A blessing or a curse?

The impact of the changing environmental conditions on different tropical mountain tree species (Southern Ecuador)

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Study Aims and Area…

As part of an interdisciplinary nutrient manipulation experiment (**NUMEX**) in Southern Ecuador (3°58'S, 79°04'W) we test the hypothesis that an increasing input of atmospheric nitrogen stimulates tree growth of different tropical tree species and changes trees' water status in relation to climatic extreme events.

The area is characterised by a humid climate with a mean annual precipitation of about 2176 mm and a mean annual temperature of 15.5°C **[Fig. 1]** (Richter & Peters 2011).

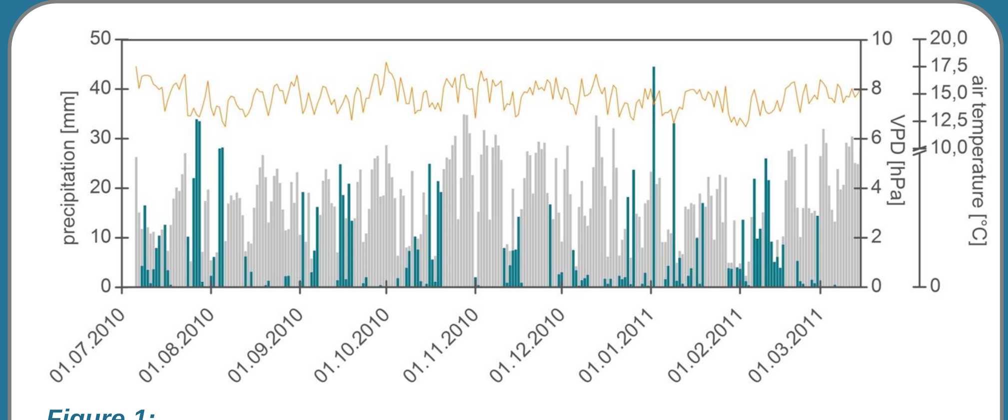

Figure 1: Climatic conditions of the NUMEX area from July 2010 to March 2011 (Daily sums of precipitation: blue bars; vapour pressure deficit: grey bars; temperature: orange line)

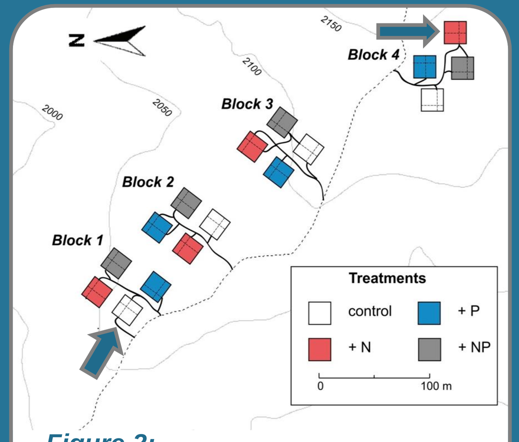

Figure 2: NUMEX design
Study plots are marked with arrows

NUMEX has a fourfold replicated block design. **[Fig. 2]**. Within each block the different treatments Control (C) [50 kg N ha-1], Nitrogen (N), Phosphorus (P) and a combination of Nitrogen and Phosphorus (N/P) were set up randomly. Since February 2008 fertilisers have been added annually (Homeier et al. 2012; Homeier et al. 2013, in press). Because of the high costs of our measurements we only investigate one N-fertilised and one non-fertilised plot [Study plots are marked with arrows in **Fig. 2**].

Methods…

… tree growth measurements:

- 8 high resolution point dendrometer (30 min interval, 5µm resolution):
  - daily radial change (dR),
  - daily amplitude (dA) and
  - cumulative daily radial change (cum dR) of tree growth

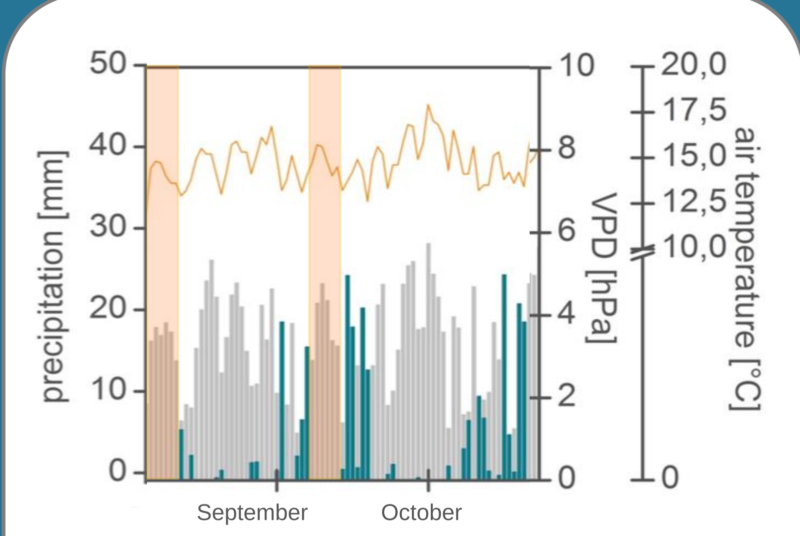

Figure 3: Example of two dry spells (dry spells are highlighted in light red)

… climatic parameters:

- Defining dry spells with at least four consecutive days without rain **[Fig. 3 and overview beside]:**

06.08. – 10.08.2010 [5]	01.10. – 04.10.2010 [4]
16.08. – 19.08.2010 [4]	21.10. – 31.10.2010 [11]
23.08. – 26.08.2010 [4]	07.11. – 10.11.2010 [4]
08.09. – 12.09.2010 [5]	19.11. – 25.11.2010 [7]
25.09. – 28.09.2010 [4]	

Tree Species…

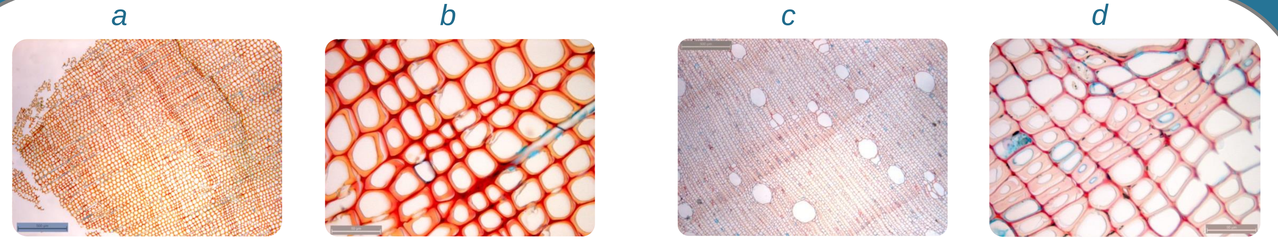

Figure 4: Microscopic images of P. oleifolius (picture a and b) and A. lojaensis (picture c and d)

- *Graffenrieda emarginata* [Melastomataceae] (evergreen broadleaved)
- *Podocarpus oleifolius* [Podocarpaceae] (evergreen conifer)
- *Prunus* sp. [Rosaceae] (evergreen broadleaved)
- *Alchornea lojaensis* [Euphorbiaceae)] (evergreen broadleaved)

Despite the constant perhumid conditions of the area the examined tree species exhibit seasonal growth rhythms, becoming visible in distinct growth boundaries. **Figure 4** shows microscopic images of *P. oleifolius* and *A. lojaensis*. The tangential bands of flattened and thickened libriformfibres or tracheids mark the growth ring boundary.

Results…

During the observation period from July 2010 to December 2010 the cumulative growth values of the different tree species differed a lot **[Tab. 1]**. With the exception of *G. emarginata*, all the fertilised trees grew more than the non-fertilised ones.

Table 1 also visualises species specific differences regarding the mean daily amplitudes of radial stem diameter variations. By far, *P. oleifolius* shows the highest values. However, all tree species obviously exhibit a high range between minimum and maximum dA, whether fertilised or not.

Tree species	Treatment	Cum. growth [mm] (July – Dec.)	mean dA [mm] (July – Dec.) *(SD)*	range dA [mm] (July – Dec.)	Median dA [mm] (July – Dec.)
G. emarginata	Control	0,468	0,060 *(0,044)*	0,234	0,049
	+N	0,345	0,029 *(0,002)*	0,064	0,028
P. oleifolius	Control	0,076	0,093 *(0,044)*	0,167	0,096
	+N	0,232	0,119 (0,064)	0,288	0,101
Prunus sp.	Control	0,105	0,061 (0,037)	0,146	0,061
	+N	0,729	0,055 (0,024)	0,112	0,052
A. lojaensis	Control	-0,121	0,044 (0,031)	0,123	0,039
	+N	1,067	0,056 (0,033)	0,139	0,052

Table 1: Descriptive statistics of all tree species

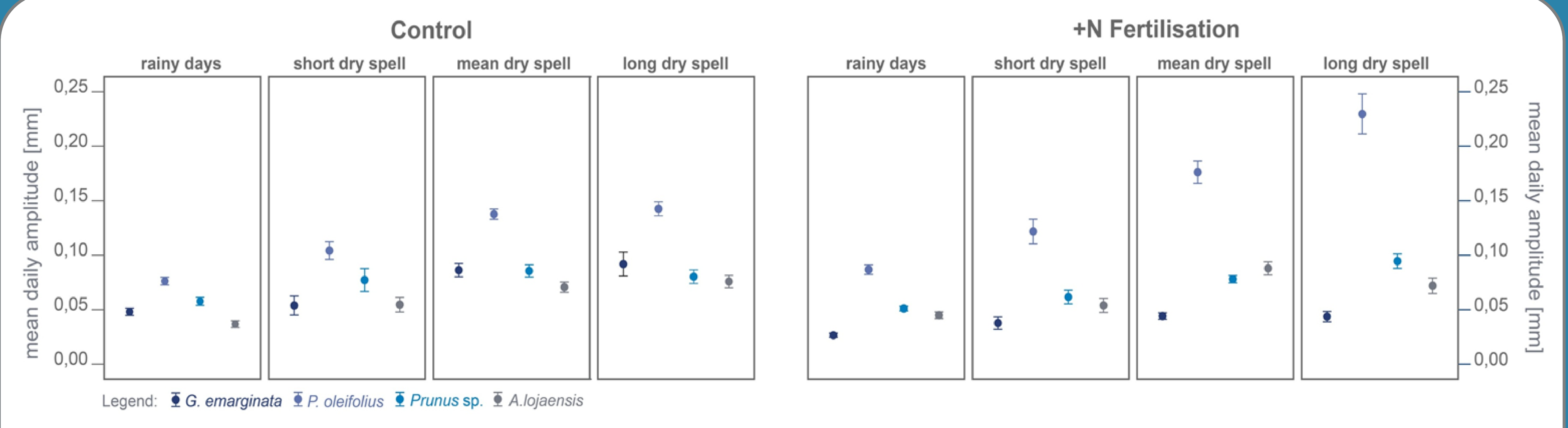

Figure 5: Mean daily amplitude (± standard deviation) during rainy days, short dry spells (1 day without rain), mean dry spells (4 consecutive days without rain) and long dry spell (7 consecutive days without rain) for both treatments.

Figure 5 shows the mean dA of all tree species, during rainy days, short dry spells, mean dry spells and long dry spells. The longer there is no precipitation, the more the trees suffer from water stress becoming obvious by the increasing dA.

Considering only the dry spells, species specific differences get more evident **[Fig. 6]**. Whereas the fertilised tree of *P. oleifolius* showed statistically significant higher dA than the control tree, *G. emarginata* showed exactly the opposite and was less susceptive to drought. *Prunus* sp. and A. *lojaensis* revealed nearly no significant differences and remained fairly constant.

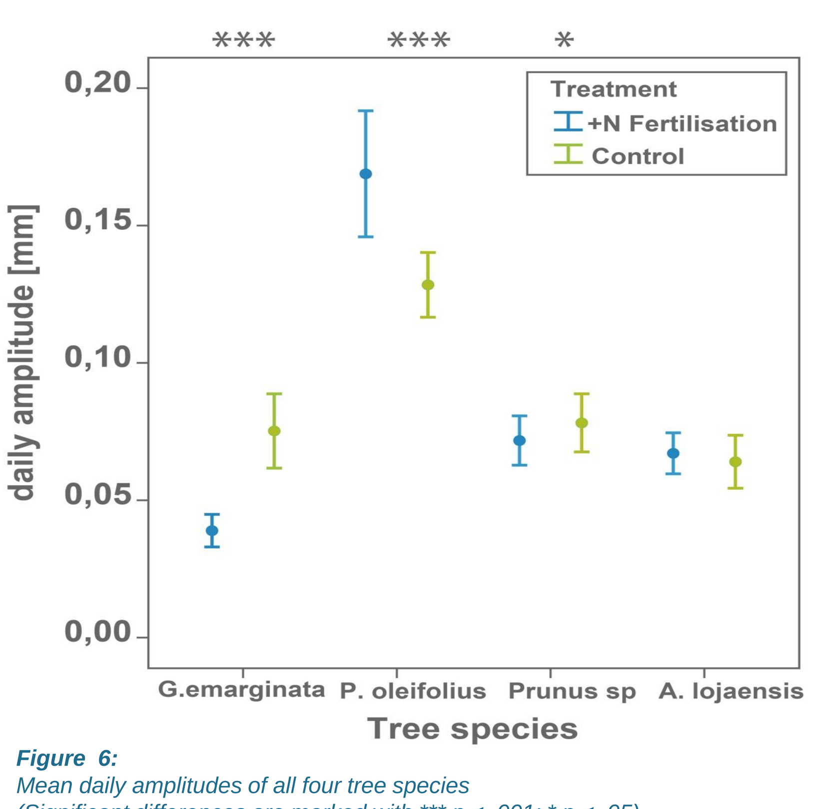

Figure 6: Mean daily amplitudes of all four tree species (Significant differences are marked with *** p < .001; * p < .05)

Conclusion

Our results indicate that an increasing input of atmospheric nitrogen deposited in the tropical mountain rainforest via long-distance wind transport from Amazonia may alter the competitive conditions of the different tree species and may lead to changes in the species composition of the forest. Especially *G. emarginata*, the most dominant tree species in this altitudinal belt, showed least positive effects of fertilization on growth and strongest reductions of climatic control on daily radial stem variations.

Outlook…

- continuing with tree growth measurements
- quantitative wood anatomy investigations and
- analysis of stable carbon isotopes by using branches

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Homeier, J., Hertel, D., Camenzind, T., Cumbicus, N.L., Maraun, M., et al. (2012) Tropical Andean Forests Are Highly Susceptible to Nutrient Inputs—Rapid Effects of Experimental N and P Addition to an Ecuadorian Montane Forest. PLoS ONE 7(10): e47128. doi:10.1371/journal.pone.0047128
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Acknowledgements…

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