ENVIRONMENTAL CHANGE AND ITS IMPACTS IN A BIODIVERSITY HOTSPOT OF THE SOUTH ECUADORIAN ANDES –MONITORING AND MITIGATION STRATEGIES

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With 1 figure

It is meanwhile undisputed that biodiversity, ecosystem functions and ecosystem services are globally threatened by human activities and climate change (e.g., Pereira et al. 2010; Cardinale et al. 2012). This particularly holds true for many tropical countries such as Ecuador which hosts the globally second hottest hotspot of biodiversity (Bendix and Beck 2009). In Ecuador, as in most of the tropical countries, scientific understanding of the ongoing environmental changes is still considerably behind reality. There are great knowledge gaps on (i) the state and consequences of climate change, (ii) the understanding of the impacts of man-made environmental changes on the ecosystems' functioning and services and (iii) mitigation strategies for adverse impacts through appropriate planning measures. Based on a broad fundament of comprehensive basic research in ecosystem functioning and services in the tropical mountain rain forest of Ecuador (Bendix and Beck 2009; Bendix et al. 2013), a new research and knowledge transfer initiative, the *Platform for Biodiversity and Ecosystem Monitoring and Research in South Ecuador* (www.TropicalMountainForest.org) was launched in 2013 to overcome these deficits in a joint venture of scientists from Germany and Ecuador and non-university Ecuadorian stakeholders. This special issue of "Erdkunde" presents selected examples of the comprehensive work conducted in the scope of this trans-disciplinary program from two regional sites, the mountain rain forest and the Tumbesian dry forest (Fig. 1).

Deforestation is one of the greatest environmental problems in Ecuador (e.g., Curatola Fernández et al. 2015) because it curtails not only organismal diversity and biotic interactions, but affects also major ecosystem services, e.g., climate and water regulation (Knoke et al. 2014), thus feeding back to climate change (e.g., Fries et al. 2012). Threat to water regulation services by deforestation and other types of land use, e.g., mining (Buytaert et al. 2005) is a focal issue for Ecuador because ~50 % of the national power demand is generated by hydro power plants (Peláez-Samaniego et al. 2007).

In the mountain rain forest core site, forest is being frequently replaced by pasture, raising the question of a change in the water relations encompassing precipitation, evapotranspiration, runoff and seepage (Knoke et al. 2014). Thus, monitoring of these units of the water balance is very important, but particularly evapotranspiration (ET) is difficult to measure in remote and rugged mountain areas. By demonstrating a good correlation between leaf transpiration of the pasture grass (*Setaria sphacelata*) and optical evapotranspiration measurements over the pasture, Silva et al. (2016) showed that laser-based scintillometer technology can principally be used to monitor ET in difficult terrain. Tolerable deviations between ET and leaf transpiration result from an oscillating water use efficiency of the pasture grass in the diurnal course, mainly driven by cloudiness, radiation and vapour deficit of air.

Indigenous trees should be used for reforestation of unused pasture areas, e.g., as a measure to restore water regulation or lost biological diversity. However, favourable sites or suitable ecological niches for trees are difficult to localize in the rugged terrain of the natural mountain rain forest. A combination of high resolution topography data, the spatial distribution of 16 indigenous tree species recorded in the scope of a natural forest experiment and niche modelling (presence only models: Maxent and ecological niche factor analysis) allowed the identification of suitable habitat conditions for tree growth with sufficient accuracy (Kübler et al. 2016).

The best measure to protect biodiversity and ecosystem services would be to prevent deforestation. This is particularly difficult in the dry forest area, which is among the most threatened ecosystems in Ecuador with an enormous pressure on the forest remnants. Ochoa et al. (2016) show that an effective

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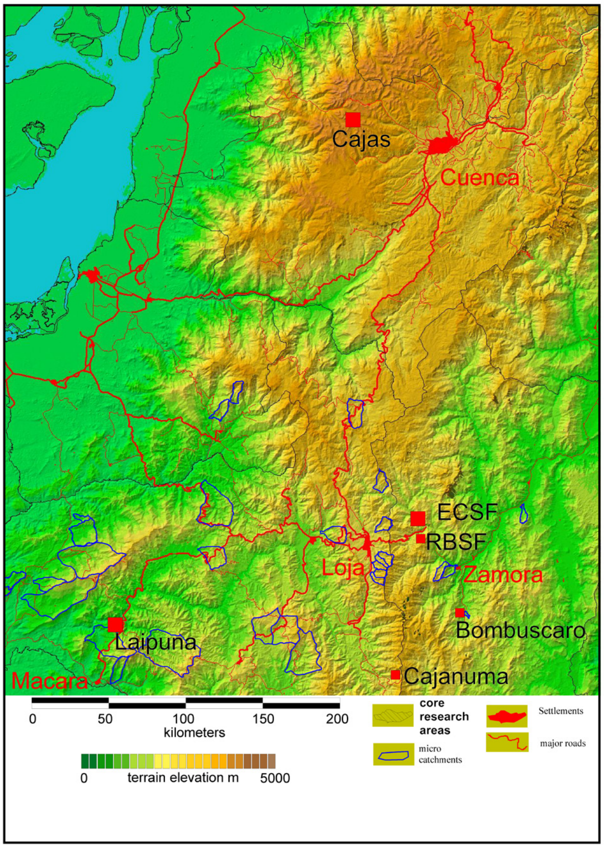

Fig. 1: Study area of the platform in southern Ecuador. The platform encompasses a thermal (elevation; 600 – 4200 m a.s.l.) and a moisture gradient (400 – 6000 mm a-1) that is realized by three core sites. In its northernmost part, the highest research area of the platform is the páramo of Las Cajas (2°50'S, 79°10'W), close to the city of Cuenca. The mountain rainforest core site is centred around the Estación Científica San Francisco (ECSF) and the Reserva Biológica San Francisco (RBSF, 3°58'S, 79°04'W) at ~2000 m a.s.l., ranging from 1000 (Bombuscaro) to 3000 m a.s.l. (Cajanuma). The driest and hottest core site of the platform is the Tumbesian dry forest in the Laipuna biosphere reserve (4°14'S, 79°57'W). For all core sites, field plots were established in the natural vegetation and the anthropogenic replacement systems

measure to control deforestation must at the same time warrant the livelihood of the local population. Based on interviews with 163 households around the Laipuna reserve, they propose to allow agricultural land use in parts of the forest area, combined with compensation payments for forest protection of the spared forest parts. An important incentive in this land use option for the farmers was to reduce their financial risk by a diversification of the forest use, e.g., by including goat grazing.

In remote areas without long term meteorological measurements as it is the situation in S-Ecuador, annual tree growth could be used as an indicator for climate change. However, in the rain forest without distinct seasons, tree ring information is hardly usable as a climate proxy. Volland et al. (2016) revealed for *Cedrela montana* trees by generating the first long term (1885–2011) $\delta^{18}O$ chronology from annual tree rings that stable isotope variations are a better climate proxy than tree width, particularly for precipitation, cloud cover and the number of humid days. With their investigation, they also confirmed the high significance of natural climate fluctuations in the area resulting from the El Niño – Southern Oscillation (ENSO) phenomenon (for ENSO in Ecuador and the study area refer to Bendix 2000; Bendix et al. 2003, 2011).

Remains of the natural mountain forest frequently extend along altitudinal gradients, associated with climatic gradients. With increasing altitude, environmental conditions for tree growth commonly become more unfavourable (e.g., Wagemann et al. 2015). In this respect, the phylogenetic niche conservatism hypothesis expects a decreasing tree species richness, phylodiversity and phylogenetic age of the representative tree families with decreasing tropicality. Tiede et al. (2016) however found in contrary to this hypothesis no effect of elevation on (i) species richness of trees, and (ii) an increasing clade level phylodiversity and family age of the tree assemblages with elevation. An explanation might be that old plant lineages of extra-tropical origin influence the recent composition of tree assemblages.

In summary, the contributions to this special issue present important information on land use and climate change in Ecuador, its relation to ecosystem services (water regulation) and mitigation strategies for the pressure on the remains of the natural forests. Furthermore, several methods are presented that might be applied in a regional monitoring system for environmental change effects on biodiversity and ecosystem services as it is demanded by the IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services; Perrings et al. 2011) and the Ecuadorian National Strategy on Biodiversity.

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