Extra Newsletter

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

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Towards a Platform for Biodiversity and Ecosystem Monitoring and Research in South Ecuador

Past Achievements of and Future Plans for a Joint German-Ecuadorian Research Program

Call for Project Proposals

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Preamble

At least since the publication of the Millennium Ecosystem Assessment (2005) it is undisputed that global environmental change, particularly land-use and climate change are threatening biodiversity, and with it, functioning and services of the ecosystems. Recording of the status quo and its changes is the first step for apprehending such processes which in turn enables the human society to counteract in a sustainable way. In our days this multifaceted syndrome is summarized under the concept of "monitoring" of e.g. biodiversity, environmental or ecosystem parameters. Monitoring in the sense of "simple" recording requires the selection of relevant indicators. In several developed countries with a comparatively low degree of biodiversity and a long standing tradition in nature observation, monitoring systems based on structural and compositional indicators have been developed and, as e.g. in Germany, implemented by the government ("Bundesanzeiger, Vol. Nr. 25, 15. February 2011").

A prerequisite for this venture is on the one hand a distributed net of monitoring stations, e.g. of climate variables and on the other hand an area-wide net of trained observers which frequently are organized in semi-professional societies. Such essential contributions by amateurs are known as citizen science. To date, such operational monitoring frameworks are completely lacking in the majority of developing countries. This also holds true for Ecuador which is known as one of the hottest biodiversity hotspots worldwide (Mutke et al. 2010).

To date, a general problem with the existing, relatively straightforward monitoring concepts in developed countries is that they address mainly descriptive indicators rather than functionality in the ecosystem. Thus such indicators cannot unveil global change impacts on ecosystem functioning and services. An extension of commonly used basic concepts is urgently required which comprises suitable functional indicators / indicator systems. Unfortunately, such indicators are hitherto widely unknown, particularly in hotspot areas of biological diversity where sophisticated basic research efforts are needed to develop relevant indicator systems for an understanding of the scope and consequences of global change.

Based on a comprehensive ecosystem research in South Ecuador, a new German-Ecuadorian collaborative research program is planned, namely a "*Platform for Biodiversity and Ecosystem Research and Monitoring in South Ecuador*". With this platform the following aims shall be pursued:

- Development of a science-directed monitoring system encompassing compositional, structural and, for the first time, functional indicators for a tropical hotspot area,
- Comprehensive training on all educational levels (academia to citizen science) to gain experts for the transfer to implement the developed monitoring system,
- Providing a platform for international cutting-edge science extending also beyond the planned research on indicators.
- Considering most vulnerable and thus, change-sensitive ecosystems (dry forest, Páramo, mountain rain forest) of southern Ecuador.

Our successful research and education engagement in southern Ecuador since 1997 makes this area to a priority site for the monitoring platform. With this Newsletter we call for project proposals for the first phase of the platform (3 years), starting spring 2013. Specific details on our achievements are presented in the following chapter (see pages 3 ff).

Financing of the current research programme (RU816) ends by March 2013. To warrant a longer-term perspective we strive for the co-funded project mentioned above where German groups could apply with the German Research Foundation DFG while the Ecuadorian partners apply for financing by Ecuadorian research funding agency SENESCYT. A memorandum of understanding is currently framed by both funding organizations in which the planned research is mentioned as a pilot project.

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Achievements of the Preceding Research in South Ecuador

1 Project History

The ***history*** of (mostly DFG-funded) research in southern Ecuador started with six projects in 1997 which were mainly aiming at biotic and abiotic inventories of this at that time widely unknown ecosystem. Nevertheless, this DFG-bundle program was the starting point of a real success story of joint German-Ecuadorian research collaboration (Fig. 1).

The first collaborative research unit (RU402) "*Functionality in a Tropical Mountain Rainforest: Diversity, Dynamic Processes and Utilization Potentials under Ecosystem Perspectives*" started in 2001 with 17 projects, increasing to 25 projects at the third phase (2005-2007). The main focus of the research program was to investigate ecosystem functioning along environmental gradients. The following research unit (RU816) "*Biodiversity and Sustainable Management of a Megadiverse Mountain Ecosystem in South Ecuador*", which will expire in 2013, almost has the same number or projects, but was and still is focusing on ecosystem functioning and services in both manifestations of the ecosystem, the natural forest and the pastures. The RU816 has also started to investigate impacts of environmental change on ecosystem functioning and services. Over the years, the research projects in the San Francisco Valley could establish a sophisticated research infrastructure and thus became more and more attractive for further research consortia. The first research program joining the platform in late 2008 was the EU-funded EDIT program ("*All Taxa Biodiversity Inventories and Monitoring ATBI+M*") with two (out of 27) projects working in Ecuador, mainly devoted to species inventories. The latest DFG-funded research program starting work in the research area was the ABA-Ecuador bundle ("*Accelerated Biodiversity Assessment*") in 2011 with three projects aiming at new and effective screening methods for rapid biodiversity assessment. While in the beginning, research projects were defined mainly be the German scientists and then performed in close cooperation with Ecuadorian staff and students, accumulating knowledge increased the willingness of the Ecuadorian partners to join the venture by co-funding projects which are designed mainly by the Ecuadorian side. Hence, in compliance of the South Ecuadorian universities with the DFG, a program for autonomous scientific staff development, the so-called *collaboration program*, was launched in late 2009 with five such projects. During the second phase of the cooperation program, the Ecuadorian research funding agency SENESCYT joined the endeavour providing funds for some of the eight new projects. The third phase of the cooperation program with now 12 projects also involving two universities from Cuenca is currently under review at DFG. After nearly 15 years of research, several projects originally designed to topics of basic research gained practical knowledge and developed techniques for transfer to application. The first example is the DFG-funded transfer program "*Nuevos Bosques para Ecuador*" with four subprojects which is devoted to afforestation of abandoned areas with native trees, based on technologies developed during the past nine years.

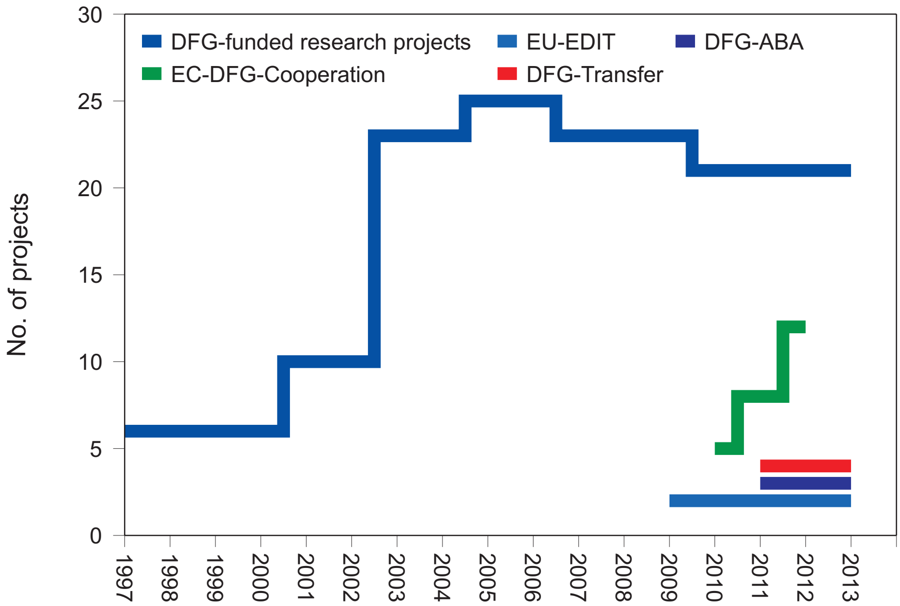

Fig. 1: Funded projects working in southern Ecuador; bluish colors indicate research projects, green colors indicate an autonomous staff development program and red colors the transfer of basic knowledge to application. Graphic: Jörg Bendix.

See also:

RU402: http://bergregenwald.de
RU816: www.tropicalmountainforest.org
EDIT: The European Distributed Institute of Taxonomy www.e-taxonomy.eu
ABA-Ecuador bundle: Accelerated Biodiversity Assessment: see TMF Newsletter no 9, pages 12-14 doi: 10.5678/lcrs/for816.cit.1002
Transfer project: "*Nuevos Bosques para Ecuador*": see TMF Newsletters no 9, pages 14-15 doi: 10.5678/lcrs/for816.cit.1002 and TMF Newsletter no 14, pages 4-5 doi: 10.5678/lcrs/for816.cit.1031

2 Scientific Achievements, Gained Knowledge Base and Data Collections

The ***scientific results*** of the research have been compiled so far in 395 publications which are currently stored in the data warehouse of the research unit. Among these are several books (among other the concluding volume of RU402: Beck et al. 2008) and 295 scientific articles published in peer-reviewed journals (Fig. 2). A strong increase of articles over the time documents the steadily increasing knowledge. Furthermore, the enhancing qualification and thus, contribution of Ecuadorian scientists to the research programs led to a clear increase of Ecuadorian-German co-authored articles, a major achievement by our capacity building activities.

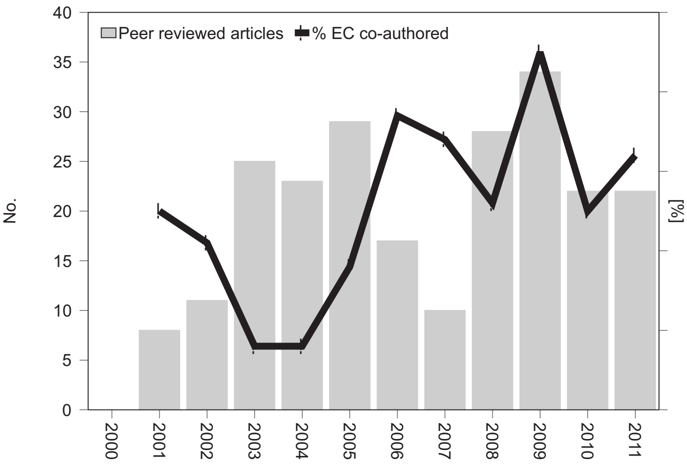

Fig. 2: Number of articles (bars) in peer-reviewed journals and percentage of Ecuadorian co-authored papers (solid line, source: Data warehouse of the RU816 by 11-2011). Graphic: Jörg Bendix.

Although by far not yet complete the most comprehensive data basis is available for the San Francisco Valley and adjacent areas. These data could be used as a base for the development of monitoring protocols. However, some data from the two additional areas (Cajas Páramo and Dry Forest at Laipuna) are also available.

Table 1: Available species inventories for the ECSF area

		Families	Genera	Species	Reference[1)]
Plants	Eukaryotic microalgae and cyanobacteria			ongoing	Friedl & Beck (ABA)
	Spermatophyta	130	407	1208	Homeier & Werner (2008)
	Pteridophyta	22	58	257	Lehnert et al. (2008)
	Anthocerotophyta	2	3	3	Gradstein
	Marchantiophyta	29	85	317	Gradstein et al. (2008)
	Bryophyta: (liverworts, mosses, hornworts)			527 (320, 204, 3)	Gradstein et al. (2007)
	Musci	40	116	205	Kürschner & Parolly (2008)
	Lichenes	46	120	323	Nöske et al. (2008)
Animals	Chiroptera (bats) 100%			21 (24)	Matt (2001)
	Aves (Birds) 100%			227 (379)	Paulsch (2008), Rasmussen et al. (1994)
	Moths			(2396)	Brehm et al. (2005), Hilt (2005), Süssenbach et al. (2003), Fiedler et al. (2008a, b), Brehm (2010), Bodner (2011)
	Butterflies (Papilionidae)			(243)	Häuser et al. (2008)
	Ants			ongoing	Leponce (EDIT)
	Bush crickets (Tettigoniidae)			(101)	Braun (2002)
	Chrysomelid beetles			ongoing	Wägele & Schmitt (ABA)
	Macro-invertebrates	28		37	Bücker et al. (2010)
	Long-legged flies (Diptera: Dolichopodidae)			ongoing	Pollet (EDIT)
	Oribatid mites			129 (167)	Illig et al. (2008)
	Testate amoebae			78 (110)	Krashevska (2008)
Fungi	Glomeromycota			83	Haug et al. (2004), Kottke et al. (2007)
	Ascomycota			4	Haug et al. (2004)
	Basidiomycota			96 (102)	Haug et al. (2004), Kottke et al. (2007), Suarez et al. (2006)

[1)] For references refer to www.tropicalmountainforest.org and select "*publications*" in the menu bar

For the area around the Estación Científica San Francisco (ECSF) inventories of biota species were mostly compiled during the initial bundle project and the first years of RU402. The state of knowledge is published in a (preliminary) checklist (Liede-Schumann & Breckle 2008) and an overview is presented in Table 1. More inventories of other groups of biota are currently in progress, in particular by the cooperating projects funded by EDIT and ABA, most of them using molecular methods (Table 1 see "*ongoing*").

With regard to ecosystem functioning and the relation of organisms to changing habitat conditions, e.g. climate and nutrient status, several biotic process parameters have been selected, some of which are still continuously recorded (Table 2).

Inventories of ***abiotic factors*** in the ***ECSF*** area are partly based on field surveys, provided by continuous logger-based data acquisition, and by remote sensing (RS) / GIS techniques (Table 3).

Table 2: Observation of biotic process parameters

	Parameter	Reference[1)]
Above ground	Tree phenology	Cueva-Ortiz et al. (2006), Bendix et al. (2006), Günter et al. (2008)
	Tree growth	Bräuning & Bruchard (2005), Bräuning et al. (2008), Bräuning et al. (2009), Volland et al. (2011), Cabrera et al. (2006), Kuptz et al. (2010), Dieslich et al. (2009), Homeier et al. (2009)
	Litter fall	Röderstein et al. (2005)
	Litter decomposition	Wilcke et al. (2005), Illig et al. (2005, 2008), Potthast et al. (2010)
	Sap flow	Motzer et al. (2005), Küpppers et al. (2008)
Below ground	Root growth	Leuschner et al. (2006, 2007), Graefe et al. (2008), Soethe et al. (2008)
	Litter decomposition	Illig et al. (2005, 2008)
	Soil respiration	Iost et al. (2008), Krashevska et al. (2008)

[1)] For references refer to www.tropicalmountainfoest.org and select "*publications*" in the menu bar

Table 3: Available abiotic inventories and monitoring parameters for the ECSF

		Parameter	Reference[1)]
Atmosphere	Point observations	Air temperature	Richter (2003), Bendix et al. (2008a, b)
		Air humidity	Richter (2003), Bendix et al. (2008a, b),
		Radiation	Bendix et al. (2008a, b), Emck & Richter (2008)
		Rainfall	Richter (2003), Rollenbeck et al. (2007), Bendix et al. (2006), Bendix et al. (2008a, b)
		Rainfall interception and throughfall	Fleischbein et al. (2005), Wullaert et al. (2009)
		Fog	Rollenbeck et al. (2008), Rollenbeck et al. (2011)
		Wind	Bendix et al. (2008a, b)
		Rain- / Fog water chemistry	Fabian et al. (2005), Boy & Wilcke (2008), Boy et al. (2008)
		Trace gas emissions	Martinson et al. (2010)
	Spatial observations	Air temperature (GIS)	Fries et al. (2009)
		Air humidity (GIS)	Fries et al. (2012)
		Clouds, fog (RS, web-cam)	Bendix et al. (2004, 2006, 2008)
		Rainfall (Radar)	Rollenbeck & Bendix (2006, 2011)
Hydrosphere	Point observations	River / catchment discharge	Goller et al. (2005), Fleischbein et al. (2006), Crespo et al. (2011)
		Evapo-transpiration	Motzer et al. (2005), Küpppers et al. (2008), Wilcke et al. (2008)
		Water chemistry	Goller et al. (2006), Bücker et al. (2010), Schwarz et al. (2011)
Pedosphere	Point observations	Soil type	Wilcke et al. (2003, 2008)
		Soil temperature	Richter (2003)
		Soil water	Huwe (2007), Bigner et al. (2008), Engelhradt et al. (2009)
		Nutrient status	Wilcke et al. (2002), Wilcke et al. (2011), Potthast et al. (2011)
	Spatial observations	Soil type (GIS)	Ließ et al. (2009, 2011)

[1)] For references refer to www.tropicalmountainforest.org and select "*publications*" in the menu bar

Fig. 3: Slash and burn practice is common in the San Francisco area. To analyze its effects on the infestation of mountain pastures by aggressive weeds the research units performed an ecological fire experiment among other experiments in consultation with the Ecuadorian Ministry of Environment. Photo: Thomas Nauß.

Inventories of ***socio-economic factors*** in the research area are hitherto mainly related to land-use systems with particular reference to three indigenous groups. Methods for data acquisition are ranging from single and/or recurring household and farm surveys up to the utilization of remote sensing data (Table 4).

In 2002 the first ***data base*** project, the metadata base of RU402, was launched. Since then the majority of collected data is uploaded by the scientists to the central data bases. Since 2007, data are stored and administered in the new data warehouse FOR816-*DW* which also handles all administrative issues of the research unit and encompasses also the literature data base. The structure of the data bases was defined and is regularly adapted to changing requirements by means of database workshops. At present 824 attributes have been defined of which 537 are currently used in the FOR816-*DW*. To date, the file system of the RU402 metadata base includes 6240 files, the data stock of the RU816-*DW* encompasses 381 (partly complex) data sets with more than 29 Mio single data values. The web interface of the FOR816-*DW* contains also the website of the research program and thus is important for the national and international visibility. Currently, 690 visits per month on average (only visits longer than 1 min duration are counted, without bots and crawlers) indicate an excellent visibility of the research program.

Table 4: Available socio-economic inventories and monitoring parameters for the research area

	Parameter	Reference [1)]
Point observations	Population statistics	Pohle et al. (2008)
	Plant use (indigenous knowledge)	Pohle & Reinhard (2004) , Gerique & Veintimilla (2004)
	Economic farm surveys	Pohle & Gerique (2006), Pohle et al. (2008, 2009), Knoke et al. (2009)
Spatial observations	Land use, land cover (RS)	Göttlicher et al. (2009)

[1)] For references refer to www.tropicalmountainfoest.org and select "*publications*" in the menu bar

Fig. 4: Since non-sustainable slash and burn practice is used to establish pastures which are often abandoned after a few years the second research unit analyzed which land-use models can reconcile farming and conservations issues. They also analyzed fertilization techniques for restoration of pastures and tested afforestation practices with indigenous trees. Photo: RU816.

3 Usable Research Infrastructure and Methods for Monitoring

3.1 Field Instrumentation

In the course of the research programs, sophisticated instrumentation was installed in the field which, depending on the changing requirements of the research programs, delivered data of important ecological factors which can be used and further on extended by future monitoring activities. The meteorological stations are a good example for the availability of longer-term data (Table 5). The majority of the stations was installed directly at the beginning of the program. After the first phase of RU402, some of them were dismantled and relocated to new study sites. Others had to be terminated after reaching their lifetime, when at the same time, new stations e.g. on experimental plots (e.g. Pasto 2) were established or older ones (as ECSF) replaced. However, the important fact is that the essential stations were continuously operated since the beginning of the program without greater interruptions (first line in Table 5: ECSF to Cerro).

This also holds true for other equipment operated in the programs since 1998 the most important of which shall be briefly summarized:

- Atmosphere in addition to Table 5: Three fog/rain water collectors for atmospheric chemistry (since 2002), rain gauges for chemical analysis (since 1998), MRR-vertical rain radar (since 2007), LAWR X-band scanning rain radar (since 2002, with interruptions), Nubiscan cloud monitor (since 2009), scatterometer (since 2002).
- Hydrosphere: Interception, stem- and throughfall measurements (since 1998), several river gauges (different starting times).
- Pedosphere: Soil moisture and temperature measurements (different starting times), soil respiration, chemical composition, SOC etc.
- Biosphere: Tree growth by dendrometer measurements at several sites (different starting times), regular readings (Table 2).

3.2 Installation of Experimental Plots

While in the first phases of research (inventory phase), measurements and field surveys were conducted on distributed and project-specific plots along concertedly established altitudinal transects, the concentration on common ecological experiments in the last phases led to the installation of experimental sites where several groups work together on a cross-cutting objective.

In the ***natural forest***, the oldest test site was furnished in 1998 and is still producing hydrological data. The experiment is set up in a micro-catchment and is devoted to balance all water and matter fluxes in and out of the catchment. Field equipment has been installed on the site and relevant analytical instrumentation is in the station and in the cooperating universities of Loja.

In 2007 the ***NUMEX*** (**NU**trient **M**anipulation **EX**periment) experiment with 12 contributing subprojects (and additionally the EDIT and ABA projects) was established. The main aim is to investigate and simulate the impact of remote fertilization on subterranean and aboveground ecosystem processes as well as on the lant and animal communities. A specific survey and measurement protocol warrants

Table 5: Operation periods of automatic meteorological stations in the main research programs of Fig. 1

Met. Station	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
ECSF El Tiro Páramo Cerro Consuelo	■	■	■	■	■	■	■	■	■	■	■	■	■ replaced	■
TS1	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Pasto1								■	■	■	■	■	■	■
Pasto 2										■	■	■	■	■
El Libano	■	■	■	■	■	■								
El Bosque					■	■	■	■	■	■	■	■	■	■
Bombuscaro										■	■	■	■	
Tapichalaca						■	■							
Vilcabamba	■	■	■	■	■	■	■							
Cajanuma	■	■	■	■	■									
Abraham												■	■	■

continuous recording of data along an altitudinal gradient (1000, 2000, 3000 m a.s.l.) and with respect to different topographic (ridge, slope, ravine etc.) positions (matrix experiment).

Because extent and impact of land-use changes belong to the major topics of the research activities from which recommendations for options of sustainable land use could be extrapolated, several application-directed joint experiments in the natural forest and on the ***mountain pastures*** have been set up. These experiments are of practical significance for a transfer from basic science to application.

The ***Pasture Fertilization experiment*** (***FERPAST***, dating back to 2007) is the analogue on the pasture site to NUMEX, mainly investigating the impact of fertilization on pasture growth and biogeochemical processes.

The ***Pasture Management Experiment*** (dating back to 2002) and the ***Ecological Fire Experiment*** (established in 2007) investigate the infestation of the mountain pastures by aggressive weeds, such as the southern bracken, and aim at an understanding of their competition with pasture grasses from physiological and ecological viewpoints. Based on that management, measures are examined to rehabilitate abandoned areas as pastures.

To investigate several options regarding timber, the "***Natural Forest-***" and "***Afforestation-***"experiments were installed (dating back to 2002). The natural forest management experiment analyses the impacts of a careful silvicultural interference on biodiversity and ecosystem functions. In the Afforestation experiment, methods and strategies are developed to use indigenous tree species for afforestation of abandoned pasture land. This experiment required the development of technologies for large-scale seed production, sapling cultivation including inocculation with suitable mycorrhiza fungi, and planting techniques (e.g. with the help of exotic shelter trees) in the field. The experiment is a collaboration with the National University of Loja (UNL), where the necessary infrastructure (greenhouse) was established.

3.3 Research Infrastructure at Partner Universities

Currently, the program can rely on vivid relations with four top universities in South Ecuador: The Technical University of Loja (UTPL), the National University of Loja (UNL), the University of Cuenca (UC) and University of Azuay (UA) in Cuenca. In the process of intensifying the excellent collaboration between the local universities and the German research programs, research infrastructure has been successfully established and/or upgraded:

- UNL: Dendroecology, greenhouse facilities with tree nursery, soil and water laboratory
- UTPL: Soil analysis, trace gases analysis, NOAA-AVHRR receiving station, X-band rain radar, laboratories for cellular and molecular biology
- UC: Laboratories for water analysis
- National Weather Service INAMHI Quito: NOAA-HRPT receiving station

3.4 Research Infrastructure at the Research Station ECSF

A comprehensive research program needs a research station which was provided by our partner, the Foundation Nature and Culture International (NCI). This station with its basic infrastructure is intended as the focal facility for the monitoring platform in the mountain rain forest area. The Estacion Científica San Francisco (ECSF) harbors the following infrastructure for research:

- Herbarium
- Basic laboratory equipment for water and soil analyses
- Gas Chromatograph
- IT infrastructure
- Library
- Multipurpose laboratory
- Lecture Hall

3.5 Models and Scenarios

Models and ***scenarios*** are important tools for (i) understanding ecosystem processes and thus, ecosystem functioning, (ii) supporting decision making processes by playing e.g. through different story lines of land-use options and (iii) assessing the future development of ecosystem parameters by means of model projections. However, to get meaningful model results, the models must be properly parameterized and validated by relevant field data. Models and scenarios will also be a very important component of the platform's research program.

Particularly in the second phase of RU816, the consortium has introduced and parameterized numerical process models for several purposes:

- **Forest growth model**: The model FORMIND (Köhler & Huth 1998) has been adapted to the ECSF area and is used to understand the influence of tree biomass production on landslide occurrence, forest succession after such disturbances, and carbon sequestration.
- **Land-use change and invasive plants**: The Southern Bracken Competition Model (SoBrCoMo) has been developed and parameterized (e.g. Bendix et al. 2010) to understand

Fig. 5: Left photo: Jürgen Homeier (second from left) and Florian Werner (standing) from the second research unit offered an ecology module. Right photo: Students from Loja (top) and Peru (bottom) sampling biodiversity data of vascular epiphytes and measuring tree parameters to analyze them with Homeier and Werner. Photos: Jürgen Homeier.

the successful invasion of pastures by the so-called southern bracken (*Pteridium* spp.), an aggressive weed. The model is also used to test the ecological and economic benefits of different land-use options.

- **Atmospheric models and climate change**: Two mesoscale climate models (ARPS, Xue et al. 2000; WRF, Janjic 2003) coupled with the land model CLM (Dai et al. 2004) were adapted to the complex mesoscale atmospheric dynamics of southern Ecuador and applied to assess (i) impacts of global climate change and (ii) land-use change on the local climate of southern Ecuador for different IPCC emission scenarios.
- **Trajectory model and remote fertilization**: The trajectory models HYPSILT (Draxler & Hess 1998) and FLEXTRA (Stohl et al. 2005) are used to analyse the transport and deposition of remotely emitted air pollutants (e.g. due to biomass burning in the Amazon) to the Andes of southern Ecuador. The models shall also be applied to future changes of the wind field and changing emission scenarios.
- **Hydrological models**: Hydrological models have been parameterized and are used on different spatial scales: (i) HYDRUS/3D (Yu and Zheng 2010) to analyse slope water flows with regard to the incidence of landslides, (ii) TOPMODEL (Beven et al. 1995) to investigate the water balance of micro catchments and (iii) several watershed models for the Rio San Francisco catchment (Plesca et al. 2011) which are used to simulate the water balance with regard to land-use and climate change scenarios.

4 Capacity Building

Right from the beginning of the German research activities, capacity building was one of the major goals accompanying the projects, meeting the intentions of the Convention on Biological Diversity (CBD) in the scope of ***Access and Benefit Sharing*** (ABS). Capacity building was mainly achieved by involving university staff, graduates and students, as well as helpers in the field and laboratory work while simultaneously assisting the local universities in developing their own infrastructure for research. Lectures, summer schools and laboratory courses were offered from time to time (Fig. 5). Ecuadorian students could prepare their final theses and graduates their PhD-thesis in the scope of the projects.

Collaboration with German students and graduates is a fruitful move in mutual capacity building.

Fig. 6a evidences the success of 15 years endeavours in capacity building by joint research. A number of the former students and graduates are meanwhile Ecuadorian principal investigators. It should be stressed that also students from other Latin American countries like Brazil and Peru have been and still are working in the research projects. The development of the share of the Ecuadorian researchers (Fig. 6b) reveals that the absolute number but also the academic level of the contributing Ecuadorian scientists has been significantly increased.

As stressed in the project history (Fig. 6) capacity building with regard to education of local staff has entered a new dimension. The local universities are striving for upgrading their scientific staff in the way that a PhD degree will be the prerequisite for an appointment as lecturer. This requires also competence in planning and conduction of research projects. The above-mentioned ***cooperation program*** for ***autonomous staff development*** between South Ecuadorian universities and the DFG started in late 2009. While the Ecuadorian PhD students are paid from university research funds DFG pays an at least 3 month stay of the PhD candidate in Germany for finalizing the thesis and graduation as PhD at the German partner university.

A recent development in capacity building, not only for academicians, are the ***transfer of knowledge projects***, the first of which ("*Nuevos Bosques para Ecuador*", see above) has recently been inaugurated. Further objectives in the research unit are prone for a development into such knowledge transfer projects.

The knowledge transfer idea is also essential for the planning of the monitoring platform because according to the National Strategy of Ecuador for Biodiversity, monitoring itself is an application task.

The "Platform for Biodiversity and Ecosystem Monitoring and Research in South Ecuador"

There is no doubt that the biodiversity hotspot of South Ecuador (Fig. 7) is heavily threatened by global change impacts: Climate change, human activities (in particular overexploitation, invasive species, and social conflicts, water and air pollution by mining and agricultural activities as compiled by the Global Biodiversity Outlook 2), and human-driven land-use changes (clearing of primary forests and conversion to agricultural areas, exotic tree plantations, but also abandoning of unused areas). In spite of the well-known positive effects of moderate disturbances on biological diversity (Hobbs & Huenneke 1992, Graham & Duda 2011) primary forests are irreplaceable for sustaining tropical biodiversity (Gibson et al. 2011), as the colonization and succession effects of the surrounding habitats (the "matrix") in the long run cannot compensate the detrimental effects of forest conversion and degradation. Observations, detecting inappropriate land use, supporting activities and decisions to prevent further disturbances, shepherding measures for a

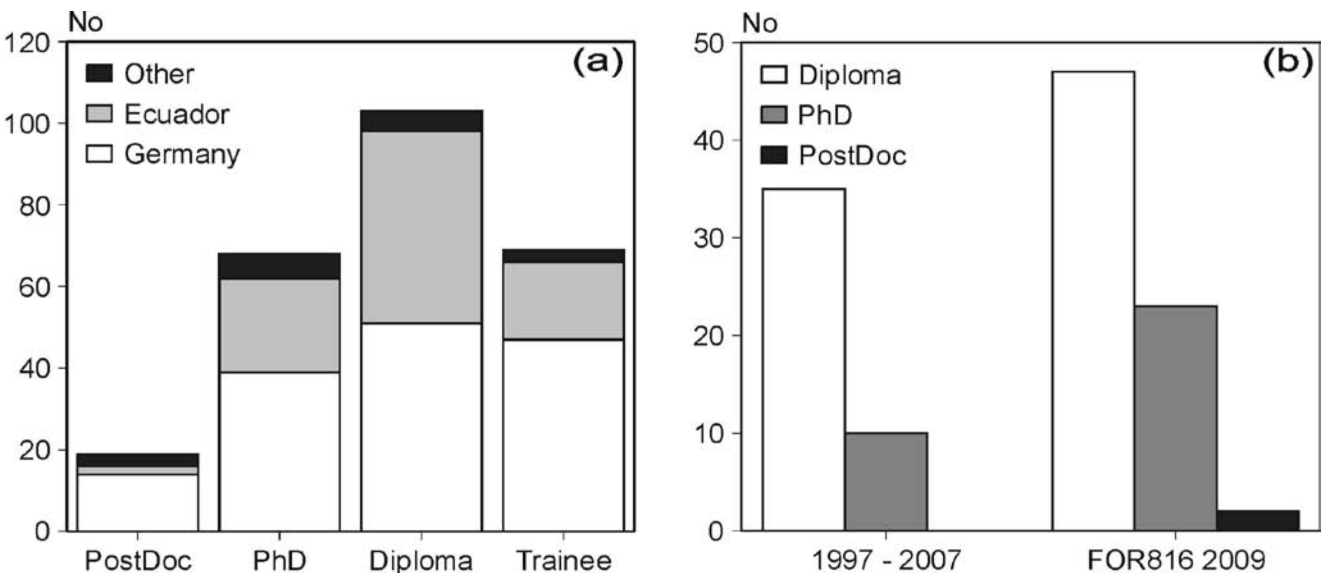

Fig. 6: (a) Researchers at different qualification levels working in the research unit (b) Number of Ecuadorian researchers since the beginning of the research activities in southern Ecuador (Source: RU816-*DW*, www.TropicalMountainForest.org). Graphic: J. Bendix et al.

better land use, and recording of environmental parameters to assess the extent of climate change and its consequences, are imperative in this conflict situation. Such observations require continuous monitoring using multifactorial indicator systems which comprise issues of earth and life sciences as well as economical and sociological aspects. Monitoring of global change impacts, in particular on biodiversity has been imposed by the Convention on Biological Diversity (CBD) on its parties and several countries, e.g. Germany have already implemented a sophisticated system of indicators and protocols for recording. However, in tropical countries, especially in those which are rich in biodiversity, such monitoring systems are still lacking or at best in a blueprint state. Developing indicators of global change processes in a tropical hotspot of biodiversity is therefore a major scientific challenge, not least because of the hitherto very incomplete base of relevant knowledge and the lack of trained observers.

1 Platform for Global Change Research

Recently, an initiator group of Ecuadorian and German scientists has formed up to discuss global change research in South Ecuador, which on a scientific basis allows rapid assessment of the status of biodiversity, ecosystems and ecosystem services. This shall be achieved in a joint German-Ecuadorian research effort, flanked by academic and public education measures. In compliance with Ecuadorian national strategies for research, education and development, the various projects shall be coordinated and synchronized in the above mentioned “Platform for Biodiversity and Ecosystem Monitoring and Research in South Ecuador”.

This platform shall become an open facility housing different kinds of research projects from area-wide recording of selected environmental parameters over continuing long-term ecological experiments, investigating satellite data, development of scenario-based strategies for sustainable land-use and conservation, up to meta-analysis of existing data. Of primary concern, however, at least for the initial phase shall be the development of conclusive indicators for the various aspects of global change, as well as capacity building for environmental observations in the academic and the public. Indicators shall not only describe the scene, events and actions but will be tools for understanding the natural status quo and the underlying processes as well as the impacts of global change.

A comprehensive discussion of the issue has been provided (Beck and Bendix (2011): Global Change in South Ecuador: Establishment and operation of a platform for biodiversity and ecosystem research and monitoring in South Ecuador. http://137.248.191.82/files/beyond2013/monitoring_final.pdf).

2 Research Features

For visualizing the architecture of the platform, the symbol of a house has been adopted (Fig. 8, next page). It is based on a fundament of a compilation of the status quo knowledge, not only of the research in the San Francisco Valley but also of available knowledge from local studies of biodiversity, selected areas, and previous as well as on-going recordings of environmental data. Ample knowledge can also be extracted from satellite data. Pooling all these data in a comprehensive data base or data warehouse should be one of the principal endeavours. The Ground Floor houses the projects dedicated to the development of multifactorial indicators for a reliable assessment of the status of and potential changes in biodiversity, ecosystem functioning and services as well as socio-economic characteristics. The majority of the projects may be localized on that ground floor.

Fig. 7: A mesocosm of tropical biodiversity: Epiphytes in the area of the Reserva Biologica San Francisco use every place available on the branches of tree. Photo: Jörg Bendix.

The First Floor shall be the residence of long-term ecological experiments, on-going as well as new ones which are aiming at understanding ecosystem functionality as well as practical management recommendations (conservation strategies, reforestation, rehabilitation of pastures etc.) and are necessary for parameterization and truthing of ecological simulations, models and scenarios. The above mentioned measures are closely connected to teaching, training and capacity building activities. The platform is also open for ingenious projects on topics less related to global change, but making good use of the accumulated data e.g. in metadata studies (Second Floor).

2.1 The Appropriate Research Areas

Three areas have been selected for the platform (Fig. 9), the Reserva Biológica San Francisco (RBSF), representing a comparatively stable ecosystem, and

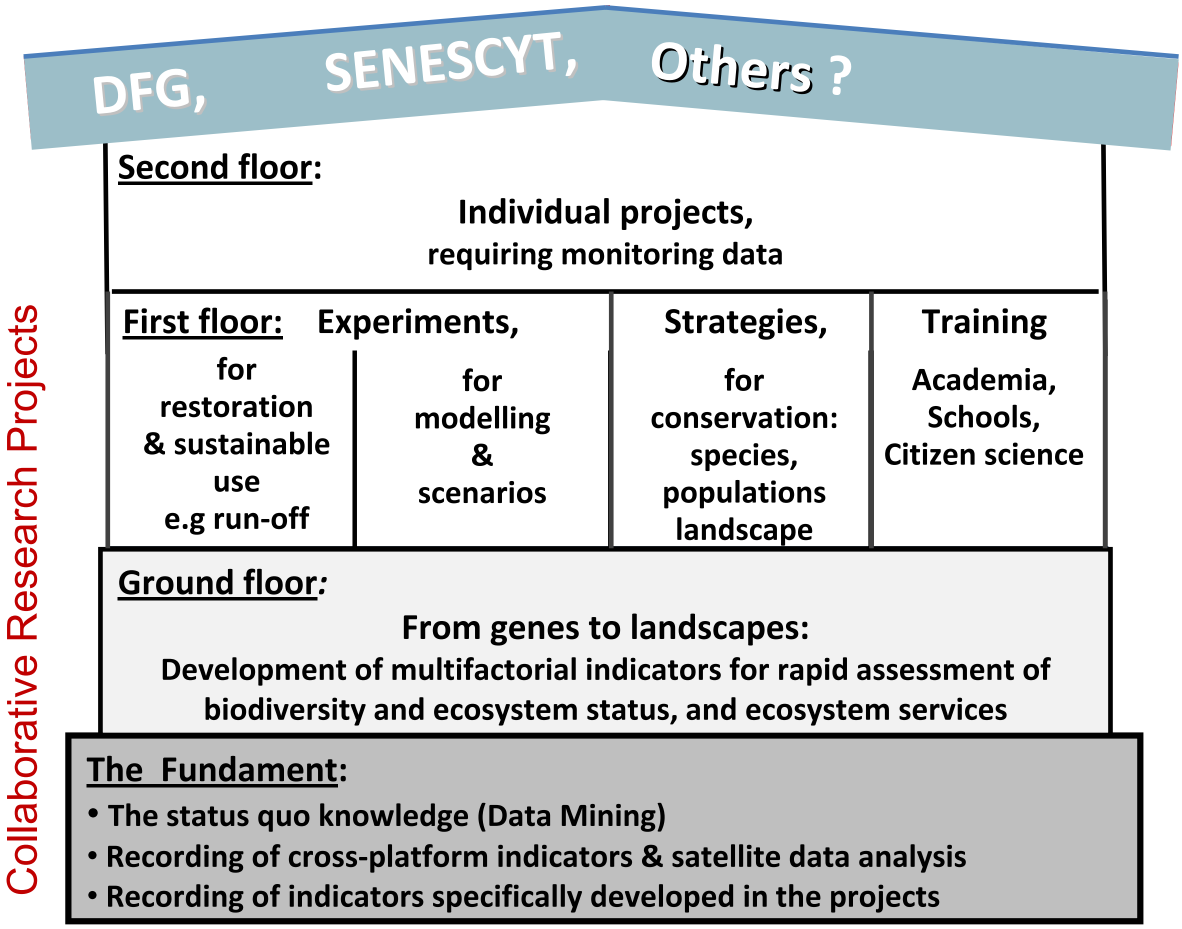

Fig. 8: The potential architecture of the "Platform for Biodiversity and Ecosystem Research and Monitoring in South Ecuador". Funding by SENESCYT (Ecuadorian projects), DFG (German projects) and possibly other donors form the roof under which the platform can exist. Graphic: Erwin Beck.

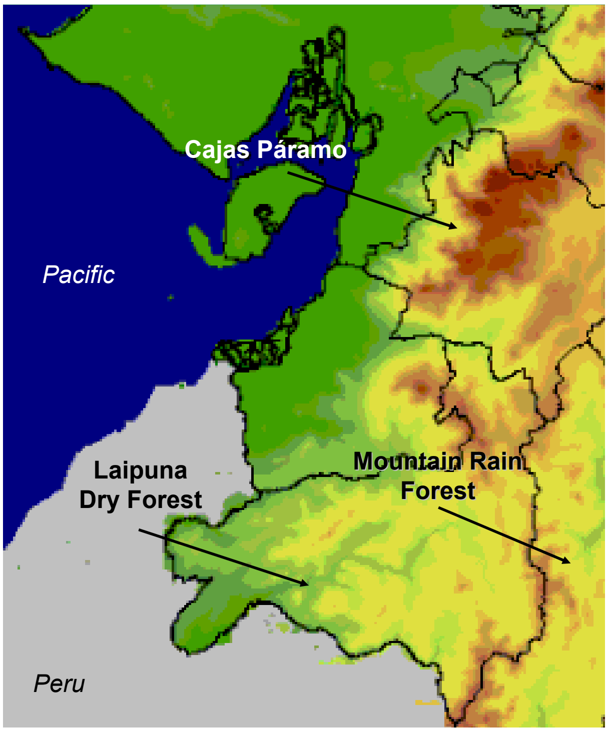

Fig. 9: Map of South Ecuador with the planned research areas. Graphic: Jörg Bendix.

two more fragile ecosystems which are expected to reveal global, in particular climate change more readily. These are the Páramo region Cajas (3500 – 4200 m asl.; above Cuenca) and the dry forest of the Reserva Laipuna (600 – 1.400 m a.s.l.; near Zapotillo). Due to the fragility of these ecosystems they belong to the endangered areas of Ecuador which need special protection.

Following the idea of gradients, all three areas present altitudinal gradients and gradients of land-use intensities, or considered from the opposite side, gradients of hemeroby. In each of the three areas a protected core area (Podocarpus National Park, Cajas National Park, Laipuna Reserva, respectively) is surrounded by a "matrix area" which is an anthropogenic replacement system of the former natural system (Fig. 10). At least at the borderline between the 2 components of each study system, mutual interactions or influences could be studied, which may turn out as sensitive indicators of global change.

RBSF as well as Laipuna have research stations and Cajas will complete its station Illincocha in the near future (Fig. 11). A wealth of studies has been performed at the RBSF since 1997 (see chapter 1), but several projects have also been conducted in Cajas and Laipuna by Ecuadorian scientists themselves or in collaboration with researchers from outside Ecuador. Unfortunately, many of such data are not accessible via publications in international journals.

Researchers may wish to perform their studies on one, two or all three sites. For many approaches, comparison will be a useful tool for research. Nevertheless, logistic problems should be born in mind, as travelling from one site to the other requires about one day and acclimatizing to the high altitude of the Pàramo should not be underestimated.

2.2 Research Strategy

Building-up of the platform will be the main endeavour of the initial phase (~ 3 years) of the new project. This will be done together with our Ecuadorian partners who have already allied into a consortium.

The core projects. Long-term or core-projects shall form the basis of the platform: A data warehouse, data mining projects, monitoring of selected ecosystem characters such as climate, which continue on-going monitoring programs or start recording of newly developed indicators. Results of these core projects are necessary for the other projects of the platform.

Identification and assessment of relevant indicators. As mentioned above, indicators of the status quo and of global change have not yet been developed for tropical hotspot regions like South Ecuador. Discussions in the initiator group have unveiled three types of indicators, at which the projects could aim:

- Cross-platform indicators,
- structural indicators, and
- functional indicators.

Cross-platform indicators are needed for all three sites, addressing the following fields and mainly contributing to the set of monitoring projects (core projects):

- Atmosphere: Climate variables at various temporal and regional scales
- Hydrosphere: Dynamics of run-off and water quality (chemical & biological)
- Pedosphere: Soils and soil properties at various regional scales
- Land-use patterns: Land-use type, spatial land surface structure, landscape fragmentation etc.
- Development of settlements, social structures, economic situation, etc.

These cross-platform indicators are essential and thus practically imperative for the platform. Several of them will (also) be addressed by the Ecuadorian projects.

Structural indicators apprehend the stability or dynamics of landscape elements at various scales, e.g.

- stability or shift of (common) borderlines of defined indicator communities, e.g. altitudinal vegetation zonation,
- qualitative and quantitative composition and distribution of organismic indicator communities,
- penetration of invasive indicator species, e.g. weeds, pests, pathogens,
- social structures in the ecosystem/region.

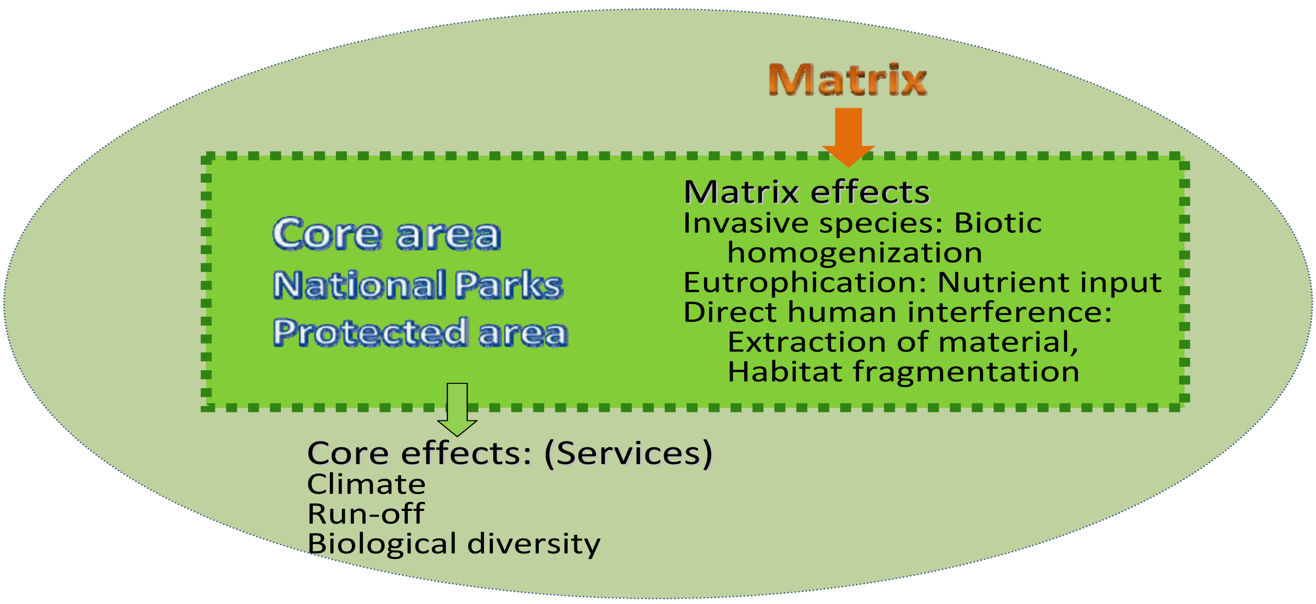

Fig. 10: The spatial situation of the research areas: (i) Each research area consists of a "Core" which is embedded in a "Matrix" (buffer or transition zone) that is influenced by humans. (ii) Both components are characterized by dominant landscapes (Páramo, forest, agricultural landscape, abandoned areas, settlements, traffic lines etc.). (iii) Both components influence each other (Core effects, Matrix effects). Graphic: Erwin Beck.

Functional indicators address functions in an ecosystem, striving for another, highly sensitive measure of environmental changes. They aim at interactions and require knowledge of functionality in the ecosystem.

Examples of objectives to be addressed by functional indicators are:
- Abiotic-biotic interactions, e.g. effects of nutrient input, depletion or pollution effects on indicator community composition, shifts of habitats
- Effects of extreme events (atmosphere or/and land use) on landscape dynamics, e.g. indicated by landslides
- Biotic interactions, e.g. food-chains, pollinator systems, seed dispersal, host-parasite interactions
- Socio-economic - abiotic - biotic interactions: e.g. Effects of land-use changes on biogeochemistry and subsequent indicator food webs etc.
- Socio-economic-political interactions, e.g. education – land-use, education – welfare, education – nature conservation, etc.

Fig. 11: The Estación Científica San Francisco (ECSF) is situated in the core area of the Reserva Biologica San Francisco (RBSF). The station offers 35 working and sleeping places, lab and IT facilities, and rooms for courses and conventions (top, photo: Erwin Beck). The building at Laipuna is already used as research station (middle, photo: Erwin Beck). The station of Illincocha at about 3900 m a.s.l. in Cajas will be completed soon (bottom, photo: Jörg Bendix).

Functional indicators are the most relevant, but also the most difficult indicators, in particular with regard to quantification of the interactive effects.

2.3 Research Levels: From Genes to Landscapes

Global change directly affects ecosystems and habitats, changes of which produce pull-down effects on lower levels of complexity and push-up effects on higher, e.g. the landscape level (Fig. 12). Research projects on drivers and indicators of global change can address all kinds of levels.

2.4 Subprograms/Modules

Research projects, irrespective of aiming at the development and application of indicators or at other relevant issues, shall be allocable to selected subject modules which have been identified by the initiator group of the platform. This will advance the coordination of projects and foster collaboration. When designing projects the subprograms or modules (A - D) displayed in Fig. 13 should be considered.

In the case of indicators, more than one module may be hit, e.g. an indicator of a change in biodiversity should also address the issue of scaling (models, scenarios) and of significance for ecosystem services. Whenever possible, conclusions or recommendations for sustainable management should be included in the projects and advises for monitoring protocols for the later transfer of the developed indicator system to monitoring application. Conception and assembly of demonstration units displaying the outcome of long-term ecological experiments could illustrate management recommendations.

Recalling the structure of the platform (Fig. 8) additional work packages of general interest will be required:
- Uniting existing knowledge in a data base
- Data mining and synthesis of accumulated knowledge
- Capacity building including citizen scientists. An important step towards monitoring is the training of laymen for reliable monitoring. Five years ago respective activities have been successfully implemented by NCI in the La Ceiba dry forest reserve. Research and training projects could complement the work of the platform. The German Ambassador in Ecuador, Peter Linder, sug-

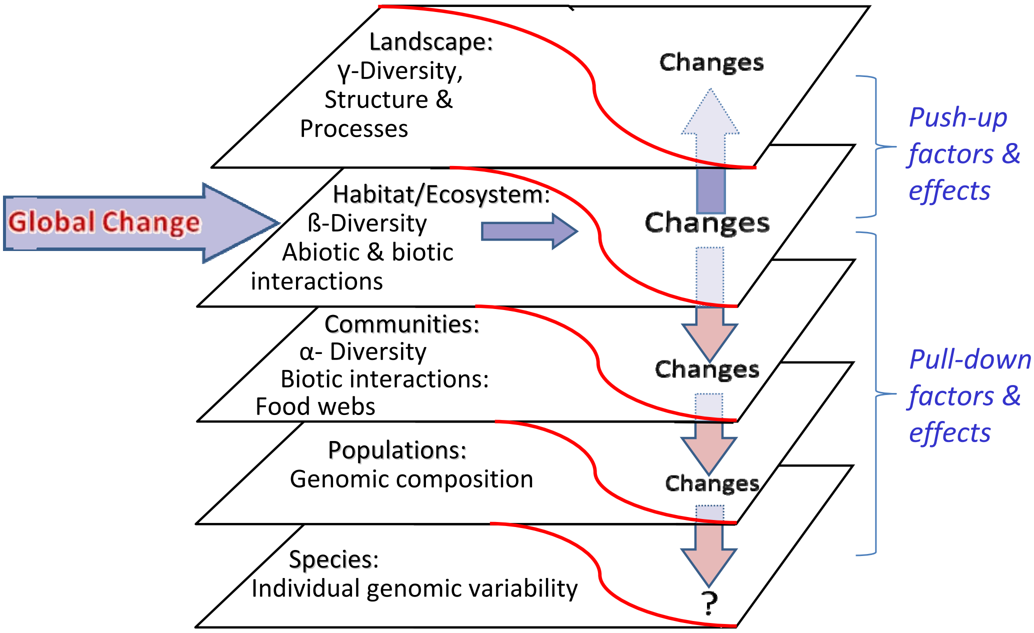

Fig. 12: Effects of global change propagate to higher and lower levels of complexity. Graphic: Erwin Beck.

gested to contact the staff of German institutions in Ecuador, e.g. teachers and advanced pupils of German schools (Cuenca).

3 The Way Towards the Platform

The planning of a new research program and a new mode of bi-national collaboration by means of a platform requires much preparatory work on the administrative as well as on the scientific side.

Administrative activities aim at a framework for cooperation of SENESCYT and DFG to enable co-financing of Ecuadorian and German research projects. Monitoring of global changes is compliant with the Ecuadorian environmental policy and thus should be supported by national funds. There is general understanding that Germany could only support German projects and Ecuador should fund Ecuadorian Activities. However, projects from both sides should meet on the platform.

- Mar 2010: A DFG-delegation chaired by President Professor Dr. Matthias Kleiner met SENACYT (Secretaría Nacional de Ciencia y Tecnología) / SENPALDES (Secretaría Nacional de Planificación y Desarrollo) representatives in Quito.

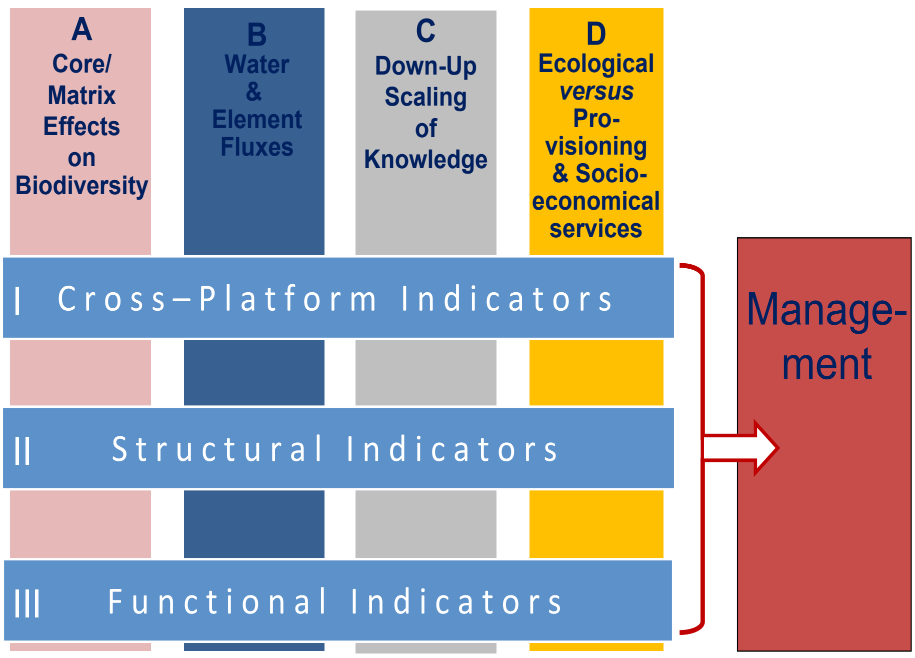

Fig. 13: Possible grouping of research projects on the platform. Draft: Initiator group, graphic: Erwin Beck.

- Oct 2010: RU speakers met SENACYT director Dr. Baldeon in Quito.
- Apr 2011: DFG Vice-President Professor Dr. Elisabeth Knust attended a first planning meeting with representatives of SENESCYT (Secretaria Nacional de Educación Superior, Ciencia, Tecnología y Innovación), Ministry of Environment MAE and other Ecuadorian authorities and institutions.
- Oct 2001: DFG Vice-President Professor Knust and RU representatives visited SENESCYT to elaborate a draft of the Memorandum of Understanding.

The second activity was the setup of the mentioned initiator group of experts for all required disciplines of the platform and of providers of infrastructure in the three ecosystems. This ***initiator group*** consists of the following persons.

Biota:
- Erwin Beck: Plant Science, Functional Ecology (University of Bayreuth)
- Konrad Fiedler: Fauna, Biodiversity, Monitoring Concepts (University of Vienna)
- Juan Pablo Suarez: Molecular Biology and Ecosystem Services (Technical University of Loja)
- Reinhard Mosandl: Forestry Science (University of Technology Munich)

Abiotic parameters:
- Carlos Valarezo: Soil science, biogeochemical cycle (National University of Loja)
- Jan Feyen: Hydrology, Models, Ecosystem Services (University of Cuenca)
- Jörg Bendix: Climatology, Remote Sensing, Models (University of Marburg)

Socio-economy:
- Thomas Knoke: Land use, Economy (University of Technology Munich)

Research strategies and infrastructure:
- Alfredo Martínez: Cajas National Park (ETAPA, Cuenca)
- Bruno Paladines: ECSF, Laipuna Dry Forest, Citizen Science (NCI, Loja)

Time schedule for application and call for project sketches

Planning and implementation of the platform needs a strict time schedule in order to continue our research after the research unit (RU) 816 has come to its regular end in March 2013. The general ***preliminary time schedule*** is as follows:

- December 2011: The current extra Newsletter of RU816 is issued as a **call for sketches of project proposals** (details below) of interested scientists who are willing to contribute to the platform research program in the required disciplines as described in the program outline given in chapter before.
- 16.-17. December 2011, Marburg: Fourth meeting of the initiator group. Discussion on the topics of the Ecuadorian collaborative program as part of the platform and consequences for the German application. Publication of the minutes on the RU's website for further planning (→ thematic coordination German-EC programs).
- **Deadline** for submission of sketches of proposal abstracts: **23rd January 2012**; digital submission per mail to the RU816 office (kuehnebi@staff.uni-marburg.de)
- Pre-selection of suitable proposals by the scientific advisory board of the RU due to **5th February 2012** and invitation of successful proposal.
- Presentation of invited proposals in a workshop on **16th – 17th February 2012**.
- Selection of appropriate proposals by the scientific advisory board of the RU due to **1st March 2012** and call for submission of the full proposal.
- Submission of Ecuadorian application to SENESCYT by March 2012.
- Writing of proposals, **deadline for submission to the speaker** of the reseach unit, Prof. Dr. Jörg Bendix**: 1st June 2012**.
- Submission of German proposal compendium to DFG: **15th July 2012**.

We would like to stress that not every submitted proposal may pass the preselection procedure. When applying six years ago for the RU816, about 30 projects out of some 70 proposals passed the preselection and finally 21 got funding by the DFG.

Preparation of Proposal Sketches

The proposal (Deadline: 23th January 2012) must not exceed 3 DIN-A4 pages. It should include:

1 Applicant, affiliation and professional status
2 Title of project, a brief summary of the intended research, research questions, aims, hypotheses etc.
3 A clear statement, to which part of the platform (which module, indicator system, see Fig. 13), level of the "house" (see Fig. 8) the proposal will and can contribute
4 The envisaged research area(s) (see Fig. 9)
5 Estimated duration of the project
6 A statement whether research experience in Ecuador already exists and whether the proposal is already coordinated with a partner of the Ecuadorian consortium; or other information on relevant previous work
7 A rough estimate of requested resources (staff, instrumentation, consumables).

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Credits and Contact

DFG Research Unit 816

More information about the Research Unit (RU 816) investigating Tropical Mountain Forests (TMF) is available at: www.tropicalmountainforest.org

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