. Photos: Andrea Nieto and Lea Kerwer



Figure 1: Seasonality in the dry forest. View from the station after the rainy season (left) and during the dry season (right). Photos: Lea Kerwer



Figure 3: Seedling experiments in the forest (1) and on a pasture (2). Sown seeds are from species fruiting at the end of the rainy season in May (3): *Bursera graveolens*, *Acacia macracantha*, *Albizia multiflora*, and *Erythrina velutina* (from left to right). Sown seeds from species fruiting during the dry season September/October (4): *Cochlospermum vitifolium*, *Eriotheca ruizii*, *Ipomea wolcottiana*, and *Geoffroea spinosa* (from left to right). Photos: Lea Kerwer

Seedlings' establishment

The second part of Subproject B3 investigates how litter cover and shade affect seedling establishment and survival, depending on the various traits of seeds. In the forest as well as on the pasture sites 480 seedling experimental plots have been put up in May

and November 2022 (i.e. at the end of the rainy season and towards the end of the dry season, respectively), using seeds of eight indigenous tree species: *Acacia macracantha*, *Albizia multiflora*, *Bursera graveolens*, *Erythrina velutina*, *Cochlospermum vitifolium*, *Eriotheca ruizii*, *Geoffroea spinosa* and *Ipomea wolcottiana* (Figure 3).

We apply shade and litter treatments on the experiments: Shading is achieved by a roof of translucent cloth while litter thickness is manipulated by manual litter removal once per week. In spite of the dry season, we have been able to record seedlings of a few seeds, which have already germinated, but the majority is expected to follow during the rainy season.



Figure 4: The team of co-workers from Canguraca and Naranjito: Rigoberto Acaro, Andrea Nieto, Lea Kerwer, José Maza, Manuel Armijos (front row, from left to right) and Jairo Moreno, Javier Armijos, José Calva, José Acaro, Francisco Moreno, Raúl Chalaco, Cristian Armijos, Guillermo Acaro (second row, from left to right). Photo: Lea Kerwer

Acknowledgements

None of this would have been possible without the great help by people from the villages of Canguraca and Naranjito, who were instrumental in installing the plots, mesh traps and the seedling experiments (Figure 4).

Reference

[1] Pennington TD, Reynel C, Daza A (2004): *Illustrated guide to the Trees of Peru*. Drawings by Rosemary Wise, dh, Sherborne, England, p. 848.

General patterns and reciprocal influences of arthropod communities, herbivory, and predation in a mountain dry forest of southern Ecuador

Jana E. Schön¹, Annemarie Wurz¹, Roland Brandl¹, and Nina Farwig¹

¹University of Marburg, Germany, members of the RESPECT RU

We aim to get a comprehensive overview of both arthropod-induced herbivory and arthropod community patterns in relation to plant community characteristics and predation in the mountain dry forest (MDF) of southern Ecuador. Therefore, we assess arthropod communities and herbivory (= leaf area loss [%]) by arthropods in the MDF. For our research, we used the joined core plots of RESPECT consisting of six 1 ha plots per land-use type (forest and pasture). Per land-use type, three plots were located each at 600 m a.s.l. and 1200 m a.s.l. Preliminary results showed no significant differences in canopy herbivory [%] between 600 and 1200 m a.s.l. However, first evaluations of one plot for each elevation-land-use type combination showed that understory arthropod abundance as well as arthropod diversity were higher at 1200 m than at 600 m and in forest than in pasture. Additionally, first predation results highlighted arthropods as the main predators of caterpillars (70 %). Further analyses of spatial and seasonal variation in herbivory as well as leaf palatability, arthropod communities, and predation of arthropods, will provide insights into the interactions between plants and arthropod herbivores in two different land-use types and elevations.

Arthropod herbivores are shaping plant populations in various ways e.g. by influencing phenotypic variation of plant traits. Especially in tropical dry forests, herbivore pressure on plants is considerably high [1] and can have strong influences on ecosystem functions such as carbon cycles. Herbivores in turn, are affected by traits of plants (bottom-up) and the intensity of predation (top-down). In **Subproject B4**, we used the 12 joined core plots in the MDF to unravel effects of both land-use type (six forest and six pasture plots) and climate, represented by elevation (each six plots at 600 and at 1200 m a.s.l.), on the patterns of understory- and canopy herbivory, as well as on seasonal variation of herbivory, leaf palatability of host plants, the composition of arthropod communities in the understory, and predation rates on arthropods.

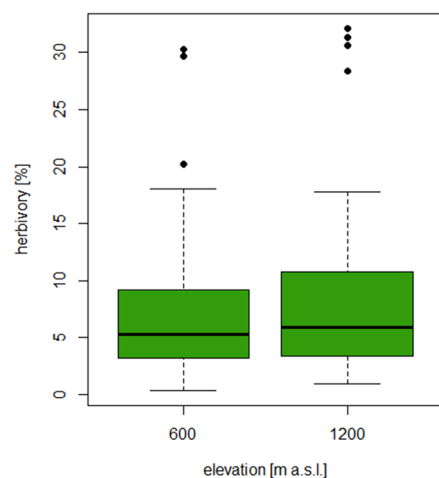


Figure 1: The mean herbivory [%] caused by arthropod herbivores per tree of 182 tree individuals at 600 m (87 tree individuals) and 1200 m (95 tree individuals) in MDF forest plots. Graph: Jana Schön



Figure 2A: Mesh trap (60 cm x 60 cm) for the year-around litter collection. **B:** Beating (20 hits) of a bush with a stick to collect arthropods in the beating sheet. **C:** Collection of falling arthropods into the 1 m² beating sheet with a pooper. Photos: Jana Schön (2) and Annemarie Wurz

Here, elevation is used as proxy for varying climatic conditions being harsher at 600 m and more favourable at 1200 m a.s.l.. According to literature, decreasing environmental favorability leads to an increase in plant defence rates [2], resulting in a decrease in plant palatability [3]. Thus, we expect both higher herbivory rates and a greater leaf palatability at 1200 m than at 600 m. Additionally, we expect lower herbivory rates in the understory than in the canopy due to lower biomass production in the understory [4] and a strong seasonal variation in community herbivory due to changes in the foliar chemical composition in the plant communities [5]. Finally, we expect interrelations between understory arthropod community compositions, predation, and herbivory in the understory of the MDF.

Canopy herbivory

Between March-May 2022, we assessed herbivory caused by arthropod herbivores

of 22 tree species growing in the forest plots at 600 and 1200 m a.s.l. To do so, we scanned for each tree 20 sun-exposed leaves collected during a joint field campaign by using eight tree individuals of each species. Scans were analyzed with the software WinFOLIA™ 2019 [6]. Our preliminary results showed no significant differences in the level of herbivory between 600 m and 1200 m (**Figure 1**).

The occurrence of seven different damage types is currently quantified [7] (Master thesis of Eva Ullrich).

Seasonal variation of herbivory

To determine the seasonal variation of herbivory, we established 18 mesh traps (**Figure 2A**) on each core plot to collect litter from the surrounding vegetation. The collection started in June 2022 and will end in June 2023. Traps are emptied every two weeks by Ecuadorian field assistants



Figure 3A: Punching of leaf discs for the feeding trial. Each disc has a diameter of 2 cm. **B:** Two discs of the same tree individual are offered for 24 h to one adult Jamaican field cricket (*Gryllus assimilis*). The crickets starved for 24 h before the beginning of the feeding trial. **C:** Overview of the feeding trial with crickets separated into starving individuals, crickets with offered leaf discs in the running experiment, and non-adult specimens, which still have to develop to the adult stage. Misdeveloped or hurt individuals were separated and excluded from the feeding trial. Photos: Jana Schön

Leaf palatability

We determined the palatability of the leaves of the same 22 tree species as used for the estimates of canopy herbivory in a feeding trial using the Jamaican field cricket (*Gryllus assimilis*, **Figure 3**). We expected a decrease of palatability across the plant functional types deciduous, semi-deciduous, and evergreen (Master thesis of Sarah Ullrich).

Arthropod composition and herbivory of the understory

To characterize changes in the arthropod composition of the understory in the MDF, we selected 12 bushes or small trees on each plot between April and May 2022. Bushes were beaten with a stick and falling arthropods were collected with a beating sheet (**Figure 2B**). All arthropods within the sheet (**Figure 2C**) were stored in 75 % ethanol. This procedure was repeated twice per plot to analyze possible seasonal variations. Arthropod samples are currently counted, determined, if possible, to the family level by an expert and assigned to feeding guilds (e.g. sap sucker, leaf chewer).

(Gabriel Acaro and David Moreno). Due to the quantity of leaves within samples, we analyze every second collection. For the determination of herbivory, the dried leaves are sorted by the Ecuadorian field assistant

Nohemy Poma before they are soaked and scanned by the Ecuadorian field assistant Magalí Gordillo. Scanned leaves will be analyzed with the software WinFOLIA™ 2019 [6] to estimate herbivory.

After sorting arthropod samples of a small subset of vegetation units, the data support our hypotheses of a greater arthropod abundance and diversity in forest- compared to pasture plots and at an elevation of 1200 m compared to 600 m a.s.l. (**Figure 4**).

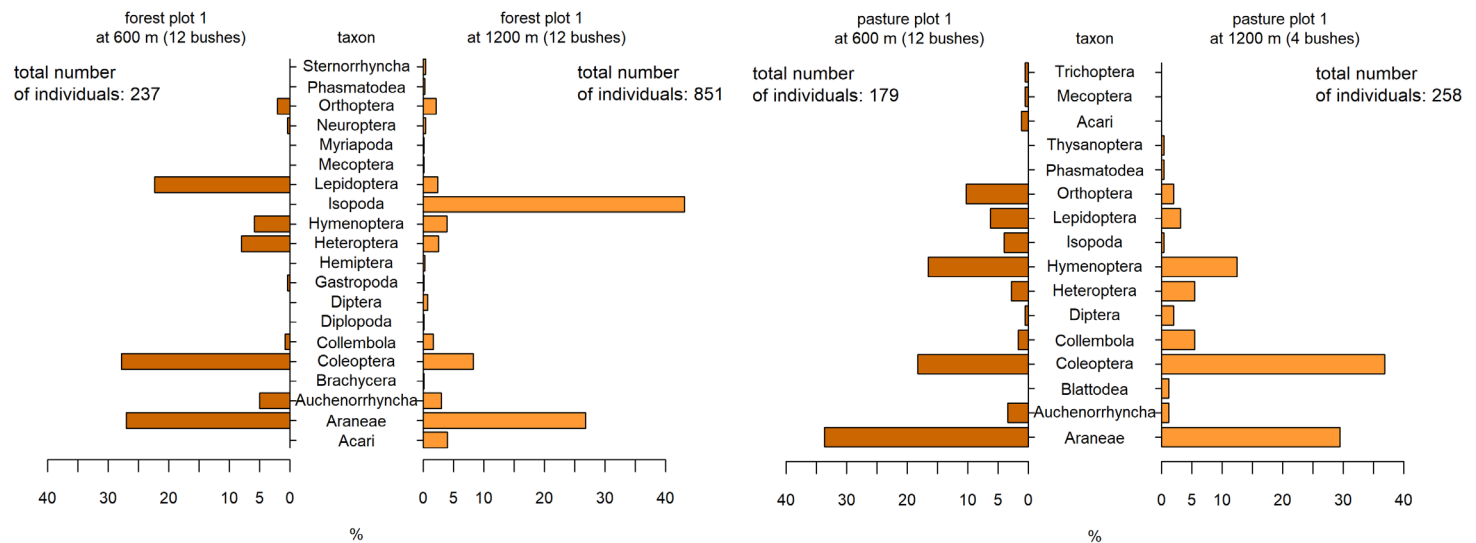


Figure 4: Proportion [%] of arthropod taxa per vegetation unit (bush or small tree) of the understory for both elevations (600 m and 1200 m a.s.l.) and the land-use types forest (left) and pasture (right). Except for the pasture plot 1 at 1200 m (four vegetation units), 12 vegetation units have been evaluated per plot. Graphs: Jana Schön

To analyze relations between arthropod mean body mass and land-use type as well as elevation, we will dry and weigh the sorted samples to calculate the mean body mass per individual.

To quantify herbivory rates in the understory, we randomly selected 20 leaves per vegetation unit, scanned them and are currently analyzing the herbivory with the software WinFOLIA™ 2019 [6].

Predation on arthropods

To quantify and categorize predation on arthropods in the understory, we deployed caterpillar dummies on understory vegetation (**Figure 5**, master thesis of Camilo Gonzalez and trainee project of Diana Ontaneda). For preliminary results see **Figure 5C**.

References

[1] Coley PD, Barone JA (1996): Herbivory and plant defenses in tropical forests. *Annu Rev Ecol Syst.* **27**:305–35.

[2] Coley PD, Bryant JP, Chapin FS (1985): Resource availability and plant antiherbivore defense. *Science* **230** (4728): 895–9.

[3] Descombes P, Marchon J, Pradervand JN, Bilat J, Guisan A, Rasmann S, et al. (2017): Community-level plant palatability increases with elevation as insect herbivore abundance declines. *J Ecol.* **105** (1):142–51.

[4] Neves FS, Silva JO, Espírito-Santo MM, Fernandes GW (2014): Insect Herbivores and Leaf Damage along Successional and Vertical Gradients in a Tropical Dry Forest. *Biotropica* **46** (1): 14–24.

[5] Yamasaki M, Kikuzawa K (2003): Temporal and spatial variations in leaf herbivory within a canopy of *Fagus crenata*. *Oecologia* **137** (2): 226–32.

[6] Regent Instruments Inc., Quebec City, QC, Canada

[7] Labandeira CC, Wilf P, Johnson KR, Marsh F (2007): *Guide to insect (and other) damage types on compressed plant fossils*. Smithsonian Institution, Natl Museum Nat Hist Dep Paleobiol Washington, DC. 1–25.

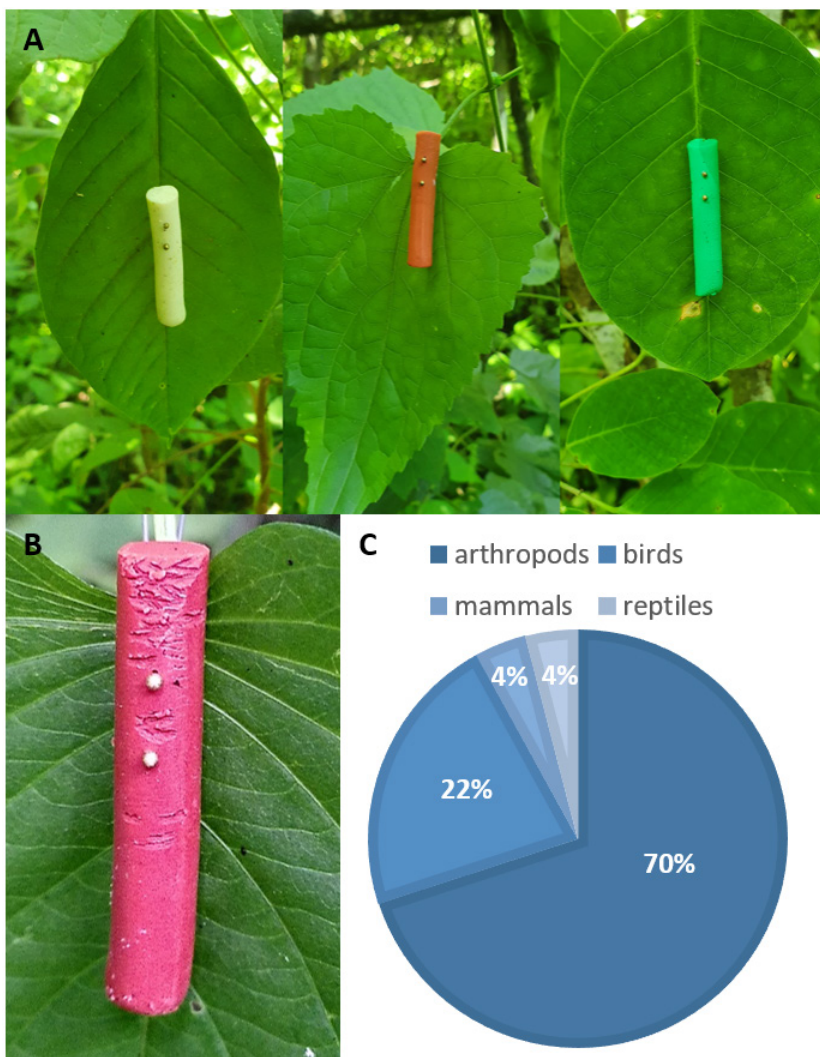


Figure 5A: Caterpillar dummies made of plastiline (white, brown, and green) deployed at understory vegetation. In two runs, we deployed 150 dummies (50 per color) per plot and collected them after four days. **B:** Predation marks at a brown caterpillar dummy. Predation marks were determined with the help of literature. Categories were e.g. reptile, bird, amphibian, Orthoptera, big ant, small ant, and spider. Color variation between the brown dummies in the pictures are due to the use of different cameras and varying light conditions. **C:** Proportion of bite marks at caterpillar dummies of certain predator groups. In total, 12.5 % of all caterpillar dummies were attacked by predators. Photos: Annemarie Wurz and Jana Schön. Graph: Jana Schön

Data Warehouse News

New features of the Research Unit's data portal

Christian Beilschmidt¹, Johannes Drönner¹, Maik Dobbermann², Oliver Limberger², and Jörg Bendix²

¹Geo Engine GmbH, Germany

²University of Marburg, Germany, members of the RESPECT RU

The upcoming RESPECT Data Portal offers a GIS-like working environment for RESPECT's project data. In the following, we give a brief overview of the utilized Geo Engine technology and planned features.

The Geo Engine

Geo Engine is a platform service that supports access to raster and vector data, spatio-temporal workflow processing and analysis of geospatial data, and flexible data access via standards-compliant interfaces. It is the successor of the VAT system [1], which already powers GFBio's [2] data portal since 2014 and GEO BON's EBV Analyzer since 2020 [3]. Geo Engine offers new functionality to empower (data) scientists dealing with large and heterogeneous data sets via different semantically equivalent interfaces (e.g., a Python interface for programming-savvy users and a GIS-like web user interface for users that like to work graphically with geodata). Among the many novel features of Geo Engine is its abstraction for data access, and its consistent temporal approach to treating every data item as a time series. In particular, this makes Geo Engine a unique system for geospatial time series processing.

The goal for the project

We set out to incorporate Geo Engine to integrate raster and vector data better for the research group. It will be possible to use Geo Engine as a web-based GIS tool with raster and vector data from the data warehouse and external raster data (Sentinel LAI, ERA5, etc.) loadable as layers and to create overlays and calculations with this data.

Additionally, it will play an important role in working with model data output and serve as a platform to exchange these outputs, visualize time series in raster data and do computational data analysis with the built-in toolbox or with Jupyter Notebooks. Customly defined workflows can be made persistent to share or redo them with ease.

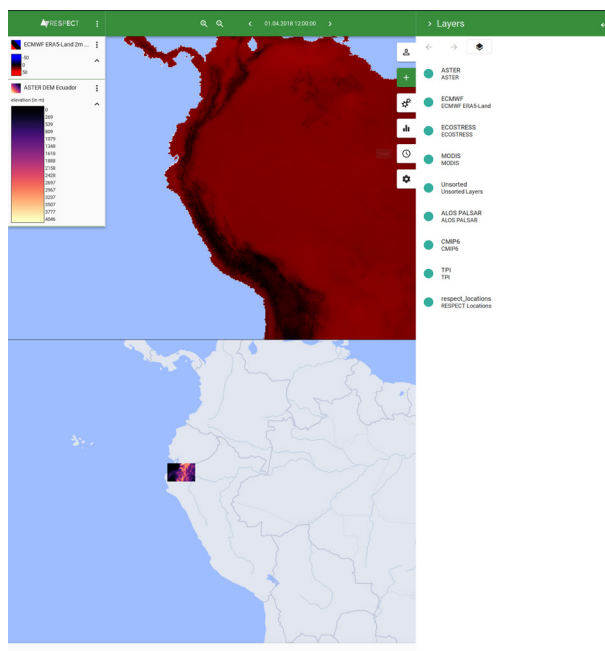


Figure 1: Two remote sensing datasets side by side: Temperature and DEM. Screenshot: Christian Beilschmidt

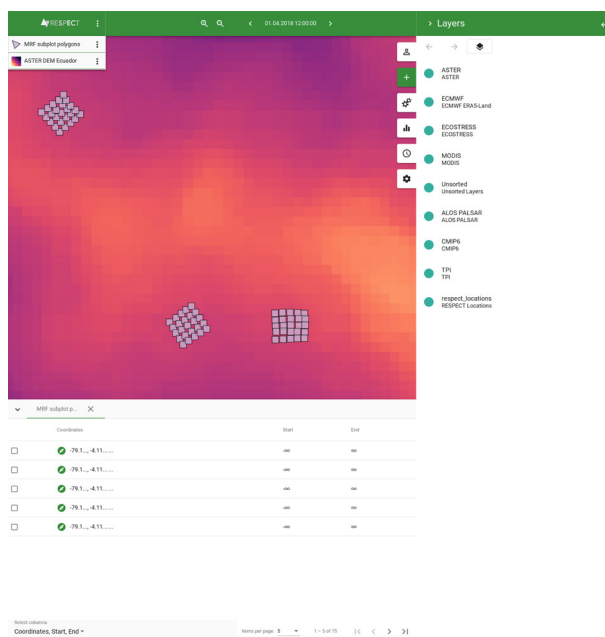


Figure 2: Subplots data as polygonal areas. Screenshot: Christian Beilschmidt

The toolbox will provide means to calculate aggregations, reprojections, interpolation, and a variety of statistics on your selected raster and vector layers. Also, it will be possible to enrich vector data with raster data.

A repository for public data

Within RESPECT, we gathered a set of remote sensing and model data from public data sources. Although these sources are available and accessible for everyone, it is very cumbersome to retrieve the data in a format to be processable and combinable. In RESPECT's Geo Engine instance, we have gathered layer from the following datasets so far:

- ECOSTRESS
- SENTINEL LAI
- ECMWF ERA5 Reanalysis
- CMIP6
- ALOS PALSAR
- ASTER

On the right in **Figure 1** we see the repository view that lists these data hierarchically by source and instrument or model, respectively. On the left, for instance, we see layers of ASTER DEM and ECMWF ERA5-Land data. Here, each layer individually references one variable of the data. One can add additional layers to the layer list (left) and browse through the map via common panning and zooming operations. Moreover, on top one can browse through time to see different points in time of the dataset.

A repository for project-specific data

Alongside public data, it is of particular interest to incorporate datasets that are specifically gathered for RESPECT or which are produced by outcomes of the RESPECT projects. Examples are gathered remote sensing data by aircraft overflights, produced model data by methods developed by RESPECT's project members, and metadata for RESPECT's area of interest, which is Ecuador, e.g., points or polygons of named plots and locations. **Figure 2** shows subplot locations in Ecuador, which can be utilized for locating areas but also for using them within Geo Engine's operator toolbox.

Operator toolbox

RESPECT's Geo Engine instance offers a basic set of spatio-temporal operators. These can be used to work with data directly within the system. The toolbox consists of operators for raster data, vector data, plots, and mixed operations. For rasters, one can use data transformations and up- and unscaling data. One can calculate expressions on multiple layers at once, interpolate data to higher resolutions and compute temporally aggregates. For vector data, one can filter data and compute relationships, e.g., point in polygon. There are several plots available, for instance, histograms, box and scatter plots, as well as temporal line plots for rasters or vector feature attributes. For combining raster and vector data, one can use a raster vector join operation. **Figure 3** shows the combination of RESPECT's subplot polygons with ASTER DEM data. The output is the enhanced subplot dataset with the average of the DEM pixels being attached as an additional attribute.

Python integration

Besides using the RESPECT Data Portal for a GIS-like experience, one can access

the same data and computations by using Geo Engine's Python package for, e.g., Jupyter Notebooks. **Figure 4** shows accessing the result of the raster vector join computation within a Jupyter Notebook. Here, the user retrieves the vector data as a geopandas (<https://geopandas.org>) data frame. Raster data can be retrieved as xarray's (<https://xarray.dev>).

User access through the data warehouse

Our data warehouse will be used as a single sign on (SSO) provider so all users who have access to our known research platform will be able to use the Geo Engine service and have access to the data stored there as well.

Summary and Outlook

We will work together with the Geo Engine team to bring those features to the platform in Q1 2023.

References

[1] Beilschmidt, C., Dröner, J., Mattig, M., Seeger, B. (2017): VAT: A System for Data-Driven Biodiversity Research. *20th International Conference on Extending Database Technology (EDBT)*.

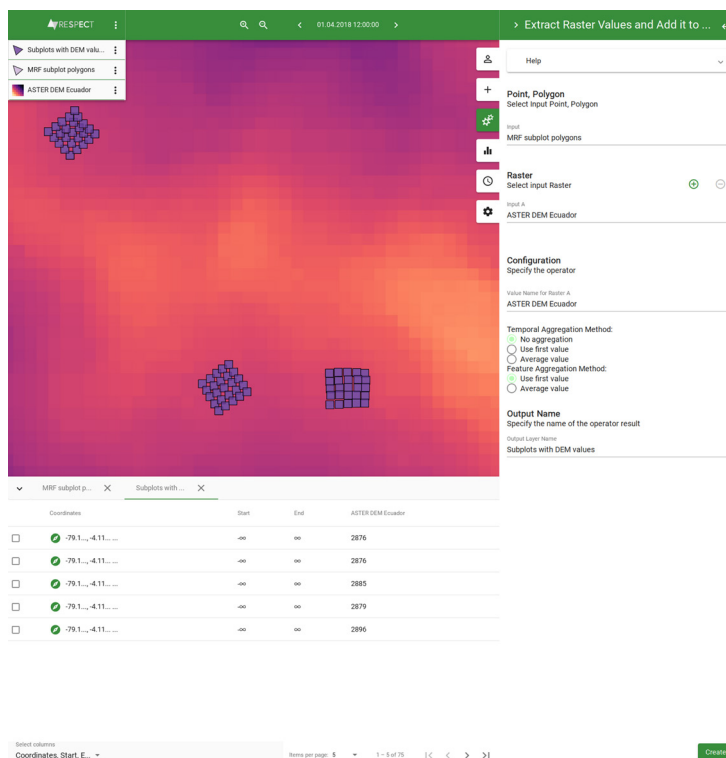


Figure 3: Subplots after being enriched by DEM raster data. Screenshot: Christian Beilschmidt

[2] Michael Diepenbroek, Frank Oliver Glöckner, Peter Grobe, Anton Güntsch, Robert Huber, Birgitta König-Ries, Ivaylo Kostadinov, Jens Nieschulze, Bernhard Seeger, Robert Tolksdorf, Dagmar Triebel (2014): *Towards an Integrated Biodiversity and Ecological Research Data Management and Archiving Platform: The German Federation for the Curation of Biological Data (GFBio)*. GI-Jahrestagung 2014: 1711-1721

[3] Beilschmidt C., Drönner J., Mattig M. and Seeger B. (2020): Building the Next-Generation EBV Analyzer GEO BON. *Open Science Conference & All Hands Meeting 2020*

```
In [ ]: import geoengine as ge
        from datetime import datetime

In [ ]: ge.initialize('https://respect.app.geoengine.io/api', token=
ge.get_session())

Out[ ]: Server:          https://respect.app.geoengine.io/api
        Session Id:     9c3b8303-f7ad-44a9-a5e6-60fb4c98c39e
        Session valid until: 2022-11-24T14:35:39.753Z

In [ ]: workflow = ge.workflow_by_id('2d20f694-a1a8-505d-8f73-0e51843d3758')
        workflow

Out[ ]: 2d20f694-a1a8-505d-8f73-0e51843d3758

In [ ]: time = datetime.strptime('2018-04-01T12:00:00.000Z', "%Y-%m-%dT%H:%M:%S.%f%z")
        workflow.get_dataframe(ge.QueryRectangle(
            spatial_bounds=[-79.18653541925835, -4.117778131685283, -79.16445547464775, -4.105836937150981],
            time_interval=[time, time],
            resolution=(0.000010728836059570312, 0.000010728836059570312),
            srs='EPSG:4326',
        ))

Out[ ]:
           geometry  ASTER DEM Ecuador  start  end
0  POLYGON ((-79.17561 -4.11427, -79.17543 -4.114...  2876  NaT  NaT
1  POLYGON ((-79.17543 -4.11415, -79.17525 -4.114...  2876  NaT  NaT
2  POLYGON ((-79.17529 -4.11404, -79.17511 -4.114...  2885  NaT  NaT
3  POLYGON ((-79.17516 -4.11394, -79.17498 -4.113...  2879  NaT  NaT
4  POLYGON ((-79.17502 -4.11384, -79.17484 -4.113...  2896  NaT  NaT
...  ...  ...  ...  ...
70 POLYGON ((-79.17275 -4.11475, -79.17257 -4.114...  2871  NaT  NaT
71 POLYGON ((-79.17254 -4.11474, -79.17236 -4.114...  2877  NaT  NaT
72 POLYGON ((-79.17234 -4.11472, -79.17216 -4.114...  2876  NaT  NaT
73 POLYGON ((-79.17215 -4.11471, -79.17197 -4.114...  2885  NaT  NaT
74 POLYGON ((-79.17197 -4.11471, -79.17178 -4.114...  2885  NaT  NaT

75 rows x 4 columns
```

Figure 4: Querying enriched subplots in a Jupyter Notebook. Screenshot: Christian Beilschmidt

Event Report

Open Day for the community

Annemarie Wurz¹

¹University of Marburg, Germany, members of the RESPECT RU

To thank and inform the communities of Canguraca, Portachuelo and Naranjito about our research, we invited all interested citizens for one day to the Laipuna research station. The open day included a project presentation, German food tasting and six workshop stations, where the visitors were able to get their hands on research methods. The day offered surprises and was a memorable event for both sides, our visitors and us researchers.

The Laipuna Reserve is surrounded by agricultural fields which are managed by the communities of Canguraca, Portachuelo and Naranjito. Thus, doing research in and around the Laipuna Reserve involves daily interactions with the residing communities. In addition, some of the locals work in our project as field assistants, cooks, house help or people renting out plots. Life around Laipuna Reserve is hard, especially in the dry season when agricultural resources are limited. Despite the simplicity of life around the Laipuna Reserve, people are generally very friendly, cheerful and generous. While collecting data in the field, we were often asked curious questions about our research. Thus, we felt the strong need to give back to the community, thank them for their support and explain our research. Therefore, we invited all interested citizens for one day to the Laipuna research station located at the edge of the Laipuna Reserve.

Unexpected workarounds

The open day for the community took place on the 1st May 2022. Nine team members



Figure 1: Since power supply stopped short before our open day, Andrea Nieto presents our research project and who is working on which of the plots with an improvised map. Photo: Annemarie Wurz

of our RESPECT Research Unit established six stations to present the research of each subproject. One day before, we prepared a welcome banner, a presentation, signs for all the stations and food. Suddenly, the power was cut. With joint forces, we put candles around the room, shared our power banks and collected water for the bathrooms. We decided not to be depressed and re-organize our plans: We replaced our beamer presentation with a simple paper map showing our research plots. On top of the power cut, we had lost the prepared presents for the community: a flyer with photos of them and our research objectives. Spontaneously, we baked cookies and packed little thank-you packages – luckily the oven was not electric.

Hands on the amazing biodiversity

On Sunday morning, our invitees arrived very punctually. We gathered everyone on the terrace and offered snacks and drinks. José, our station manager, started with a welcome speech followed by PhD student Andrea Nieto. With great passion and many jokes, she presented our project and research goals (**Figure 1**). After this introduction, people were less shy and ready to explore the house. We distributed the invitees to the six stations. The first station was called “Colección de insectos” (= collection of insects) and PhD student Jana Schön demonstrated how to collect arthropods from the vegetation (**Figure 2**). With a stick and cotton sheet, she bet the vegetation and asked our invitees to use self-made pooters to suck the insects into plastic tubes. Amazed by the diversity of animals, kids as well as their parents were enthusiastic to give it a try.



Figure 2: Jana Schön demonstrates the collection of arthropods with a pooter. Photo: Felix Matt

The second station was named “Trampas de hojas y semillas” (= traps for leaves and seeds) and led by PhD student Andrea Nieto. Andrea showed everyone how traps can collect seeds and leaves (**Figure 3**). With a camera, Andrea demonstrated how she



Figure 3: Andrea Nieto explains the traps to collect seeds and leaves. Photo: Annemarie Wurz



Figure 4: Oliver Limberger and Eirik Heilmann are explaining spectral leaf measurements applied in Subproject A1. Photo: Annemarie Wurz

documents seed properties. She asked our invitees to get hands-on with the camera and take their own shot. Station three was called “Mediciones de hojas” (= leaf measurements) and was led by PhD student Oliver Limberger and the bachelor and master students Eirik Heilmann and Eva Ullrich (**Figure 4**): Oliver demonstrated how to do spectral measurements on leaves, Eva showed how to measure herbivory on leaves and Eirik demonstrated how to measure other leaf properties.

Predators attacking artificial caterpillars

The fourth station was called “Grillos” (= crickets) and was organized by master student Sarah Ullrich (**Figure 5**): Here, she explained how she uses crickets to test the palatability of leaves of different tree species. Our invitees were very curious to see the crickets in their boxes eating on leaves. The fifth station was named “Orugas” (=



Figure 5: Sarah Ullrich presenting her feeding experiment with crickets. Photo: Felix Matt



Figure 6: Diana Ontaneda presents her caterpillar collection made of plasticine used in the feeding experiments of Subproject B4. Photo: Annemarie Wurz

caterpillars) and managed by researcher Diana Ontaneda (**Figure 6**). Diana, a Loja local, explained with great enthusiasm how she uses artificial caterpillars made of plasticine and different colors to investigate who predate them and how much. She asked our invitees to attach the artificial caterpillars with needles to the surrounding vegetation. Great laughter was heard by some of our guests. The final station was called “Semillas y Plántulas” (= seeds and seedlings) and was prepared by PhD student Lea Kerwer (**Figure 7**). She demonstrated how she is using a sieve to assess seeds in the soil and explained her seedling experiment.

After everyone had visited all stations, all gathered on the terrace to try some tra-



Figure 7: Lea Kerwer demonstrates what matters when measuring the size of seedlings. Photo: Felix Matt

ditional German food: Arme Ritter. Arme Ritter is bread bathed in milk and egg and fried. We served it with cinnamon sugar as well as self-made fruit puree. The food was very popular. Then the music started and we all danced together to Latin beats. Even the oldest of the communities stood up and were moving their legs. Also, people cheerfully had conversations in different groups around the house. Our infrastructure host Nature and Culture International (NCI) was represented by Felipe Serrano and Pedro Paladines. They gave us positive feedback as they were also very happy to learn more about our research. We all agreed that this event was a full success and shall be repeated in the future.

Events

The 6th **European Conference of Tropical Ecology** (<https://gtoe2023.bc.cas.cz/>) will be hosted in Ceske Budejovice, a small university town in the South of the Czech Republic from 19 to 23 June 2023. The conference will be organized in collaboration with Faculty of Science of University of South Bohemia in Ceske Budejovice, Biology Centre of Czech Academy of Sciences and with help of The Czech Society for Ecology. The call for symposia is open until January 15th, 2023. We will organize a symposium on elevation gradients from our RESPECT Research Unit.

UTPL News¹⁾

Assessment of structure and biomass of tropical mountain dry and rain forests – first results from southern Ecuador

Víctor González-Jaramillo¹

¹Universidad Técnica Particular de Loja (UTPL), Departamento de Ingeniería Civil, Ecuador, Counterpart of the RESPECT Research Unit

The structure of tropical mountain dry and rain forests can be accessed by means of remote sensing data such as LiDAR or UAV. It shows a significant difference, which is due to characteristics of the trees that grow in them, that directly influence the capacity of Above Ground Biomass storage.

Forests have become one of the key elements to mitigate the adverse effects of climate change, well considered in international political agreements and particularly in the Sustainable Development Goals (SDGs) of the 2030 agenda. Forests have the capacity to absorb atmospheric CO₂ and convert it into biomass, which can be quantified either as Above Ground Biomass (AGB) or biomass carbon content (C). Beyond, tropical forests offer essential functions by delivering ecosystem services such as cleaning polluted air, warranting water supply, preventing soil erosion and providing habitats for a high diversity of species.

At the same time, South American forests have undergone great changes and high deforestation rates are reported over the last decades [1], also in Ecuador [2]. Deforestation is mainly driven by generating agriculture land, non-sustainable wood extraction and livestock breeding.

Along the altitudinal and climate gradients in southern Ecuador, different types of mountain forests can be found, ranging from the tropical mountain forest (TMF) in the upper middle part of the Andean mountain range to the tropical dry forest (TDF) located in the lowest and most arid parts. Both forest types are analysed in the RESPECT Research Unit where one major question is their carbon sink function under climate change.

It must be stressed here that the spatial variability is high due to the complex topography and in a patchy structure of changing climatic and edaphic co-factors on a small scale. In less protected sites of the TMF for instance, such as the mountain tops or slopes (ridge sites), the harsh climatic conditions result in smaller trees, while in sheltered areas (ravine sites) and/or sites with a better nutrients status trees are getting taller and show higher AGB values.

However, spatial-explicit AGB quantification in remote areas of the Andes with high tree diversity is difficult and can hardly be done by traditional methods because the solution of allometric equations require variables such as tree height, tree diameter at breast height (DBH) and wood density [3]. Field data from different tree groups can help to derive AGB from remote sensing data (satellite images, Airborne Laser Scanning ALS data, unmanned aerial vehicles (UAV), but particularly for ALS and UAV, but always considering that large-area applications are limited. Nevertheless, for smaller areas, ALS and UAV data have a very high potential to retrieve the parameter tree height, and estimate the diameter at breast height at the individual tree level.

For the TMF, we have both, ALS and UAV at hand, that were obtained under the German Research Foundation DFG (ALS under BE1780/17-2) and executed under the Bilateral Cooperation with South Ecuadorian Universities in Ecosystem Research (BE1780-20-2; 27-2; 32-1). From the ALS data Digital Terrain Model (DTM) and the Digital Surface Model (DSM) were derived and used for individual tree detection including different parameters such as tree height and DBH that later have been used to estimate AGB [4, 5]. From the UAV data, after a photogrammetric process it was obtained a point cloud, which was then processed as the data from the LiDAR and the same parameters were derived at the individual tree level. The UAV results were compared with LiDAR result, taking as reference the high resolution and precision of the data coming from the LiDAR sensor. For TDF, preliminary UAV data is available, in which case correspond to 4 plots, considered as disturbed forest.

The TMF results revealed an average AGB of approximately 106 Mg/ha, while in the

upper part of the same area (elfin forest) under harsh climatic conditions only an average AGB of ~33 Mg/ha was observed. In the lowest and most arid parts (TDF), work has initially been carried out in an area of disturbed forest, where a maximum AGB of 23 Mg/ha was determined.

As can be seen, the reduced AGB values obtained for some expressions of the TMF and TDF can be explained because dominant trees represent approximately 70% of the biomass present in each site. The research shows that in the dry forest trees have lower heights than those present in the TMF.

References

- [1] Food and Agriculture Organization of the United Nations. Global Forest Resources Assessment (2015): *Desk Reference; Food and Agriculture Organization of the United Nations*. Rome, Italy.
- [2] González-Jaramillo, V.; Fries, A.; Rollenbeck, R.; Paladines, J.; Oñate-Valdivieso, F.; Bendix, J. (2016): Assessment of deforestation during the last decades in Ecuador using NOAA-AVHRR satellite data. *Erdkunde*, **70**, 217–235. DOI: 10.3112/erdkunde.2016.03.02
- [3] Chave, J.; Andalo, C.; Brown, S.; Cairns, M.A.; Chambers, J.Q.; Eamus, D.; Fölster, H.; Fromard, F.; Higuchi, N.; Kira, T.; et al. (2005): Tree allometry and improved estimation of carbon stocks and balance in tropical forests. *Oecologia*, **145**, 87–99.
- [4] González-Jaramillo, V.; Fries, A.; Zeilinger, J.; Homeier, J.; Paladines-Benitez, J.; Bendix, J. (2018): Estimation of Above Ground Biomass in a Tropical Mountain Forest in Southern Ecuador Using Airborne LiDAR Data. *Remote Sens.* **10**, 660. DOI: 10.3390/rs10050660
- [5] González-Jaramillo, V.; Fries, A.; Bendix, J. (2019): AGB Estimation in a Tropical Mountain Forest (TMF) by Means of RGB and Multispectral Images Using an Unmanned Aerial Vehicle (UAV). *Remote Sens.* **11**, 1413. DOI: 10.3390/rs11121413

1) In this section university counterparts present news and research around RESPECT's Research Unit and our collaboration.

UC News¹⁾

A first step towards rainfall nowcasting in the tropical Andes

Rigoberto Guerrero-Coronel¹, Johanna Orellana-Alvear¹, Rolando Célleri¹, Ruetger Rollenbeck², and Jörg Bendix²

¹Department of Water Resources and Environmental Science, University of Cuenca (UC), Ecuador, Counterpart of the RESPECT Research Unit

²University of Marburg, Germany, members of the RESPECT RU

We present first results of nowcasting extreme rainfall events in the South of Ecuador. We also identified which rainfall events are more difficult to nowcast and inform about what we are planning to study next.

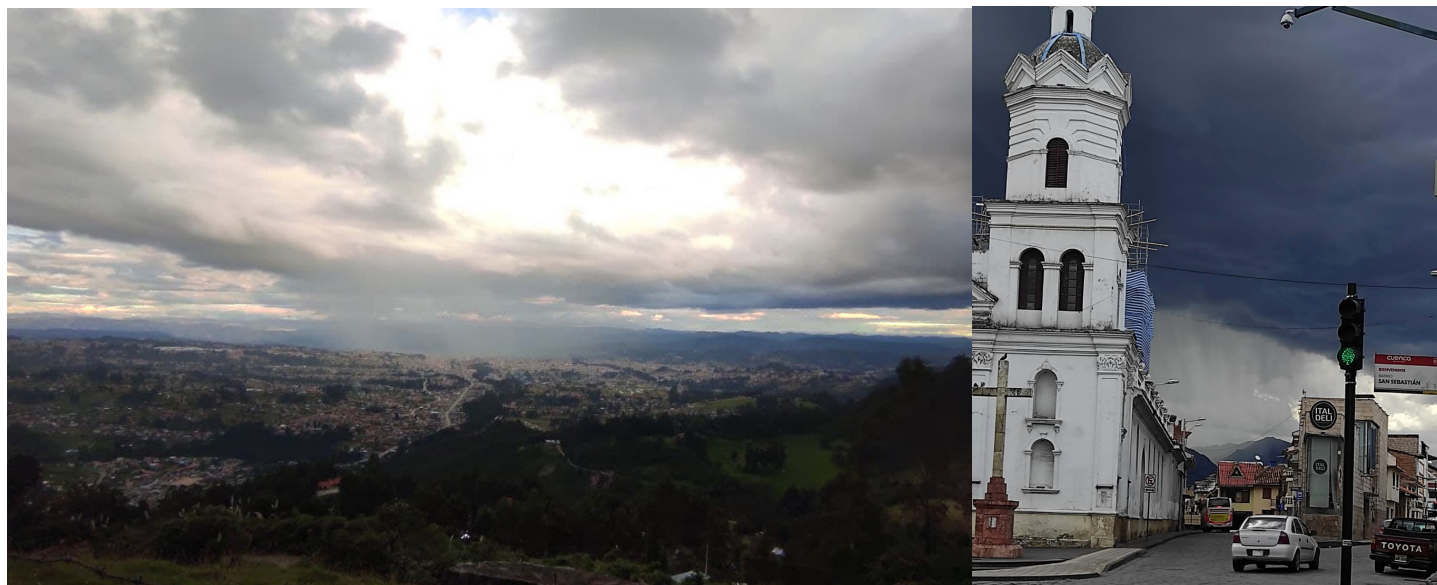


Figure 1: Extreme Rainfall events in Cuenca-Ecuador. Photos: Rigoberto Guerrero-Coronel

The ability to forecast the occurrence of a precipitation event in the very near future linked to the knowledge of where it will take place and its magnitude is of substantial importance for risk management, and can prevent human life losses due to rainfall-triggered natural disasters. This is called nowcasting, and basically consist in tracking rainfall cells with specific characteristics at lead times from 5 to 60 min.

In Ecuador, several natural disasters such as flash floods and landslides are related to rainfall (**Figure 1**); thus, the importance of an accurate nowcasting can help to reduce the social, economic and infrastructure damages. However, the complex orography and high variability of rainfall in the southern Ecuadorian Andes are a challenge for the application of nowcasting methods.

As a first attempt to nowcast rainfall, we studied 19 events using the CAXX X-band

radar (part of RadarNetSur), located at 4450 m a.s.l. at the west of Cuenca (**Figure 2**). By using the rainymotion library (python 3) we evaluated the performance of five different optical flow (OF) methods (Dense inverse Search [DIS], DeepFlow, PCA-Flow, Farnebäck and PWC-net) to track rainfall cells. They differ in their capabilities to deal with small or large displacements and velocity of the motion of the rain cells as well as computer time consumption. That is, using five minutes radar images, rain cell intensity coincidences between two consecutive images were identified and its movement was tracked to generate a displacement vector. That vector was used to advect the cell to a selected lead time (predicting the near future location based on its last position and movement).

Furthermore, we analyzed the following rainfall characteristics: spatiotemporal evolution of rainfall, spatial-2D and spatiotemporal-1D autocorrelation, and duration-

fractional coverage in order to understand what are the spatiotemporal characteristics of each rainfall event and their relation with the nowcasting performance. These characteristics synthesize information about the structure and evolution of the storm during its lifetime and areas with rain rates registered above different intensity thresholds.

The results showed similarities in the displacement vectors (magnitude and velocity) generated in the rain cells tracking process among all the OF methods. Nevertheless, DeepFlow and PCA-Flow methods were the most robust.

We found that heterogeneous events are more difficult to nowcast, due to spatiotemporal rainfall features showing high intra-event variability. In consequence, OF methods had better performance in tracking rain cells with low intensity (advective and stratiform) than those of high intensity (convective) rain cells. This is most likely



Figure 2: X-band Weather Radar (CAXX) located at 4550 m a.s.l at the West of Cuenca. Photo: Snapshot of Empresa de Telecomunicaciones, Agua Potable, Alcantarillado y Saneamiento de Cuenca (ETAPA EP) video

due the spatiotemporal structure of rainfall showing higher heterogeneity in convective events. In consequence, a heterogeneous rainfall structure causes the absence of rain cells persistence (constant rain intensity) which is the major hurdle to successfully track the rain cells. Finally, in future studies the DeepFlow method will be used to analyze rainfall advection-orography dynamics and to implement deterministic-probabilistic nowcasting models.

1) In this section university counterparts present news and research around RESPECT's Research Unit and our collaboration.

Ecuador / ECSF News

Travel advice for Ecuador

All passengers must present a digital health declaration (Declaración de salud del viajero, <https://declaracionsalud-viajero.msp.gob.ec/>) before boarding for Ecuador and present it again on arrival in Ecuador.

However, the presentation of a PCR test or proof of vaccination is no longer required. In Ecuador itself, there are no longer any COVID-19-related restrictions, and the mask requirements in Ecuador have also been cancelled.

Security in EC

Since the pandemic, the crime rate has been rising in Ecuador. Please avoid ATMs outside the bank and use the machines inside the bank. If this is not possible, take a companion with you and never get money from an ATM after dark. Avoid walking in the city after dark, rather call a proper taxi. It is best to walk around Loja at night only in groups. A healthy amount of mistrust towards unknown people who approach you will not hurt.

Please also consult the general travel and safety advice of the German Foreign Office for Ecuador (<https://www.auswaertiges-amt.de/de/ReiseUndSicherheit/ecuador-sicherheit/223232>) from time to time for updates.

Reservations for ECSF and Laipuna

We kindly ask you to inform Felix Matt as early as possible about trips to the Estación Científica San Francisco (ECSF) and Laipuna, even in the planning phase or with uncertain travel dates. Time and again, staff members at the ECSF or Laipuna need spare parts or field equipment from Germany at short notice and we are urgently looking for a way to have them brought along. Of course, early information also helps us to plan and prepare the stay at the two research stations.

Please make the reservation for Laipuna in the usual way as a reservation for the ECSF. The planned stay in Laipuna will then be specified in an extra e-mail to Felix Matt.

We ask all RESPECT members to print out their personal station ID (downloadable in the personal section of the website), laminate it and carry it with a valid official ID (can also be a copy of the passport) with them at all times in Ecuador. When entering the National Park, the rangers often ask for an ID for registration. A printout of the valid research permit should also be carried in your backpack.

New research permit

The new research permit (2022/23) has been applied for and will soon be available for download on the website.

Felix Matt & Baltazar Calvas,
local coordinators

Miscellaneous

New tree species described

A new *Virola* species has recently been described from Podocarpus National Park and the San Francisco Reserve [1]. *Virola bombuscaroensis* is a common tree at our Bombuscaro study site and is also rarely found in the San Francisco Reserve. It is only known from Ecuador's Zamora-Chinchipec Province and thought to be Critically Endangered following IUCN criterion B2a [1].

Jürgen Homeier

Reference

[1] Santamaría-Aguilar D., Lagomarsino L.P. (2022): New Species of *Virola* (Myristicaceae) from South America. *PhytoKeys* **197**, 81–148.



Figure: Fruits of the newly described tree *Virola bombuscaroensis*. Photos: Jürgen Homeier

NCI News¹⁾

More protected land areas around the Estación Científica San Francisco (ECSF)

Pedro Paladines¹⁾

¹⁾Administrator of NCI's Estación Científica San Francisco (ECSF)

After biologists from the Universidad Técnica Particular de Loja (UTPL) made an inventory of amphibians, Nature and Culture International (NCI) supported ongoing monitoring. A total of 30 species were detected in a small area, several of them endemic and several are new to science. NCI now plans to obtain funds to acquire new areas, which might be of interest for ecologists and researchers of the RESPECT Research Unit.

Twelve amphibians new to science

In the last years, due to its high levels of biodiversity and endemism, the Rio San Francisco Valley (RBSF) and surrounding areas have raised the interest of numerous researchers regarding the presence of many amphibian species. Based in previous studies conducted in the area since 1930, the Universidad Técnica Particular de Loja (UTPL) carried out recent studies (Figure 1). They have discovered the presence of 30 species of amphibians in the area so far (Figures 2 and 3), eleven of which are considered endemic for such a small territory, and twelve are also considered new species for science. To date, two of them have already been described, one is in process, and the other nine are waiting to be described. Most of these amphibians are listed as Vulnerable (VU), Endangered (EN) and Critically Endangered (CR) on



Figure 1: A member of the Bio Lab of the Universidad Técnica Particular de Loja (UTPL) is searching for amphibians. Photo: EcoSsLab, UTPL



Figure 2: The *Noblella heyeri* frog. Photo: EcoSsLab, Universidad Técnica Particular de Loja (UTPL)



Figure 3: This species is named *Pristimantis balionotus*. Photo: EcoSsLab, Universidad Técnica Particular de Loja (UTPL)

the International Union for Conservation of Nature and Natural Resources (IUCN) Red List. Even four species of those historically registered in the mountain pass Abra have not been found after exhaustive research [1], and of the new species identified, the data is insufficient or non-existent to be able to catalog them, but it is estimated that their conservation status is critical.

Plans to protect new areas

Since April 2022, Naturaleza & Cultura Internacional (NCI), together with the UTPL, and thanks to the financing of Rain Forest Trust (RFT) and the Swift Fund, began the implementation of a new conservation project at the San Francisco Valley area and around it. This project aims to protect and conserve the natural ecosystems of the Abra de Zamora Key Biodiversity Area, which lies within the northern buffer zone of the Podocarpus National Park (PNP), including the RBSF Research Station Area.

To protect this incredible area NCI and the UTPL plan to identify and evaluate the key sites and habitat conditions of the endemic and threatened amphibian species in the next five years, and then implement actions to monitor and manage this habitats. NCI will also seek conservation mechanisms in approximately four or five thousand hectares of private and government owned land within the Abra de Zamora, while working together with the Ministry of Environment, Water and Ecological Transition (MAATE) to achieve the expansion of the Podocarpus National Park as a main goal.

Up to now, four properties have already been purchased for a total of four hundred and fifteen hectares. Two of these properties with a total of approximately one hundred and fifty hectares are located next to the ECSF area and the other two in the sector of the La Zurita stream. These areas and those probably purchased in the future could be used by the researchers and projects of the RESPECT FOR 2730 Research Unit and other new projects.

Reference

[1] Székely, P., Eguiguren, J.S., Ordoñez-Delgado, L., Armijos-Ojeda, D. and Székely, D.(2020): Fifty years after: A taxonomic revision of the amphibian species from the Ecuadorian biodiversity hotspot Abra de Zamora, with description of two new *Pristimantis* species. *PLoS one*, **15** (9), e0238306, DOI: 10.1371/journal.pone.0238306

1) In this section infrastructure providers, non-university partners, and institutions present news around our Research Unit. This time Pedro Paladines from the NGO *Nature and Culture International* (NCI, <https://natureandculture.org>) reports about new amphibian species and plans to acquire new areas which could be of interest for scientists.

People and Staff

Photo: Charuta Murkute



Charuta Murkute from Brandenburg University of Technology Cottbus (BTU) has joined the **Subproject A1** from April 2022 as a new PhD student. She is working on eddy covariance data and investigates water and carbon fluxes as well as microclimato-logical conditions at the mountain dry forest in the Laipuna Reserve. *Katja Trachte*

Photo: private



Ing. **José Luis Peña Caivinagua** supports **Subproject A3** as a technician with the installation, operation and maintenance of various experiments (measurement of atmospheric deposition, microbial processing of phosphate, depth of nutrient uptake by trees) and with the sampling of soil and water samples in the dry forest of Laipuna during the upcoming two years of research. He is also in charge of the weekly sampling and analysis of water samples (rainfall, throughfall, litter leachate, soil solution) and litterfall in the Reserva Biológica San Francisco and in the Podocarpus National Park (Bombuscaro), and of the read-out and maintenance of several automated measurement stations of project A3. *Andre Velescu*

Photos: Lea Kerwer



David Moreno and **Gabriel Acaro** are in charge of collecting seed- and litter samples from the meshtraps for **Subprojects B3, B4 and B1**. Within Subproject B3, **Josefina Acaro** has recently started to assist with morphological seed measurements, while **Cristian Armijos** helps sort-ing seeds captured in the mesh traps into morphological groups. **Diana Ontaneda** and **Kleiver Azanza** are technicians from

Loja helping with soil moisture- and litter measurements (Diana) and taking pictures of the canopy (Klever). **Domingo Acaro** and **Manuel Armijos** are conducting the weekly treatments of the seedling experiment of Subproject B3. *Lea Kerwer*

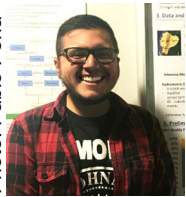
Photo: Jessica Mereci



Jessica Mereci recently started her PhD field work within **Subproject B1** of Jürgen Homeier and Christoph Leuschner in August 2022. She is studying tree functional traits, especially of rare tree species, to evaluate how species abundance is affecting tree properties and tree functions in our 15 study plots in the mountain rain forest and the mountain dry forest. She is funded by a scholarship from DAAD.

Jürgen Homeier

Photo: Pablo Peña



Pablo Peña started his PhD project at the Institute of Landscape Ecology and Resources Management of the University of Giessen (**Subproject A2**) in February 2022. Under the supervision of Dr. David Windhorst and Prof. Dr. Lutz Breuer, he is investigating mixing processes of stable isotopes of water in light of preferential flow within the vadose zone of both Mountain Rain Forest and Mountain Dry Forest systems. To this purpose, he conducted fieldwork campaigns to set the equipment installations in the experimental plots.

David Windhorst

Photo: Bikash Poudel



Bikash Poudel started his PhD project at the Institute of Landscape Ecology and Resources Management of the University of Giessen (**Subproject A2**) in November 2022. Within the subproject he is responsible for the development of a new module for the simulation of the turnover and transport of stable water isotopes. The module will be the part of hydrological sub-model of the Land Surface Model "HUMBOL-TD" which is currently being developed under the project. The overall goal is to improve the performance of the hydrological sub-model.

David Windhorst

Photos: Andrea Nieto and Lea Kerwer



Andrea Nieto (left) and **Lea Kerwer** started their research in the Functional Ecology and Global Change Group of the Senckenberg Biodiversity and Climate Research Centre (Frankfurt, Germany) in spring 2022. Both are working in **Subproject B3** in the dry forest of Laipuna. Andrea focuses on seed morphology and bird diversity. She collects seeds using mesh traps, monitors the fruiting of woody species and conducts bird point counts. Lea focuses on seedling recruitment. She conducts seed-sowing experiments using native tree species and implements shade and litter treatments. She also monitors natural seedling recruitment in forests and agroforests.

Lea Kerwer

Photo: Diana Ontaneda



In October 2021 **Subproject B4** got support by **Annemarie Wurz**, a new Postdoc of Prof. Dr. Nina Farwig at the University of Marburg. Within the RESPECT

project, she works in both the mountain dry- and rainforest of southern Ecuador. Currently, she is co-coordinating the data collection by developing research questions and methods within the topic of herbivory by arthropods. Together with Jana Schön, she is supervising students and performing data collection. In addition, she is currently writing a paper on biodiversity and ecosystem functioning relationships. For this paper, she is combining data from Ecuador and Tanzania to analyze how the effect of diversity on ecosystem functioning varies depending on environmental heterogeneity. She and her colleagues found a saturating increase in the effect of diversity on ecosystem functioning with increasing environmental heterogeneity.

Annemarie Wurz, Jana Schön

Photo: Sarah Ullrich



Since July 2021, **Eva Ullrich** is working on her master thesis in **Subproject B4** under the supervision of Prof. Dr. Nina Farwig. Together with her team members Annemarie Wurz, Jana Schön, Sarah Ullrich, Diana Ontaneda, and Camilo Gonzalez, she took part in the field campaign in the tropical dry forest of Laipuna from March until the end of May 2022. She examines arthropod-induced herbivory patterns in tree canopies of the dry forest in Laipuna. Hereby, she quantifies herbivory rates, and different herbivory damage types. For the analysis, she investigates the relation of various leaf traits to herbivory by considering two different elevation levels (600 m, 1200 m a.s.l.). In the future, she would like to do research in the Amazon rainforest in Ecuador.

Jana Schön

Photo: Eva Ullrich



Sarah Ullrich is another student working on her master thesis in the **Subproject B4** under the supervision of Prof. Dr. Nina Farwig since July 2021. She also took part

in the joined field campaign in the tropical dry forest of Laipuna from March until May 2022. There, she conducted a feeding trial in which she fed leaf discs of different tree species to the Jamaican field cricket (*Gryllus assimilis*), a generalist herbivore, to examine species-specific leaf palatability. She analyzes differences in leaf palatability depending on the elevation level of species occurrence as well as depending on the plant functional type (deciduous, semi-deciduous, evergreen) of the respective tree species.

Jana Schön

Photo: Camilo González



Camilo Fabián González Arévalo is an Ecuadorian master student from the Universidad Nacional de Loja (UNL), who joined the **Subproject B4** during the joint field campaign in April 2022. In his master thesis, supervised by Annemarie Wurz, he investigates the patterns of predation on caterpillars in the tropical dry forest of Laipuna. He quantifies predation rates of various predacious groups and reveals differences in the composition of predator

communities dependent on the land-use type (forest vs. pasture) and elevation level (600 m and 1200 m a.s.l.). In the future, he would like to start a PhD program by continuing to investigate insect communities.

Jana Schön

Photo: María Belén Jiménez Quezada



The Ecuadorian trainee **Diana Noelia Ontaneda Jiménez** joined the **Subproject B4** during their field campaign in Laipuna end of March 2022. Under the supervision of Annemarie Wurz,

she is investigating color effects of caterpillar dummies on predation rates in the dry forest. Together with Camilo Gonzalez, she discovered, that around 70 % of caterpillar dummies showing bite marks were attacked by arthropods, 22 % by birds, 4 % by mammals, and 4 % by lizards. Overall, predation rates did not differ between pastures and forests and the two elevation levels, except for predation rates in pastures at 1200 m a.s.l. which were lower compared to the pasture at 600 m and forest at both elevation levels. Regarding specific effects of the color of caterpillars on predation, preliminary results show that brown caterpillars exhibited the highest predation rates, followed by white, and green ones. In the future, Diana would like to participate in postgraduate studies working in conservation ecology and especially expand her expertise in entomofauna. With this knowledge, she would like to create tools evaluating the conditions of environments at large scales and propose measures to improve them. Additionally, she dreams of developing an alternative biodegradable fabric to contribute to the reduction of human-induced greenhouse gases emitted by our behavior such as consuming fast fashion with all its resulting pollution and environmental damages.

Jana Schön

Photo: Wolfgang Wilcke



Esthela Margarita González Sarango (left) of the National University of Loja (UNL) has successfully passed the exam of her doctoral thesis “Biochar as soil amendment in afforestations on Ultisols of the Ecuadorian Amazonia” at the Karlsruhe Institute of Technology (KIT) on 30 November 2022. She receives

About Us

RESPECT Research Unit

The megadiverse tropical mountain rainforest of the Ecuadorian Andes is globally among the ecosystems that are most threatened by environmental change. Bio- and geoscientists as well as environmental modelers of our interdisciplinary Research Unit (RU) RESPECT “Environmental changes in biodiversity hotspot ecosystems of South Ecuador: RESPonse and feedback EFFECTs” investigate the resistance of different systems ranging from natural forest to pasture under climate change. The joint focus of the RU is a better understanding of ecosystem water regulation and biomass production. The research is kindly funded by the Deutsche Forschungsgemeinschaft (German Research Foundation, DFG). In the Tabebuia Bulletin, scientists and stakeholders inform about their progress and latest research results of the RU (FOR 2730) that started in March 2018. The Bulletin is named after the Tabebuia tree that displays charismatic yellow blossoms and is native in the Neotropics.

All members of the RU are working on the same research plots in the tropical mountain rainforest, dry forest and their replacement systems at five elevations. We are addressing the research question with two approaches

- (i) a statistical response-effect framework (REF) and
- (ii) an improved newest generation Land Surface Model (LSM).

her doctoral hat from the (hopefully) next coming doctor **Nuria Basdediós**. Esthela conducted this thesis in an Ecuador-funded associated project of **Suproject A3** headed by Carlos Valarezo of the UNL. We congratulate Esthela and wish her all the best for her future!

Wolfgang Wilcke

Photo: Annemarie Wurz



Aljoscha Geißler worked from May to June 2022 in **Subproject B4** as a research assistant. Under supervision of Annemarie

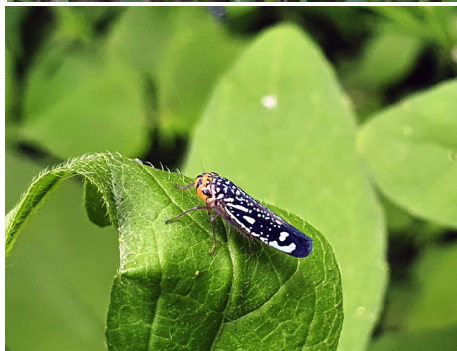
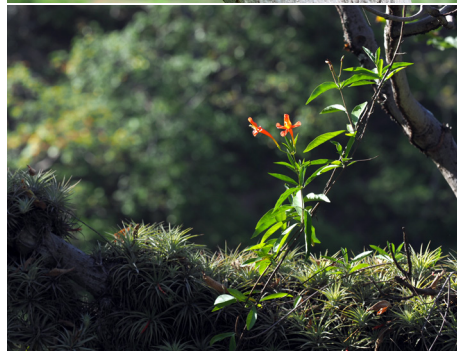
The latter is “biodiversified” by adapting it to the local vegetation and, for the first time, by including focal biological processes. For statistical analysis, model forcing and parameterization, we also make use of comprehensive data sets gathered in more than 20 years of ecological research in this area, stored in a custom-tailored data warehouse.

In 1997, a small group of German researchers funded by the DFG started to investigate the biodiversity rich mountain rainforests. In 2001 the first DFG RU (FOR 402) operated with a significantly larger consortium than the starting group. A second RU (FOR 816) continued from 2007 to 2013. A joint knowledge transfer program (DFG-PAK 823-825) between German researchers, Ecuadorian universities and non-university partners continued interdisciplinary research on developing prototypes for sustainable landuse and functional monitoring in the years 2013 to 2017.

Over the years, cooperation with Ecuadorian partners gradually intensified and now include the *Universidad Técnica Particular de Loja* (UTPL), the *Universidad Nacional de Loja* (UNL), the *Universidad del Azuay* (Cuenca), the *Universidad de Cuenca*, the foundation *Nature and Culture International* (NCI) and the *Instituto Nacional de Biodiversidad* (INABIO). Two knowledge transfer projects funded by DFG are closely linked to our RU: The programs *Nuevos Bosques para Ecuador* and *Radar Net Sur*.

Wurz, Camilo González and Diana Ontaneda he investigated predation on caterpillars in the dry forest ecosystem of Laipuna. To do so, he and the team deployed 150 caterpillar dummies per plot, collected them four days later and checked for the bitemarks of e.g. birds, ants and spiders. They used the KoboToolbox app to record the data. Currently Aljoscha is in Göttingen and has started a bachelor’s degree on ecosystem management recently.

Annemarie Wurz



Impressions from the study sites. Photos: Felix Matt (4), Jana Schön (1)

Editorial Board

Botany

Prof. Dr. Dr. h.c. Erwin Beck,
University of Bayreuth, Faculty of Biology, Chemistry and Geoscience, Germany, e-mail: erwin.beck@uni-bayreuth.de

Prof. Dr. Achim Bräuning,
University of Erlangen-Nuremberg, Institute of Geography, e-mail: abraeuning@geographie.uni-erlangen.de

Zoology

Prof. Dr. Nina Farwig,
Conservation Ecology, University of Marburg, Germany, e-mail: farwig@biologie.uni-marburg.de

Dr. Eike Lena Neuschulz, Senckenberg Biodiversity and Climate Research Centre, Frankfurt, Germany, e-mail: Eike-Lena.Neuschulz@senckenberg.de

Hydro-, Soil- and Geochemistry

Dr. David Windhorst,
Justus Liebig University Giessen, Germany, e-mail: David.Windhorst@agrار.uni-giessen.de

Modelling

Prof. Dr. Thomas Hickler,
Biodiversity and Climate Research Center Frankfurt (BiK-F), Germany, e-mail: thomas.hickler@senckenberg.de

Climate, Socioeconomy, Ecosystem Services, and all other Topics

Prof. Dr. Jörg Bendix,
University of Marburg, e-mail: bendix@staff.uni-marburg.de

Credits and Contact

RESPECT Research Unit (DFG FOR 2730)

More information about the Research Consortium:
www.tropicalmountainforest.org

Spokesperson of the FOR

Prof. Dr. Nina Farwig,
University of Marburg, Conservation Ecology, 35032 Marburg, Karl-von-Frisch-Straße 8, D-35043 Marburg, Germany,
phone: ++49 (0)6421 28-25707.
e-mail: farwig@staff.uni-marburg.de

Coordinating Office

Mrs. Birgit Kühne-Bialozyt,
University of Marburg, Faculty of Geography, Deutschhausstraße 10, D-35032 Marburg, Germany, phone ++49 (0)6421- 2826543, e-mail: kuehnebi@staff.uni-marburg.de

Copyright

© DFG FOR2730. All rights reserved.

Citation

DFG Research Unit FOR2730, Laboratory for Climatology and Remote Sensing (LCRS), University of Marburg, Marburg, Germany. *Tabebuia Bulletin*, Issue 9, 2022. DOI: 10.5678/9xq8-jy86

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