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FIELD STATION PROFILES

ALEXANDER VON HUMBOLDT WOULD HAVE LOVED IT: **ESTACIÓN CIENTÍFICA SAN FRANCISCO**

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NAME OF FIELD STATION

Estación Científica San Franscisco (ECSF)

GEOGRAPHIC LOCATION

- Ecuador, Province Zamora Chinchipe
- Lat. 3°58'18" S (-3.971667), Long. 79°4'45" W (-79.079167), 1860 m a.s.l. (WGS84); 713270.567 Easting, 9560756.728 Northing, UTM Zone 17S

THE RESEARCH AREA

In southern Ecuador, the Andes peaks hardly rise beyond 4000 m altitude due to the geologically young Amotape-Huancabamba depression. The rock body itself is strongly dissected by basins and valleys. The climate at the eastern slopes is dominated by strong easterly winds carrying humidity from the Atlantic and the Amazon basin to the Andes. The resulting perhumid tropical climate (up to 6000 mm rainfall per year) abruptly changes into regions of semiarid to arid climates (< 300 mm per year) west of the main Cordillera ridge. Both extremes of the climate lie in an airline distance of 30 km. No wonder that the area belongs to the hottest hotspots of biodiversity worldwide. In addition to an outstanding richness in plant species, the area is known for its high bird diversity and an extremely rich arthropod fauna for which a world record in moths has been reported. The ECSF research station is located in the humid eastern slopes of the main Cordillera, in the deeply incised valley of the Rio San Francisco, a tributary to the Rio Zamora and thus to the Amazonas river system (Figure 1a). The core research area of around 11 km^2, the Reserva Biológica San Francisco (RBSF), belongs to the Podocarpus National Park (PNP), stretching on the north-facing slopes of the valley from ~1800 m at the valley bottom to the mountain crest at ~3200 m altitude. Within this elevational range, the research area shows a complex topography of ridges, steep slopes, deep valleys and ravines (Figure 1b). In addition to the RBSF core area around the ECSF, there are two satellite areas in the PNP at the researchers' dispo-

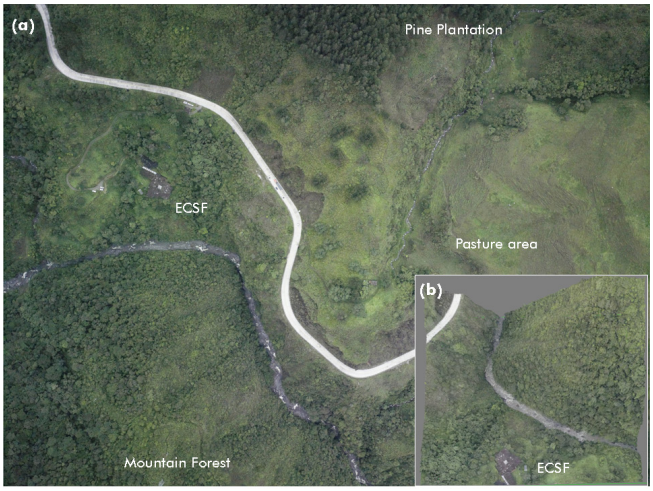

Figure 1. (a) High resolution aerial photograph showing the location of the ECSF research station in the Rio San Francisco Valley. The natural forest is on the north-facing slopes (left side of the river / valley) and the corresponding anthropogenic ecosystems, mostly pastures and some Pine plantations (*Pinus patula*) on the opposite side. On the pastures, green colour indicates active farmland, greyish colours the abandoned and heavily bracken-infested areas. (b) The Digital Surface Model (DSM) from an Airborne Laser-Sanning (ALS) survey shows the steepness of the terrain.

sal. One site (Bombuscaro) presents a premontane rainforest (12 humid months) at an elevation of 1000 m a.s.l., with trees up to 40 m high. Several cabañas are available at the rangers post (4.11444°S, 78.965°W). The highest site in the PNP (Cajanuma up to >3400 m a.s.l.) comprises an elfin forest merging into a Yalca with a well-established self-service Lodge (Refugio Mirador, 2800 m, 4.116971°S, 79.171074°W) as a base (for a detailed area description, the reader may refer to Bendix *et al*. 2013).

THE HABITATS

Montane forest: The pristine forest of the PNP shows a diffuse altitudinal zonation starting with a lower evergreen broad-leaf montane forest that grades into an upper variant at around 2150 m. This passes into a narrow elfin forest belt that forms a relatively species-rich upper tree line between 2700 and 3000 m. The mountain rainforest is extremely rich in plant species. More than 300 tree species were recorded in 1000 ha of the San Francisco Reserve. The species richness of the epiphytes is likewise prominent especially in the transition zone from the lower to the upper montane forest. Among the 131 spermatophyte families represented in the pristine forest Lauraceae, Melastomataceae, Cunoniaceae and Ericacea are the most species rich families. While the altitudinal zonation appears rather fuzzy, a horizontal zonation is obvious: A dense forest is typical of the ravines whereas more open woodland, rich in palms, is characteristic for the crests (Homeier *et al*. 2013). The core area encompasses also another unique type of upper montane ridge vegetation, the *Purdiaea nutans* (Clethraceae) forest.

Sub-páramo shrubland (Yalca): This habitat extends from the treeline up to the crest of the mountain ranges. While in the northern and central Andes the upper treeline is between 3700 and 4700 m altitude and represented by only a few woody species, up to 39 tree species have been recorded in the relatively narrow tree line of the research area (Peters *et al*. 2014).

The anthropogenic replacement system: The south-facing slopes of the valley are private property where the forest has been cleared (Fig. 1a), partly up to the crest of the mountains. Common land use practices comprise timber extraction from Pinus plantations (*Pinus patula*), but more often a conversion of the forest into pastures by slash and burn. Here, pasture grasses have been introduced e.g. from tropical Africa, such as *Setaria sphacelata*, *Melinis minutiflora* and *Pennisetum clandestinum*, or have invaded (*Axonopus compressus*, *Holcus lanatus*) the cleared slopes. Remnants of the original forest still exist in the ravines but have not proven as nuclei for a natural reforestation, once the agricultural use has been suspended. The main reason for that is the heavy infestation of the pastures by the tropical bracken fern (*Pteridium arachnoideum* and *Pteridium caudatum*, see Fig. 1a) which is fostered by the common practice to use fire for rejuvenation of the pastures and to combat the weeds. Pastures completely overgrown by bracken have been abandoned to a great extent (e.g. Knüsting *et al*. 2018).

Checklist of Flora and Fauna: A provisional checklist of flora and fauna of the San Francisco valley and its surroundings is available (Liede-Schumann & Breckle, 2008).

ACCESS, INFRASTRUCTURE AND FEES

The ECSF is located in close vicinity to the Province capital Loja that can be reached from the two international airports Quito and Guayaquil either by plane (tame.com.ec) to Catamayo airport (also known as Loja airport LOH), or by bus directly to the city of Loja. The use of a taxi is recommended from the Airport Catamayo to Loja (15 US $). Continuing to the station by taxi is another 15 US $ (needs negotiation with the driver). Alternatively, the station is easy to reach from the central bus terminal in Loja by public bus lines heading to Zamora that operate nearly half-hourly. The trip from Loja to the ECSF takes about 45 minutes and costs 1 or 1.25 US $. The walk from the bus stop down to the ECSF station takes 5 minutes.

The ECSF Station: The ECSF is situated on a small horizontal plateau on the otherwise steep left (south facing) slope of the San Francisco valley about 80 m above the river. It was inaugurated in 1996, and since 1997 serves as a research station that can accommodate up to 26 researchers. A one-storied laboratory wing with 6 rooms was attached to the main building two years later (Figure 2a) and a lecture-hall building with a class-room, lab, toilet, and store rooms was added in 2008 (Figure 2b). Terraces and balconies allow to stay and work outside even during rain (Figure 2c,d). The central building encompasses 9 bedrooms (mostly bunk beds; Figure 2e), 5 bathrooms (toilet, lavatory, shower), office, kitchen (Figure 2f), dining hall with library (Figure 2g), a patio (Figure 2h), a drying room, a computer / IT-room (Figure 2i) on the ground floor, several labs for soil and water analyses, technical workshops (Figure 2j,k) and biological labs for plant and animal studies (Figure 2l). The new building harbors a multi-functional room which can be used as lecture hall or working space (Figure 2k).

Equipment: The laboratories provide basic equipment such as benches, shelves, tap and demineralized water, electricity (110 V and 220V), balances, mechanical and electrical tools, drying ovens, refrigerators, and more. Basic

field tools are available, such as pruners, shovels, machetes, and others. Special scientific tools and equipment need to be brought along by the researchers. High-speed internet (fiber optic) and WLAN is available in the entire station and two permanent computer working places have been installed. However, most of the researchers use their own laptops. A small library is also available. The data-base of the station is managed by the University of Marburg (Germany) which also hosts the web-page of the currently running DFG research unit 2730 RESPECT (*Environmental changes in biodiversity hotspot ecosystems of South Ecuador: RESPonse and feedback effECTs*): www.tropicalmountainforest.org

Facilities in the field: Several trails provide access to the RBSF. To minimize damage by trampling and slipping on the muddy soil the steeper stretches have been furnished with wooden or concrete steps (lower parts) and rope-handrails. To cross the river, a hand-driven ropeway with a four-seated gondola ("tarabita") has been constructed. Observation towers with platforms allow working in the canopy of the forest and beyond. Two towers, 30 and 35 m high, are available at 2000 m elevation (ECSF-RBSF) and

Figure 2. Insights into the ECSF research station

Administration and staff: The station is owned by the US-Ecuadorian foundation Naturaleza y Cultura Internacional (NCI), running its Ecuadorian office in Loja, Av. Pío Jaramillo A. 13-120 y Venezuela, Loja – Ecuador, Casilla 1101-332 (URL: *http://www.naturalezaycultura.org/*, e-mail: *nciecuador@naturalezaycultura.org*). In addition to the manager of the station (Pedro Paladines), a scientific coordinator of the German research unit (Dr. Felix Matt, e-mail: *felix.matt@staff.uni-marburg.de*) is in charge of the research projects and the utilization of the facilities in the ECSF / RBSF. Both should be informed whenever a new research project is launched. A caretaker serves the station during daytime and serves as a guard at the entrance during the night. If needed, kitchen staff is available.

one, 40 m high, at 1000 m (Bombuscaro). Two more will be available soon in 3000 m a.s.l. (Cajanuma). The towers are equipped with electricity and meteorological instrumentation. A network of climate-hydro stations is established as well. On the south-facing slopes of the valley, research can be done with permission of the landowners who commonly ask for financial compensation. For long-term observations, areas can be rented. It is advisable to involve NCI in the negotiations with the farmers. Renting of a car (with driver) or of workers and horses for transportation of heavy materials in the forest is possible.

STATION FEES (US$)

Daily Station fees including all meals, entrance to the RBSF, work place, internet and washing machine service are US$ 35.00 per person and day.

LEGAL REQUIREMENTs

Ecuador is part to the Convention on Biological Diversity (CBD) and to its Nagoya Protocol (NP). Therefore any kind of research on organisms and biological materials (in the sense of genetic resources) as well as traditional knowledge (TK) requires permission of the relevant authority SENESCYT (Secretaría Nacional de Educación Superior, Ciencia, Tecnología e Innovación), currently substituted (for issues of biodiversity) by the Ministry of Environment (Ministerio del Ambiente de Ecuador, MAE). MAE is also the Focal Point of the CBD for the "mobilization" of resources (i.e. transportation including exportation of biological material) and the GTI (Global Taxonomy Initiative). A third authority is involved in biological research, the National Biodiversity Institute (Instituto Nacional de Biodiversidad, INABIO), which assesses applications for biological research in Ecuador and especially applications for transportation and export of biological materials. To start a biodiversity project in Ecuador, negotiations with INABIO are recommended in order to decide whether the project is considered as academic, non-commercial research or as commercially oriented research. Any kind of biological research (and on TK) requires a framework contract for access to genetic resources with MAE. However, a project rated as academic research might be incorporated in an already existing framework contract between INABIO and MAE. To establish a framework contract (Contrato marco), *Prior Informed Consent* (PIC) must be sought from INABIO / MAE and *Mutual Agreed Terms* (conditions, including ways of benefit sharing) must be negotiated with the MAE. This could take some time, and therefore association of a guest researcher project with a framework contract of INABIO is the better solution for basic research. At the moment, "Digital Sequence Information" is not an issue restricting data publication, but molecular genetic work with the desired "genetic resource" must be applied for in the *PIC*. Export of biological material, and transportation between the Provinces of Ecuador requires a Mobilization Permit (Autorización de Movilicación) from MAE, which needs approval by INABIO. For research performed in the PNP, an additional permit is necessary which can be obtained (without difficulties) from the respective park authority at the local offices of MAE depending on the place you will work at.

In Zamora City for the Bombuscaro Administrative Center of the Park:
Address: Calle Francisco de Orellana y Sevilla de Oro;
Phone number: 593 7 2605315
In Loja City for the Cajanuma Administrative Center of the Park:
Address: Calle Sucre entre Imbabura y Quito
Phone number: 593 7 2577125

The Station Administrator or the Scientific Coordinator can provide assistance or advice with the legal requirements.

KEY RESEARCH

Since its opening in 1997, ECSF hosted a multitude of German environmental projects in geo- and lifesciences, mostly performed in cooperation with scientists and students of the local universities (Universidad Técnica Particular de Loja UTPL, Universidad Nacional de Loja UNL, Universidad de Azuay UDA, Universidad de Cuenca UC) and partner universities from Quito by interdisciplinary research teams. Not much was initially known on the Neotropical mountain rain forest as an ecosystem and about its biodiversity. Therefore, inventories of the abiotic and biotic components of the natural and the anthropogenic ecosystems dominated the research during the first years and, although specialists from other countries joined the groups, detection of new species is still going on. Plants, birds, bats, bush crickets, ants, moths and several taxa from the soil meso- and microfauna are the groups which have been extensively studied (Liede-Schumann & Breckle, 2008) underlining the reputation of southern Ecuador as one of the prominent hotspots of biodiversity worldwide (Figure 3).

Based on the scientific results, the entire area has been awarded the rank of a UNESCO Biosphere reserve (Podocarpus - El Condor; *http://www.podocarpuselcondor.org/*). In the course of the past 22 years, the main focus of research concentrated more and more on the ecosystems, their functioning, and the effects of the ongoing climate and land use changes on ecosystem functioning and services (Beck *et al*. 2008, Bendix *et al*. 2013). One of the big advantages of the San Francisco valley for ecosystem research is that the natural tropical mountain rain forest ecosystem is located directly opposite to the anthropogenic replacement systems pasture, afforestation and abandoned pastures. This allows the identification of differences of abiotic and biotic interactions after land use change, the proper mechanistic and statistic modeling of ecosystem functioning of both ecosystem manifestations and thus, a tho-

Figure 3. Two iconic species of the mountain forest at the ECSF: the leaf shedding golden trumpet tree (*Handroanthus chrysanthus*) with its eye-catching yellow flowers (left) and the Inca Jay (*Cyanocorax yncas*) with its very extensive voice repertoire (right).

rough estimate of global change effects on the same elevational level. The other advantage is the elevation gradient from 1000 m to 3500 m (the anthropogenic sites ranges until 2800 m) which mimics climate change effects (space for time). Here, interesting responses to the changes of the abiotic environment could be unveiled, such as a shift of the plant biomass in favor of the subterranean plant parts with increasing elevation. Results from long-term measurements now can explain much of the weather pattern including local peculiarities like the regularly early morning rains and the influence of biomass burning in the Amazon on the nutrient budget of the region. In general, the natural vegetation turned out as a highly dynamic system in which the common gap dynamic is dramatically intensified by frequent landslides, triggered by the high amounts of precipitation, the steepness of the slopes, a high rock creep and an age-dependent increase of the weight of the wetted vegetation. The administration of the PNP is amenable to ecological experiments such as fertilization of the forest to mimic long-term nutrient input from the Amazon. The non-sustainability of the anthropogenic land use system has also attracted considerable interest and reforestation and pasture restoration protocols have been successfully developed based on ecological analyses of the weaknesses of the current land use practices. Ecuador still suffers from a high deforestation activity. Between 1990 and 2012, 1.8 Mio ha of forest have been cleared. On the other hand, the country has declared the objectives of reducing deforestation, mitigating climate change and conserving its natural resources in its constitution (Art. 414). On the basis of the results obtained so far, comprehensive land use concepts have been developed in a transdisciplinary program including non-university stakeholders, which balance regulating and provisioning ecosystem services (Knoke *et al*. 2014, 2016). Furthermore, concepts for functional ecosystem monitoring including remote sensing applications have been designed (Farwig *et al*. 2017; Beck *et al*. 2017). The entire research and knowledge transfer concept has been published in laymen terms to foster public awareness for environmental change issues in the vulnerable biodiversity hotspot of the Ecuadorian Andes (Bogner *et al*. 2016). The results of the research have been documented in 748 mostly peer-reviewed publications, with an increasing share of Ecuadorian (co)authors. On top of that, 6 books have been published ranging from check lists to monitoring protocols. Important is the unique data base with 634 data sets which are available as baseline data for re-use by all researchers starting new research activities at the ECSF and beyond.

FIVE SELECTED PUBLICATIONS

Beck E, Bendix J, Kottke I, Makeschin F, Mosandl R, eds (2008) Gradients in a tropical mountain ecosystem of Ecuador. Ecological Studies 198. Springer, Berlin, Heidelberg, New York

Beck E, Knoke T, Farwig N, Breuer L, Siddons D, Bendix J, eds (2017) Landscape restoration, sustainable land use and cross-scale monitoring of biodiversity and ecosystem functions. A science-directed approach for South Ecuador. NCI-Loja. (Free Download under: http://vhrz669.hrz.uni-marburg.de/tmf_respect/publications.do?citid=1696)

Bendix J, Beck E, Bräuning A, Makeschin F, Mosandl R, Scheu S, Wilcke W, eds (2013) Ecosystem services, biodiversity and environmental change in a tropical mountain ecosystem of South Ecuador. Ecological Studies 221. Springer, Berlin, Heidelberg, New York

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Farwig N, Bendix J, Beck E (2017) Introduction to the Special Issue "Functional monitoring in megadiverse tropical ecosystems". Ecological Indicators 83:524-526

Website link: ***http://www.tropicalmountainforest.org***

Link to a list of all publications uploaded to the data warehouse:

http://vhrz669.hrz.uni-marburg.de/tmf_respect/publications.do?cmd=showall

Link to a list of all data sets uploaded to the data warehouse:

http://vhrz669.hrz.uni-marburg.de/tmf_respect/data_pre.do?cmd=showall

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