Newsletter

DFG Research Unit 816:
Biodiversity and Sustainable Management of a Megadiverse Mountain Ecosystem in Southern Ecuador

Issue 7
October 2009

Speakers' Corner

Preparing the Second Phase

In these days the board of the speaker is completely occupied with the preparation of the visit of the President of the German Research Foundation (DFG), Professor Dr.-Ing. Matthias Kleiner, to Quito and Loja, the succeeding review process and the annual status symposium.

During the presidential visit, future perspectives of biodiversity and environmental research in the science space of South Ecuador will be discussed with headship personnel of the science funding and coordinating agencies: the Secretaría Nacional de Planificación y Desarrollo (SENPLADES), the Secretaría Nacional de Ciencia y Tecnología (SENACYT) and the Agencia de Cooperación Internacional (AGECI), the Ecuadorian Ministry of Environment (MAE), the local universities, Universidad Técnica Particular de Loja (UTPL) and National University of Loja (UNL), and the foundation Nature and Culture International (NCI). To present our mutual achievements but also to talk about research perspectives beyond 2013, the Research Unit (RU) organizes a respective symposium for the DFG delegation at UTPL on 19th October 2009 with the title "Future Perspectives of biodiversity and environmental research in Southern Ecuador". Before this symposium, Professor Kleiner will have the opportunity to get

The scientists are interested in functions, interactions and sustainable management of the tropical mountain rainforest. In this special issue working groups covering several scientific disciplines give an insight into their latest research results uncovered in this megadiverse ecosystem. Photo: RU 816

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to know the science and life at the ECSF research station. Afterwards, he will meet important local persons at an evening reception at *Casa Lojana* at Loja.

Review Process

The review meeting is well prepared and the speakers thank particularly the station managers for the vast organizational efforts, the RU members for understanding and accepting the special situation and restrictions at the Estación Científica San Francisco (ECSF), and all persons contributing to the field and counterpart visits as well as preparing the post-review field excursion. I am confident that we can convince the reviewers about the great progress of the RU achieved in the first phase which is particularly visible with this newsletter.

ATBC-gtö Conference

Between the compilation of the application booklet and the preparation of the events mentioned above, the speaker organized and managed the joint meeting of the Association for Tropical Biology and Conservation (ATBC) and the Society for Tropical Ecology (gtö) entitled "Impacts of Global Change on Tropical Ecosystems - cross-cutting the Abiotic, Biotic and Human Spheres" in Marburg, Germany, from 26th to 31st July. During truly summer weather conditions, the conference with approximately 600 participants from 45 countries was a great success. The RU was very prominent with organizing eight symposia and numerous talks (see last Newsletter, page 3: http://tinyurl.com/TMFnews06). Particularly, the special poster display area of the RU with the demonstration of DFG-science TV spots was a major attraction at the conference and contributed to the international visibility of our research.

The Marburg Declaration

A major outcome of the conference was the "Marburg Declaration" (reference in the box below) on "The Urgent Need to Maximize Biodiversity Conservation in Forest Carbon-Trading" which internationally underpins the urgent need also for our research activities.

Jörg Bendix and Erwin Beck,
Speaker and Deputy Speaker of the RU

Download: Marburg Declaration

Press release (German):
http://www.uni-marburg.de/aktuelles/news/2009b/0735.pdf
Declaration text:
http://www.uni-marburg.de/aktuelles/news/2009b/0735.pdf

Jörg Bendix introduced focus, approaches, structure and scope of the Research Unit (RU) during the ATBC-gtö Conference at Marburg. The posters from the RU were entitled "DFG funded collaborative research on tropical biodiversity, ecosystem functioning and services – cross cutting the biotic, abiotic and human spheres". Photo: Maik Dobbermann.

News from the ECSF

GPS and GIS Courses

The RU and NCI cooperated to offer a course about the global positioning system (GPS) and geographical information systems (GIS) for people from the Ministry of Environment (MAE). The three day course took place at the Research Station (ECSF) from 9th to 11th of September. Jorge Cueva and Luis Chalán from NCI explained basics of GIS: The learning matter was put into practice with ESRI ArcGIS.

Jörg Zeilinger from the RU explained basics and principals of GPS, autonomous and differentially corrected measurements, the handling of the different soft- and hardware of Trimble GPS equipment, as not only the RU possesses Trimble equipment, but also the MAE and NCI. Measurements were conducted around the ECSF and corrected afterwards with the data of the reference station of the RU. In addition to eight employees of MAE Loja and Zamora, we also had participants from the municipalities of Loja and Zamora.

The audience of the GPS course was introduced to the positioning services provided by the satellite system. Photo: Alberto Bravo.

Participants of the course learned how to take measurements with the mobile GPS unit in the field. Photo: Alberto Bravo.

Visit from the German Embassy

On 27th and 28th of August Raymond Dequin, the Deputy Chief of Mission of the German Embassy in Ecuador, visited our RU at the ECSF. Jörg Zeilinger introduced him to the RU and showed the work of several groups in the labs and in the forest. Raymond Dequin also met Ivan Gayler, president of NCI, together with board and senior staff members which also stayed at the research station during these days.

Jörg Zeilinger introduced Raymond Dequin from the German embassy to the objectives of the Research Unit and guided him to some places of research around the station. There they met Ivan Gayler, founder of NCI, Byron Swift, new president of NCI and Renzo Paladines, director of NCI (from left to right). Photo: Boris Hillmann.

Road between Loja and Zamora

In the next weeks the road works between Loja and the ECSF will be completed and travelling will be without delays. However, between ECSF and Zamora road works are going on, therefore traffic to and from Zamora will still be delayed occasionally. This also affects the buses driving from the ECSF to Loja.

Jörg Zeilinger & Felix Matt

News from NCI

Protecting the Jambue Watershed

In late June, Nature and Culture International (NCI) purchased two major areas of cloud forest in the Jambue River Watershed. These properties are almost contiguous and constitute a private reserve of 900 hectares. They are of strategic interest since they are situated in a sector of the watershed adjacent to Podocarpus National Park and the municipal reserves that are currently being declared. Altitudes in these zones vary between 950 and 2000 meters above sea level. A great variety of similar sites that are very close to the "Bombuscaro" can be found in this region: some of them are covered with native forest and others have been used as pastures, which will be allowed to regenerate naturally. For more information please contact Felipe Serrano (fserrano@naturalezaycultura.org)

Biosphere Reserves

On September 16th and 17th, a meeting took place in Loja to discuss the Ecuadorian Network of Biosphere Reserves. Amongst others, the mayors of the municipalities within Ecuador's four biosphere reserves were invited. The workshop provided a plenum for the municipalities to share their experiences with the reserves.

It is remarkable that the Ministry of Environment (MAE) is becoming more open to the necessity of acting over the entire surface of the biosphere reserves, cooperating with other key players – and not being limited only to SNAP areas (sistema nacional de áreas protegidas) like National Parks.

Helmut Sonnert

The Dry Forest Ecosystem

Tropical dry forests are renowned as some of the most endangered ecological communities. It is characterized by a majority of plants that defoliate for several months a year as a mechanism to withstand prolonged drought and high temperatures. Over 20% of the flora is classified as endemic and an even greater percentage of endemism exists among other biological groups. Currently the advance of the agricultural frontier and selective logging of valuable timber are the main threats to this fragile ecosystem.

The best preserved dry forests can be found in southern Ecuador and northern Peru, which is the center of the endemic Tumbesian zone. About 20 years ago, almost 35% of Ecuadorian territory was covered by dry forests, but today it is estimated that 50% of these forests have disappeared. The majority of this ecosystem is located in the province of Loja between 0 and 1100 meters above sea level. Approximately 31% (3,400 km^2) of the province is covered with this type of forest.

Eduardo Cueva

During the dry season the mighty Ceibo branches seem to protrude even more over other trees of the Tumbesian dry forest. Photo: NCI Ecuador.

Research in the threatened Tumbesian Forest

According to several studies, the Tumbesian dry forest is the most threatened biomes in continental Ecuador. Nature & Culture International (NCI) has been working to preserve this ecosystem since 2000 through the establishment of several reserves such as Laipuna in Macara, and La Ceiba and Cazaderos-Progresso in Zapotillo. NCI also works at Piura in Peru.

In the Laipuna Reserve NCI measures the growth of the most common trees in this biome since 2003. Phenological monitoring is being carried out on 293 trees of 13 tree species whose frequency and usage are the most representative of the dry forest.

The variation of growth is extremely high (Table). The species showing the highest growth rates (bold values), unfortunately have no timber value, except Gualtaco and Faique. The first is widely used to build houses and fences and Faique is used as fodder and firewood. Note that the Gualtaco is one of the most widely used species in this ecosystem.

There are three groups of species displaying rapid, medium, or slow growth measures (Figure). In 2006 and 2007, the Guayacán, Guallachi, and Laurel mainly suffered a decline during the dry period.

Conclusions

- General growth rates are low, except the Ceibo (*Ceiba trichistandra*) and Polo Polo (*Cochlosperum vitifolium*) – both having no timber value.
- The rapid and medium growth species will be recommended for recovery and reforestation.
- The most interesting species are the Gualtaco (*Loxopterigium huasango*) and Faique (*Acacia macracantha*).

Future Research

Based on these investigations, NCI is planning a number of follow-up activities:

- Extend the growth-studies to other tree species that grow in other regions of dry forests.
- Growth charts for species still need to be created in addition to calculations of potential revenue through silvicultural management. It can be predicted that revenues from this type of management would not be high. Further investigations should be completed to determine the economic potential of multipurpose tree systems for small landowners.
- In this region, one of the problems has been the planting of corn and the subsequent loss of forest areas and traditional gardens in recent years. However, the latest drop in corn prices motivated farmers to recover traditional gardens. The information about local species that is being obtained from this research will support the creation of traditional orchards or the restoration of forests.
- Currently, NCI is investigating the amount of carbon fixation in the higher-elevation Tumbesian mountains. During the next few months, these investigations will be extended to lower elevations.
- NCI will perform follow-up research at the permanent one-hectare inventory plots that were established at the Laipuna, La Ceiba, and Numbala reserves, and at the ECSF. Similar plots at other reserves will be installed in the future.

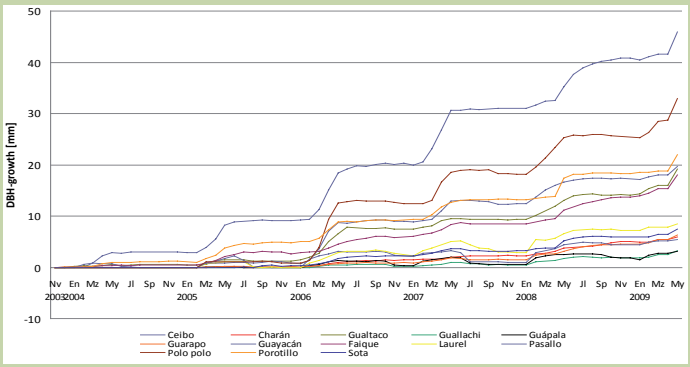

Figure: Growth development of 293 trees from 13 species measured as diameter at breast height (DBH). Graph: Eduardo Cueva

Table: Growth rate of 293 trees in the dry forest measured during a five year period. DBH: Diameter at breast height.

Common Name	Scientific Name	Average Growth Rate DBH [cm/year]	Growth Rate Variation
Ceibo	Ceiba *trichistandra*	**0,71**	0,06-1,35
Charán	*Caesalpinia glabrata*	0,14	0,01-0,37
Faique	*Acacia macracantha*	**0,35**	0,05-0,82
Guallachi	*Fulcaldea laurifolia*	0,08	0,00-0,25
Gualtaco	*Loxopterigium huasango*	**0,35**	0,00-0,72
Guapala	*Simira ecuadorensis*	0,07	0,01-0,15
Guarapo	*Terminalia valverdae*	0,15	0,00-0,52
Guayacán	*Tabebuia chrysantha*	0,10	0,01-0,43
Laurel	*Cordia alliodora*	0,20	0,00-0,55
Pasallo	*Eriotheca ruizii*	0,25	0,01-0,62
Polo polo	*Cochlospermun vitifolium*	**0,67**	0,00-1,67
Porotillo	*Erythrina velutina*	**0,41**	0,02-0,82
Sota	*Maclura tinctoria*	0,18	0,00-0,47

Eduardo Cueva
(ecuevanci@naturalezaycultura.org)

In this section NCI (www.natureandculture.org) introduces its activities. NCI is a non-governmental organization whose mission is to assist in the conservation of biological and cultural diversity.

Science News

Mycorrhizal Communities in Ericads on Degraded Areas

One aim of the project is to investigate the mycorrhizal community of different Ericaceae in degraded areas (DFG No **A1.7**). The findings will help to estimate reintegration potential of forest species in degraded areas.

The degraded Zig Zag Slide at the RBSF is one of the few sites where Ericaceae coexist with two different mycorrhizal types in high abundance. Therefore, it is suitable for testing the hypothesis: Ericaceae with two different mycorrhizal types, cavendishioid (predominant in rain forest sites) and ericoid (abundant in degraded areas), use the same mycorrhizal community.

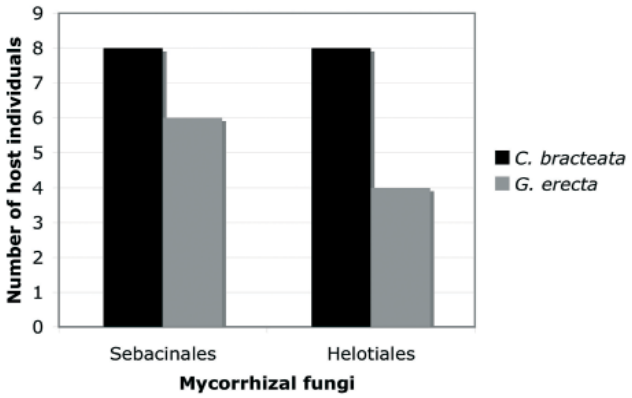

Figure A1.7: Occurrence of Sebacinales and Helotiales in *C. bracteata* and *G. erecta*. Fisher's exact test revealed no significant difference in the occurrence of Sebacinales ($p = 0.659$, $\alpha = 0.05$) and Helotiales ($p = 0.396$, $\alpha = 0.05$) in *G. erecta* and *C. bracteata*. The mycorrhizal fungi were identified with molecular methods (DNA isolation, PCR, cloning, RFLP and sequencing). Graph: Sabrina Setaro.

Table A1.7: Molecular operational taxonomic units (MOTUs) of Sebacinales and Helotiales in *C. bracteata* and *G. erecta* that occur in both host species (first column) or in either one of the host species (second column). Fisher's exact test revealed a slight difference close to significance of shared and exclusive MOTUs in Sebacinales and Helotiales ($p = 0.065$, $\alpha = 0.05$). A threshold of 3% sequence dissimilarity for the ITS of the ribosomal DNA was applied to distinguish MOTUs of Sebacinales and Helotiales.

	in *C. bracteata* **and** *G. erecta*	in *C. bracteata* **or** *G. erecta*
Sebacinales	2	5
Helotiales	0	19

Eleven individuals of *Cavendishia bracteata* (cavendishioid mycorrhiza) and ten individuals of *Gaultheria erecta* (ericoid mycorrhiza) were sampled from the Zig Zag slide in 2007. Both host plants are colonized by Sebacinales (basidiomycetes) and Helotiales (ascomycetes). There was no significant prevalence of Sebacinales or Helotiales in either host (Figure A1.7).

Seven different Sebacinales were identified, of which two occurred in both hosts. The Helotiales, in total 19, never occurred in both hosts and where only shared between different individuals of *G. erecta* or *C. bracteata* (Table A1.7). This suggests that *G. erecta* and *C. bracteata* have the same Sebacinales but a different Helotiales community. However, this finding was not supported statistically. The results indicate that there is no obligatory host specificity for mycorrhizal fungi of Neotropical Ericaceae.

Sabrina Setaro

Arbuscular Mycorrhiza for Tree Seedling Survival

The main goal of the project (DFG no **B1.1**) is to improve the out-planting performance of native, potential crop tree seedlings by inoculation with arbuscular mycorrhiza fungi (AMF) in close cooperation with group no **C2.1**. In the former RU402, natural soil was used to inoculate potential crop trees. In a second nursery culturing cycle their arbuscular mycorrhiza (AM) roots served as inoculum for *Heliocarpus americanus* and *Cedrela montana*, resulting in significantly better growth (Urgiles et al. 2009). As these potential crop trees harbored well-performing indigenous AMF, their roots were used as starter material for AMF isolation in our project. Unexpectedly, AMF from diverse families could be isolated and not only frequently reported generalists. Half of the species relate to previously reported DNA sequences from corresponding nursery material, namely a *Glomus* cf. *etunicatum*, an *Acaulospora* sp. and *Archaeospora* cf. *trappei*. The other half, surprisingly, was never detected before.

All isolates were DNA barcoded (3.3 kb) for later nursery- and field-tracing by 454 pyrosequencing. A mixed inoculum was produced and *H. americanus, C. montana*, and *Tabebuia chrysantha* seedlings were inoculated in the nursery experiment (see Figure B1.1). This did not result in significantly better growth after inoculation, although a much higher mycorrhization was evident. Many plant seedlings do not, in terms of biomass, positively respond to AMF in the greenhouse but are AM dependent in the field (Smith et al. 2009).

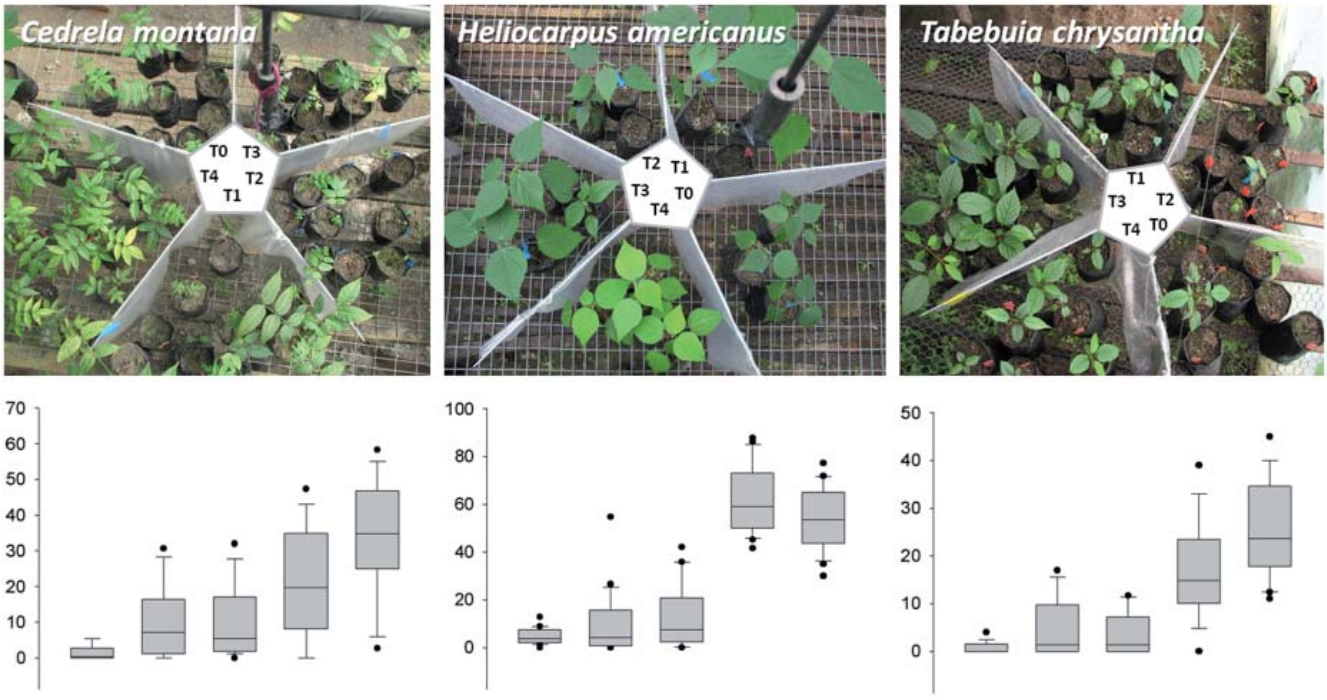

Figure B1.1: Randomized setup of the nursery experiment. T0, sterilized standard nursery soil; T1: full fertilization (Osmocote slow release); T2: ½ fertilization+killed AMF; T3: ½ fertilization+living AMF; T4: AMF only. Top: Setup in the greenhouse. Bottom: Mycorrhization rates in % [Medians ± quartile ranges, highest and lowest values each]; treatments from left to right: T0-T4. Photos and Graph: Claudia Krüger and Arthur Schüßler.

The main parameter for their performance, therefore, is field establishment. We evaluate the nine months after out-planting field-data this October. The first evaluation in June indicated a higher survival rate of inoculated seedlings.

Arthur Schüßler

References

Krüger M, Stockinger H, Krüger C, Schüßler A (2009) DNA-based species level detection of *Glomeromycota*: one PCR primer set for all arbuscular mycorrhizal fungi. New Phytologist 183: 212-223. http://dx.doi.org/10.1111/j.1469-8137.2009.02835.x

Smith FA, Grace EJ, Smith SE (2009) More than a carbon economy: nutrient trade and ecological sustainability in facultative arbuscular mycorrhizal symbioses. New Phytologist 182: 347-358. http://dx.doi.org/10.1111/j.1469-8137.2008.02753.x

Urgiles N, Loján P, Aguirre N, Blaschke H, Günter S, Stimm B, Kottke I (2009) Application of mycorrhizal roots improves growth of tropical tree seedlings in the nursery: a step towards reforestation with native species in the Andes of Ecuador. New Forests: Volume 38: 229-239. http://dx.doi.org/10.1007/s11056-009-9143-x.

Nutrient Limitations and Tree Diversity

To study the effects of topography and related soil conditions on the composition and diversity of tree species we (DFG no **A2.2**) established a matrix of 54 permanent forest plots (400 m² each) in close cooperation with group no **A2.4**. At three elevations (1000, 2000 and 3000 m), 18 plots were equally distributed to three topographical positions: lower slope, mid slope and upper slope. In June 2009 the thesis students Jaime Peña and Servio Sanmartín finished their field work. They collected fine litter in all plots once a month during the last year.

In addition to the expected decrease of litter production with elevation we found a strong influence of the topographic position. Lower slope forest was always most productive, e.g. at 2000 m the mean leaf litter production of 7.8 t ha^{-1} yr^{-1} of this forest type was about 40% higher than in close-by upper slope forests (Figure A2.2, next page).

Litterfall contents of N and P were in the lower range of values from tropical forests elsewhere, especially at the 3000 m site. The high nutrient use efficiencies for N and P point at increasing nutrient limitation by both N and P at higher elevations.

The wide range of values for nutrient (N and P) input through litterfall at 2000 m is indicative of the high spatial heterogeneity of environmental conditions in the San Francisco Reserve.

Jürgen Homeier

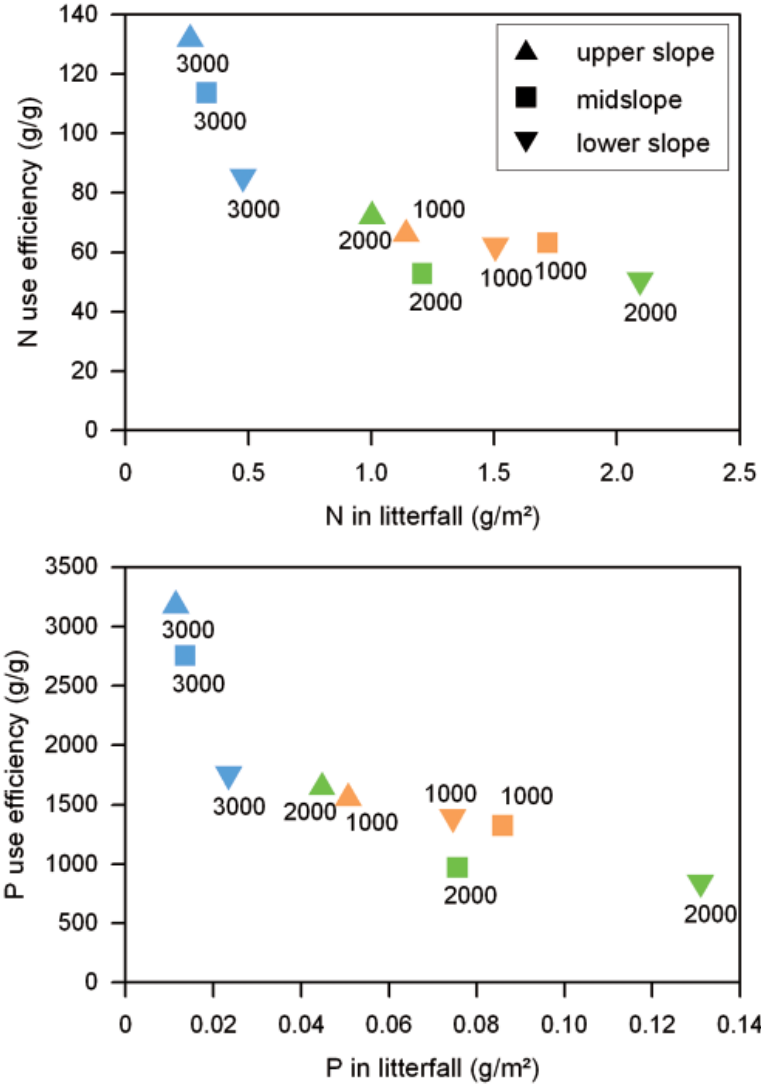

Figure A2.2: Effects of elevation and topographic position on the nutrient use efficiency (total dry mass/nutrient ratio) and the flux of the respective nutrient with the monthly litterfall. Calculations are based on the nutrient concentrations of litter samples collected in December 2008 from all 54 plots. Graph: Jürgen Homeier.

Micro- and Macroscale Changes in Density and Diversity of Testate Amoebae

In group **A2.3** we analyzed the microhabitats of epiphytes and addressed two fundamental questions regarding the diversity and density of free-living protists, testate amoebae (Krashevska, V., 2009): how do they respond to

- altitudinal changes (macroscale - forests at 1000 m at Bombuscaro, 2000 m at ECSF and 3000 m a.s.l. at Cajanuma) and
- the location of epiphytes on trees (microscale - tree height of 0 m (base of tree trunk, TH I), 1 m (TH II) and 2 m (TH III))?

At the macroscale diversity and density of testate amoebae peaked at intermediate altitude (2000 m, Figure A2.3a). At the microscale diversity of testate amoebae reached a maximum at TH I, whereas density of testate amoebae reached a maximum at TH III (Figure A2.3b). The overall diversity of testate amoebae in epiphytes was high (113 species) with an average richness of 53 species and average diversity of 15,165 ind. g^{-1}, exceeding that in litter and soil.

However, only two to nine species were dominant representing 54-85% of total living testate amoebae. These consisted predominantly of cosmopolitan species occurring in humid habitats of low pH, such as *Assulina muscorum* and *Euglypha strigosa*. Results show that for testate amoebae density the macroscale appears most important whereas changes in diversity are more pronounced at the microscale.

Valentyna Krashevska

Reference

Krashevska V. (2009): Diversity and community structure of testate amoebae (protista) in tropical montane rain forests of southern Ecuador : altitudinal gradient, above ground habitats and nutrient limitation. Dissertation. Technische Universität Darmstadt.
http://tuprints.ulb.tu-darmstadt.de/1231/1/Krashevska.pdf

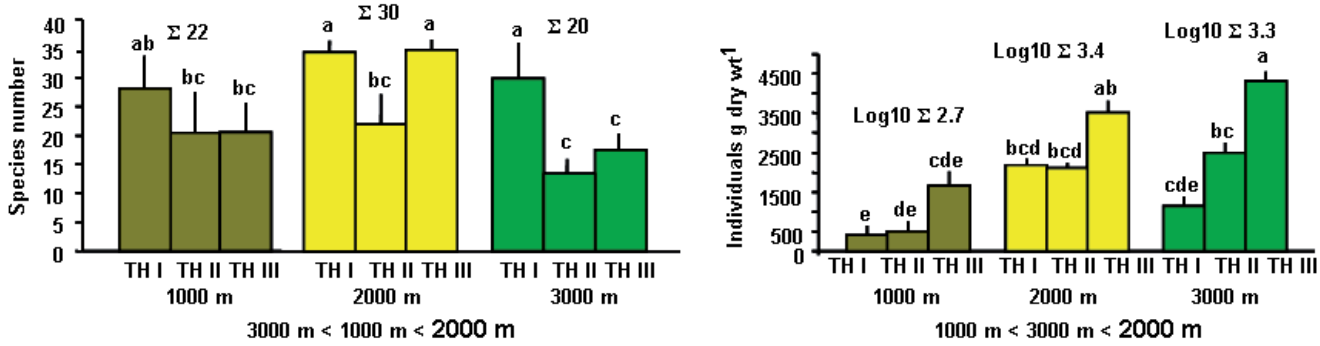

Figure A2.3a: Diversity and density of testate amoebae at the macroscale. Means with standard errors. Bars with different letters vary significantly (Tukey's HSD test, $\alpha < 0.05$). Graph: Valentyna Krashevska.

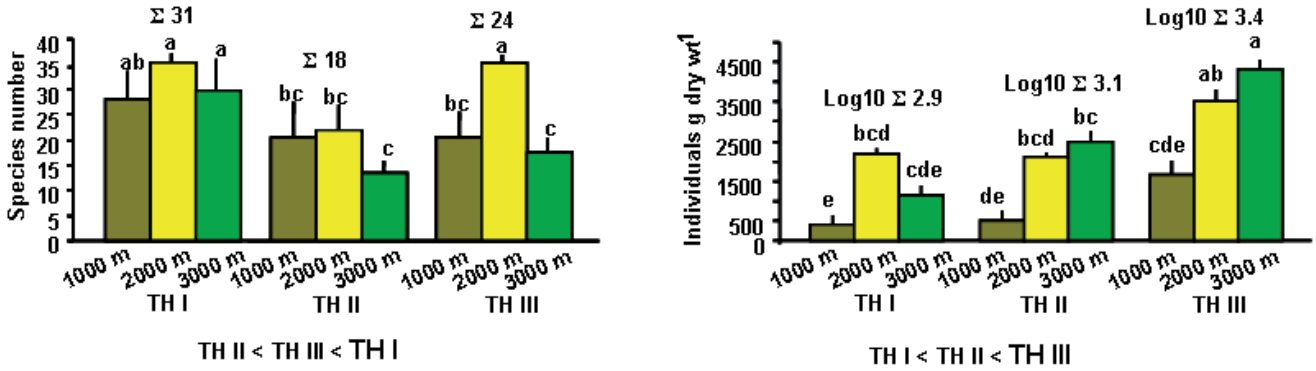

Figure A2.3b: Diversity and density of testate amoebae at the microscale. Means with standard errors. Bars with different letters vary significantly (Tukey's HSD test, $\alpha < 0.05$). Graph: Valentyna Krashevska.

Dynamics of Epiphyte Diversity in Disturbed and Undisturbed Forests

Gradstein's thesis students Nerida Gutiérrez and Fausto Reátegui (DFG no **A2.5**) are currently analysing epiphyte community data from the "Handtuchfläche", the large secondary forest patch just off Q2/T2 at RBSF (2150 m a.s.l.). This stunted 45 yr old forest is remarkably species-rich and heterogeneous in terms of vascular epiphytes.

It turned out that the floristic composition of epiphytes was closely related to measures of stand structure (e.g. basal area, canopy height) and resulting microclimate (midstorey light levels). These floristic changes were paralleled by abundance patterns of epiphytic bryophytes, which flourished in more sheltered plots. In contrast to light levels and stand structure, the spatial distance to mature forest – a proxy for potential dispersal constraints – was not correlated significantly with epiphyte species composition.

Interestingly, species richness did not increase monotonically with structural stand development but rather peaked at intermediate levels (Figure A2.5). It thus appears that epiphyte succession can be overstrained by rapid stand development. These results corroborate the notion of micro climate as key predictor for epiphyte assemblages in disturbed habitats.

Florian Werner

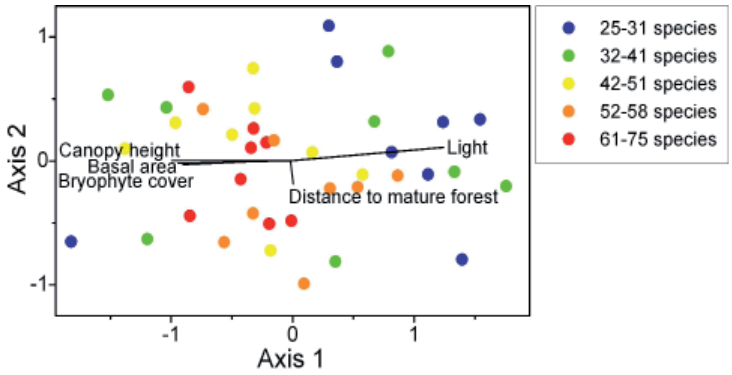

Figure A2.5: Floristic composition and species richness of vascular epiphytes in 40 plots of 5x5 m in the 45 yr old secondary forest patch "Handtuchfläche". Distances between plots reflect compositional dissimilarity (ordination method: non-metric multidimensional scaling [NMDS] based on relative Sørensen distance; stress = 0.17). The relationship between floristic composition and selected environmental parameters is shown by means of joint plotting. Graph: Florian Werner

Organic Matter in Soils: Availability of N

Within subproject **B2.1** the effects of fertilization on biogeochemical processes in pasture soils are investigated. A laboratory incubation experiment with the addition of ^{14}C- or ^{15}N-labelled urea showed that urea accelerated the mineralization of soil organic matter directly after addition up to 17% compared to the non-fertilized control. The availability of NH_4-N and NO_3-N increased between 2 to 7 times in active (plots from the FERPAST experiment) and abandoned pasture soils (plots from the FIRE experiment), respectively.

This was mainly due to an urea-induced enhanced release of NH_4 and NO_3 from the soil organic matter pool (Hamer et al., in press) and might be beneficial for the growth of the pasture grasses in the long-term. Results from the field experiment FERPAST (Pasture Fertilization Experiment) indicate that total above ground biomass production of *Setaria sphacelata* increased in average about 1 t ha^{-1} a^{-1} due to urea fertilization within the first year of the experiment. Furthermore, net N-mineralization rates significantly increased in 0-5 cm soil depth in the plots fertilized with urea (Figure B2.1).

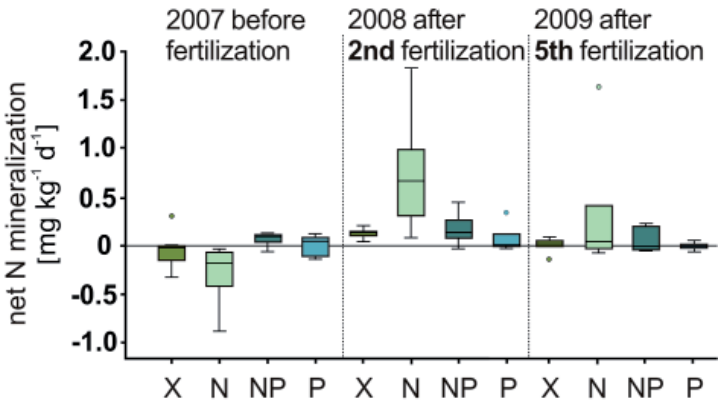

Figure B2.1: Net N-mineralization rates of control plots without fertilization (X) and plots with urea (N), urea + rock phosphate (NP) and rock phosphate (P) fertilization determined in November 2007 before fertilization, after the 2nd fertilization in June 2008 and after the 5th fertilization in June 2009 (soil depth 0-5cm; n=6). Graph: Ute Hamer & Karin Potthast.

Differences between the years 2008 and 2009 seem to be related to lower precipitation and thus lower soil moisture content in 2008.

Ute Hamer & Karin Potthast

Reference

Hamer, U., Potthast, K., Makeschin, F., (2009). Urea fertilisation affected soil organic matter dynamics and microbial community structure in pasture soils of Southern Ecuador. Applied Soil Ecology 43: 226-233. http://dx.doi.org/10.1016/j.apsoil.2009.08.001

Sahara Dust Returns with Recent La Niña Events

In a recent publication of subproject **B2.3** (Boy & Wilcke, 2008) we postulated that during strong La Niña events Sahara-derived Ca and Mg is deposited at our study site. This was attributed to an increased likelihood of the passage over the whole Amazon basin by Sahara dust with the easterly wind trajectories during La Niña-related weather conditions.

Figure B2.3a now clearly illustrates that during the two subsequent La Niña events in 2005/2006 and 2007/2008 - as indicated by the negative sea surface temperature anomalies in the region 3.4 of the Pacific in front of the Ecuadorian coast - again increased Ca and Mg concentrations and pH in rainfall occurred supporting our hypothesis.

During the dust-free period between 2000 and 2005, we observed a seasonal cycle of acid inputs caused by the Amazonian forest fires (Boy et al., 2008) and an overall negative trend of the pH in rainfall as indicated by the tentative trend line. Thus, the element deposition from the atmosphere is controlled by two different teleconnections with contrasting effects on the north Ecuadorian mountain forests. The cumulative long-term effect of these two processes and their susceptibility to climate change are unknown but will likely be of paramount importance for the maintenance of the high biodiversity.

Wolfgang Wilcke

References

Boy, J. and W. Wilcke (2008): Tropical Andean forest derives calcium and magnesium from Saharan dust. Global Biogeochem. Cycles, 22, GB 1027, http://dx.doi.org/10.1029/2007GB002960

Boy, J., R. Rollenbeck, C. Valarezo und W. Wilcke (2008): Amazonian biomass burning-derived acid and nutrient deposition in the north Andean montane forest of Ecuador. Glob. Biogeochem. Cycle 22, GB4011, http://dx.doi.org/10.1029/2007GB003158.

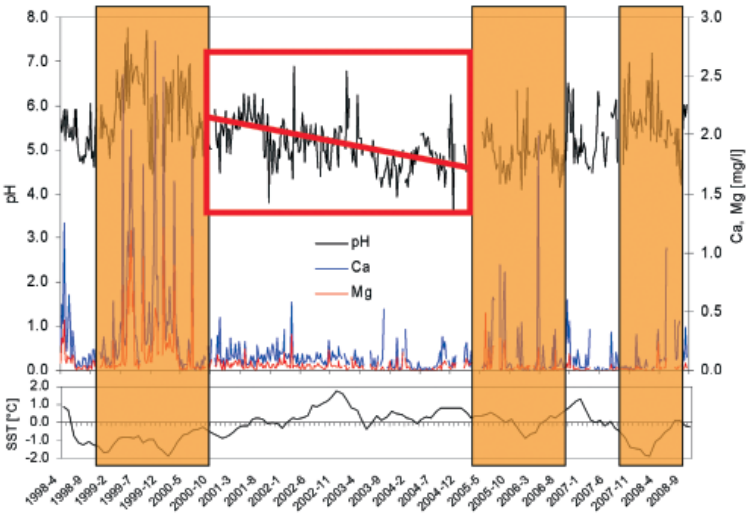

Figure B2.3a: Course of pH and Ca and Mg concentrations in rainfall at the gauging station of Microcatchment 2 between 1998 and 2008 (above) and course of the sea surface temperature anomalies (SST) in the region 3.4 in front of the Ecuadorian coast (NOAA 2009, below). Pronounced negative SST periods (La Niña events) associated with increased pH and Ca and Mg concentrations are highlighted in orange. The period framed in red shows an acidification trend of rainfall between the La Niña events. Graph: Wolfgang Wilcke.

Model Framework to Access hydro-biogeochemical Processes

The aim of the subproject **B3.2** was to improve our understanding of catchment scale hydro-biogeochemical processes. In April 2007 we therefore installed 11 gauging stations in the catchment in a nested design (Figure B2.3b). Through discharge measurements and biweekly water sampling at all stations, we obtained a large database on isotopic signatures, nutrients and element concentrations. With the data obtained during the last 2.5 years, we are now able to estimate the changes taking place when cloud forest is converted to pasture.

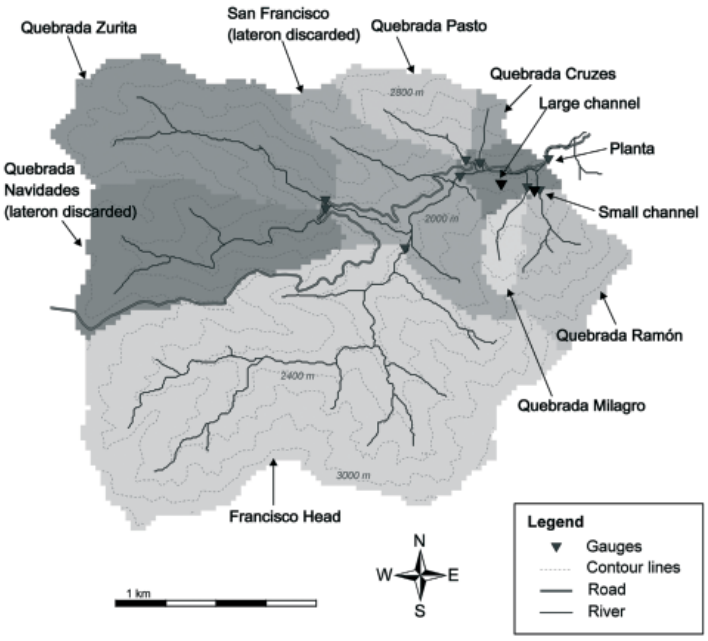

Figure B2.3b: Gauging stations throughout the catchment. Map: Amelie Bücker.

Concentrations of Ca, Na, K, Mg and SO_4 in pasture streams are considerably higher than in forest streams, whereas NO_3 concentrations are lower. Land-use is the main factor changing water chemistry, but other influences such as vegetation processes (affecting K) and other anthropogenic controls such as gravel excavation and road construction play a role, too. In the next steps we will apply a hydro-biogeochemical model at the catchment scale, and we will set up an erosion monitoring system at the Planta.

Amelie Bücker

References

Bücker, A., Crespo, P., Vaché, K., Cisneros, F., Frede, H-G., Breuer, L. (in press). Identifying controls on water chemistry of tropical cloud forest catchments - combining descriptive approaches and multivariate analysis. Aquatic Geochemistry. http://dx.doi.org10.1007/s10498-009-9073-4

Figure B2.3c: Amelie Bücker (left) measures depth and flow velocity of the Rio San Francisco close to Sabanilla. Photo: private.

Reforestation with Native Species Requires Intensive Consideration of Interactions

Group DFG no **C2.1** in cooperation with the group **C3.4** showed that differences in soil properties had strong effects for *Eucalyptus saligna* and *Alnus acuminata* in reforestation trials. Manual above ground weeding showed species specific effects: *Tabebuia chrysantha* and *Heliocarpus americanus* showed improved height growth, while that of *Cedrela montana* was reduced. There is evidence that *Alnus acuminata* can compete in growth with exotic species. Early successional species and exotics performed best on pasture dominated sites. Height growth of the mid successional species *Cedrela montana* was facilitated by bracken fern under certain soil conditions, and shrubs facilitated growth of *Tabebuia chrysantha*.

Figure C2.1a: Five years old individuals of *Cedrela montana* on a pasture plot with treatment of ground vegetation. Photo: Sven Günter.

The results indicate that reforestation with native species in Ecuador is possible but requires intensive considerations of interactions with soil properties and accompanying vegetation. Macroscopic soil core analysis can be a suitable instrument for detecting small scale variation of soil properties. However, a characterisation of both small scale variation as well as variation on higher spatial scales, for instance by aerial photographs, is essential for effective planning of reforestation measures in the Andes. *Sven Günter*

Reference

Günter S., Gonzalez, P., Álvarez, G., Aguirre, N., Palomeque, X., Haubrich, F. & Weber, M. (2009): Determinants for successful reforestation of abandoned pastures in the Andes: soil conditions and vegetation cover. Forest Ecology and Management. http://dx.doi.org/10.1016/j.foreco.2009.03.042

Figure C2.1b: To be able to establish light gradients hemispherical images were used to measure foliate coverage. Photo: Sven Günter.

How Light Influences the Establishment of Native Trees

The development of successful planting strategies requires knowledge of environmental demands on and ecological requirements of native species during their establishment. This knowledge is currently lacking for mid- and late-successional species in neotropical mountain forests. Therefore DFG group no **C2.1** planted two deciduous, mid-successional (*Cedrela montana*, *Tabebuia chrysantha*) and two evergreen, late-successional native tree species (*Nectandra membranacea, Podocarpus sprucei*) into felling gaps. Photosynthetic performance and height growth of these species were assessed along light gradients during seedling establishment to test whether species-specific light responses were related to plant successional traits.

Both mid-successional species benefited from higher light levels in gaps up to 30% canopy openness 60°. In larger gaps *C. montana* exhibited a significant decline in growth. As expected, growth of the late-successional species was only marginally increased at higher light levels. Nevertheless, the photosynthetic apparatus of *N. membranacea* displayed rapid acclimation to higher light conditions in gaps. The results may offer an ecological basis to increase the abundance of valuable timber species through enrichment planting in Ecuadorian mountain rain forests. *Sven Günter*

Reference

Kuptz, D., Grams, T. & Günter, S. (2009): Light acclimation of four native tree species in felling gaps within a tropical mountain rain forest. Trees-Structure and Function. http://dx.doi.org/10.1007/s00468-009-0385-1.

Landslide Dynamics

Our project (DFG no **A3.3**) aims at understanding processes that trigger natural landslides and their interaction. Considering soil physical as well as hydrological and vegetation related factors, we integrate knowledge that has been gathered by different research groups. Soil landscape models are developed relating soils with their position within the landscape determined by relief and hydrological properties. A continuous soil map (Figure A3.3a) produced by state of the art regionalization techniques and a process based simulation model of forest dynamics (FORMIND, Figure

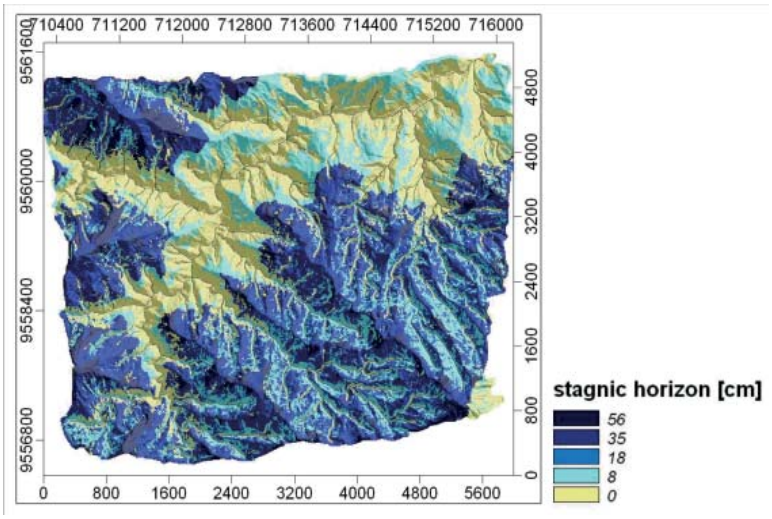

Figure A3.3a: Stagnic horizon depth within ECSF area modelled with Classification and Regression Trees. Graph: Mareike Ließ.

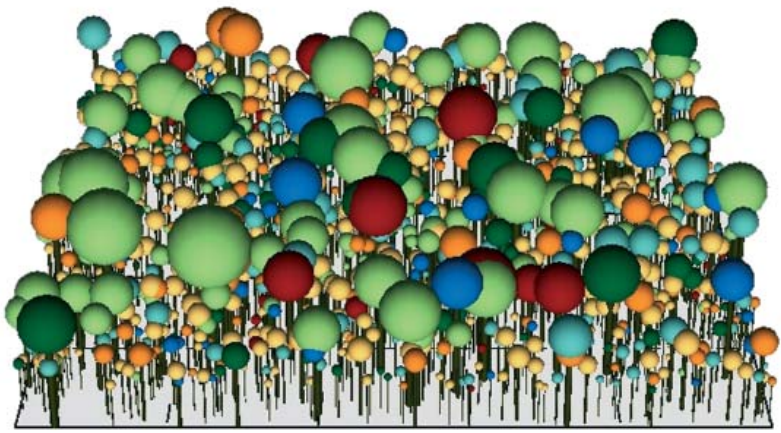

Figure A3.3b: Visualization of FORMIND for ridge forest with seven plant functional types in different colors. Graph: Claudia Dislich

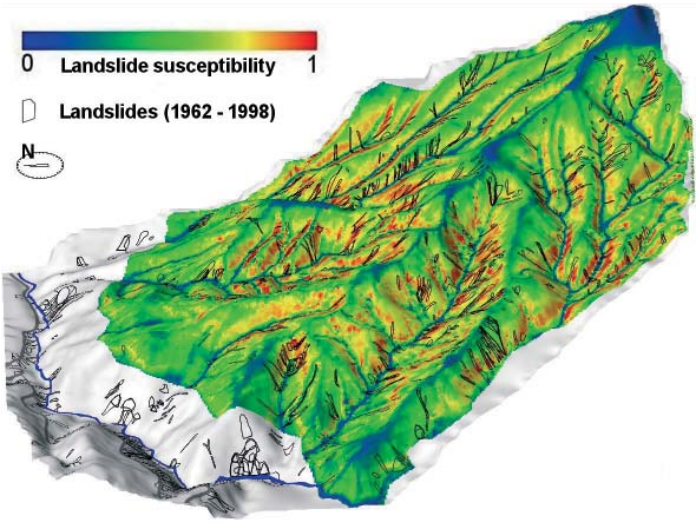

Figure A3.3c: Landslide susceptibility map of ECSF area calculated by Maximum Entropy method. Graph: Peter Vorpahl.

A3.3b) will be integrated into a spatially explicit model of landslide dynamics.

Statistical analyses revealed that within the ECSF area hydrological processes are not as important for the calculation of landslide susceptibility (Figure A3.3c) as they are in colder climates. Vegetation and soil thickness seem to be major factors. The role of vegetation for landslides is ambiguous: it destabilizes slopes due to its weight while roots act as stabilizers. First results show that due to shallow roots and high local biomass, vegetation as a whole might act as a trigger for landslides.

Claudia Dislich, Mareike Ließ, Peter Vorpahl

Stronger Soil Development under Forests

Subproject **C3.4** deals with the development of an agroforestry site and risk classification model in the research region of Southern Ecuador. Different rocks (phyllite/clay schist (PC) and metasilt-/-sandstone/quartzite (MSQ)), frequent land slide activities and vegetation cover hinder a facile mapping rock/soils in the study area. To get information about rock distribution and weathering status of the soils in the ECSF area, Ti content as immobile and sum of main element content (Σ - Al, K, Fe, Mg, Na, Ca) as mobile elements of rocks and soils were compared (Ti/Σ relationship). We used the unweathered rocks as background to follow the weathering status of the soil horizons.

All top soils down to 0.3 m depth plot to lower Σ values compared with the rocks indicating a strong decrease of main elements (Figure C3.4a).

Along soil profile sequences from subsoil horizons to top soil horizons the main elements decrease strongly and Ti content increases simultaneously (Figure C3.4b). Using a generalization of the soil development trend (Figure C3.4b) we can predict a) the increase and decrease of elements due to the rock weathering, and b) to recalculate the original soil substrate (OSS) of the most soil samples.

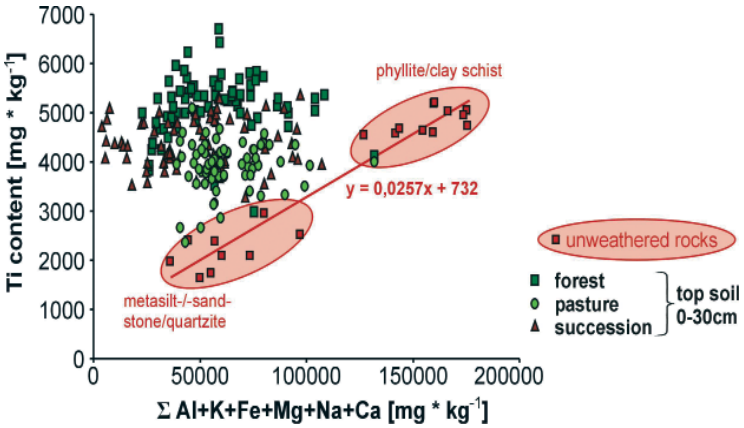

Figure C3.4a: Comparison of the Ti content and the sum of main elements (Σ) of rocks and soils from different land use. Graph: Frank Haubrich.

Figure C3.4c shows the recalculated OSS of the forest, pasture and succession plots compared with the original rocks. The forest soils are developed more dominantly from PC, while pasture and succession soils derived from a mixture of PC and MSQ. Under the recent soil development the differences in OSS equalized indicate a longer and undisturbed soil development under forest (Figure C3.4c).

Frank Haubrich and Franz Makeschin

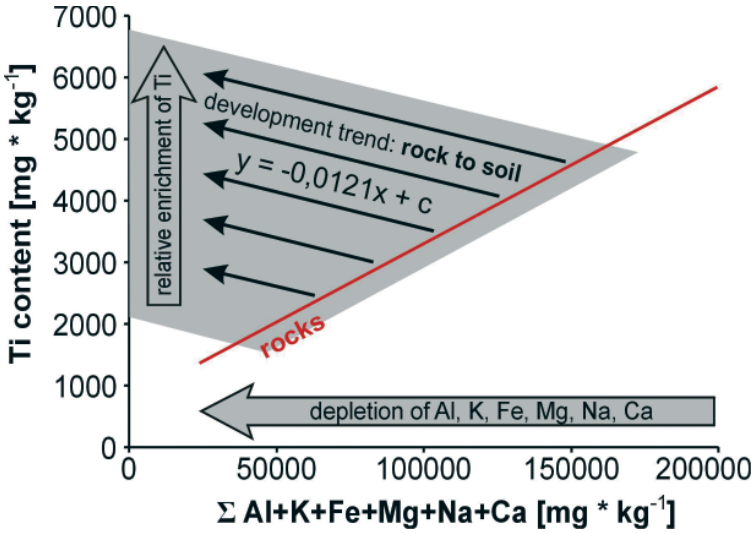

Figure C3.4b: Generalized trend of the chemical elements and the soil development from rock to soil. Graph: Frank Haubrich.

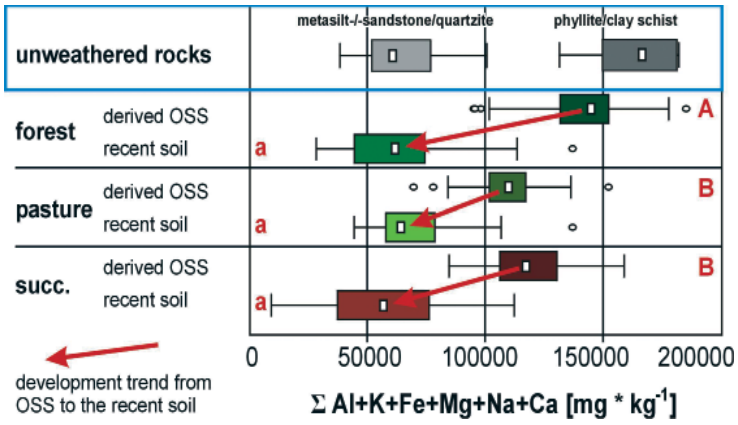

Figure C3.4c: Development trend of recalculated original soil substrates (OSS) of forest, pasture and succession plots to the recent soils (different red letters indicate significant differences ($p < 0.05$), A, B = derived OSS, a = recent soils). Graph: Frank Haubrich.

Regional Climate Model Runs Confirm Hypothesis

The unusual morning maximum of rainfall at the Reserva Biológica San Francisco (RBSF) was hypothesized to be a result of lowland-highland interactions: nocturnal cold air drainage flow from the Andes causes the formation of Mesoscale Convective Complexes (MCS) in the Andean foothills. These in turn are propagated to the RBSF area, leading to instabilities and rainfall. A first satellite and radar based study conducted by group no **B3.1** provided phenomenological and statistical evidence that this mechanism particularly holds for the relative dry season in the austral summer (Bendix et al. 2009).

A study with idealized runs with the adapted Regional Climate Model ARPS corroborated (Figure B3.1) that

- katabatic flows develop over topographical elements (slopes and valleys),
- confluence of katabatic flows in a lowland basin with a concave terrain line like in the southern part of the east-Ecuadorian Andes occur and
- a complex drainage flow system regime directed into such a basin can sustain the confluence despite varying slope angles and slope distances.

In a second simulation study, we witnessed the important role of the confluence for MCS generation as well as the intensification of convection due to additional Low Level Jet (LLJ) activity.

Katja Trachte, Rütger Rollenbeck, and Jörg Bendix

References:

Bendix J, Trachte K, Cermak J, Rollenbeck R, Nauß T 2009: Formation of convective clouds at the foothills of the tropical eastern Andes (south Ecuador). J Appl Meteorol Climatol 48: 1682–1695. http://dx.doi.org/10.1175/2009JAMC2078.1

Trachte K, Nauß T and Bendix J 2009: The impact of different terrain configurations on the formation and dynamics of katabatic flows - idealised case studies, Boundary layer Meteorol. (manuscript in revision)

Bracken Prefers Sunny Weather

In close cooperation groups **C3.1** and **Z1.1** analyze the competition between the weed bracken fern (*Pteridium arachnoideum*) and the major pasture grass of the area, *Setaria sphacelata*. The parameterization of the Southern Bracken Competition Model (SoBraCoMo, Figure C3.1a) with regard to structural and optical plant traits was finished.

First simulations (Figure C3.1b) with the radiation scheme shows that, under cloudy sky conditions (mainly diffuse irradiance), photosynthetically active radiation (PAR) absorption is slightly higher for

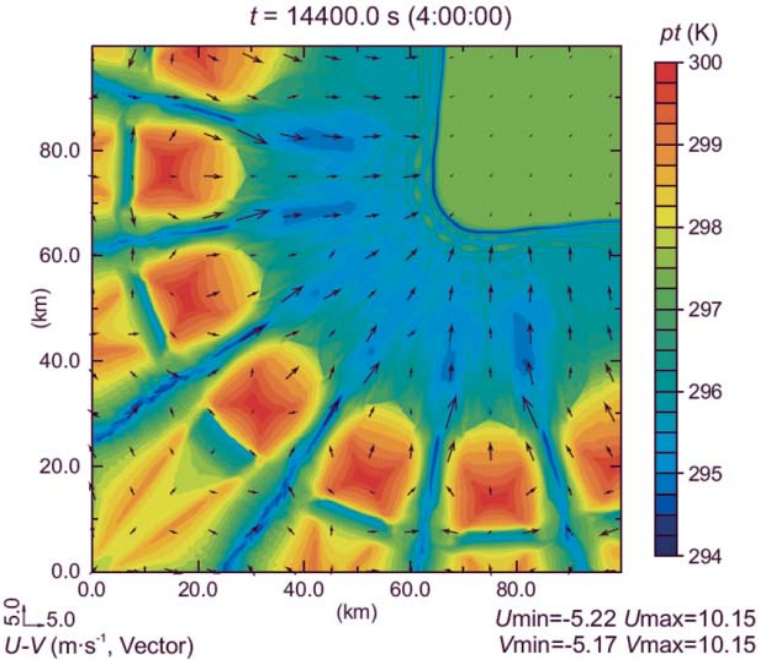

Figure B3.1: Example for an idealized simulation of cold air drainage flow under a concave shape of the terrain line. The figure shows the horizontal cross-section (xy-plot at z = 50 m above ground level) of the potential temperature (shaded, K) and the wind field in u-v direction (vectors, m s^{-1}) of BSNV simulation for time step 14400 s, and a clear convergence of cold air drainage flow from the Andes and the warm Amazon air (upper right corner). Graph: Katja Trachte.

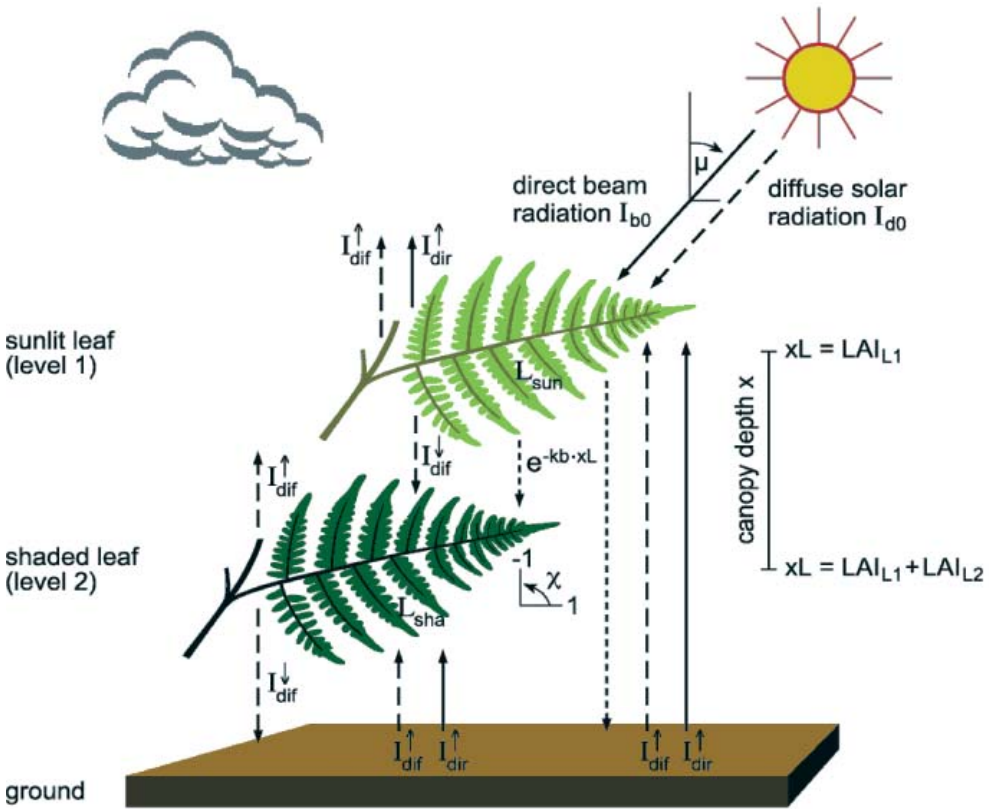

Figure C3.1a: Radiation scheme of the Southern Bracken Competition Model (SoBraCoMo). Scheme: Silva Brenner and Jörg Bendix

Setaria while under clear sky conditions (mainly direct irradiance), the average bracken individual is characterized by a higher PAR absorption potential (~74 MJ m^{-2} a^{-1}). The latter situation – which occurs if the maximum daily irradiance exceeds 615 W m^{-2} – is mainly due to the nearly orthogonal incidence of the direct solar beam onto the horizontally oriented frond area which implies a high amount of direct PAR absorption during the noon maximum of direct irradiance.

Such situations of solar irradiance favoring a higher PAR absorption of bracken occurred in ~36% of the observation period (1998-2005). By considering the annual course of PAR irradiance in the San Francisco Valley, the clear advantage of bracken on clear days (36% of all days) is completely compensated by the slight but more frequent advantage of *Setaria* under overcast conditions (64% of all days). This means that neither bracken nor *Setaria* show a distinct advantage in PAR absorption capability under the current climatic conditions of the study area.

Silva Brenner, Kristin Roos, Erwin Beck, and Jörg Bendix

References:

Bendix, J.,Silva, B., Roos, K. Göttlicher, D., Rollenbeck, T., Nauß, T. and Beck, E. 2009: Model parameterization to simulate and compare the PAR absorption potential of two competing plant species. Int. J. Biometeorol. (*accepted*)

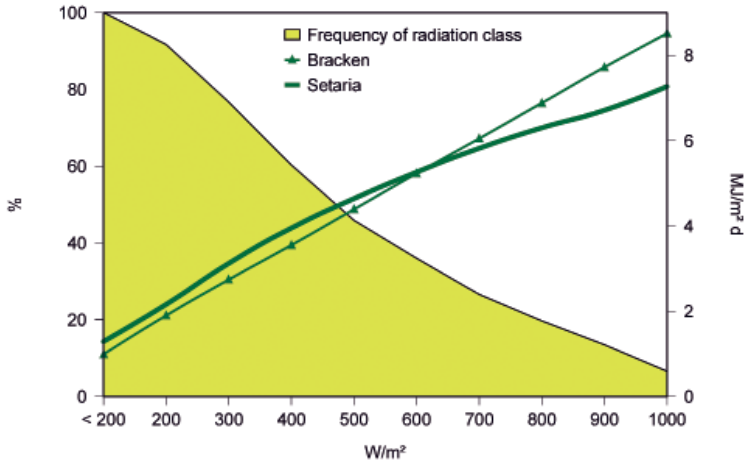

Figure C3.1b: Frequency and intensity of the daily irradiance maximum between 12:00 and 13:00 h for the ECSF meteorological station (1998-2005) and total daily PAR absorption by bracken and *Setaria* (right y axis), respectively, based on the relative diurnal course of radiation from 5th Dec 2007. Graph: Jörg Bendix and Silva Brenner.

Data and Publications

In the last months there was again a massive upload of datasets from various working groups. We are presenting now nearly 200 datasets including over 19 million single datavalues. The attribute list is now automatically updated and can be downloaded from the web site (www.tropicalmountainforest.org in the "Documents & Services - General Information" section). If you wish to upload new data, please check in the new list of attributes whether some are appropriate for you.

Some new features are implemented to the datawarehouse: the complete dataset listing or the search results and the publication listing are now presented on single pages with only ten items making the page reproduction much faster instead of listing all datasets/publications. The publication section was also filled with numerous new articles and thesis by the subprograms and has some new search functions (filtering on publication type and new sorting functions).

All the new datasets and publications make a look at them worthwhile. We wish to thank all contributing members of the RU. *Dietrich Göttlicher*

People and Staff

Prof. Dr. Wolfgang Wilcke, the principal investigator of project B2.3, moved to the University of Berne on October 1st. His new address is: Geographic Institute, University of Berne, Hallerstr. 12, 3012 Berne, Switzerland, Phone: +41 31 631 88 75, Fax: +41 31 631 85 11.

Dr. Sven Günter from project C2.1 received the facultas docendi (cumulative habilitation: postdoctoral lecture qualification) at the Technische Universität München, Germany. His thesis is entitled: "Silvicultural contributions to the restoration of forest resources in tropical montane ecosystems in southern Ecuador". During his habilitation he published 21 research papers summarizing to 18.3 ISI points.

The plant *Valeriana convallarioides* shields its blossoms with succulent leaves. The image was taken near Cajanuma at 3350 m a.s.l. in the Páramo vegetation. Photo: RU 816.

Imprint

DFG Research Unit 816 (RU)

More information about research, the scientific and the local advisory board, and all principal investigators is available at:
www.tropicalmountainforest.org

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