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How does nutrient availability influence rates of photosynthesis and leaf respiration in Amazonian tropical forest?

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When considering factors influencing the global carbon cycle, it is essential that we better understand the extent to which leaves in contrasting tropical forest systems maintain a positive carbon balance (i.e. which factors affect the balance between leaf photosynthesis and leaf respiration). Although some data exist on photosynthesis in tropical rainforests, much less information is available on the variability in rates of leaf respiration. Such data are urgently required, first to understand how this relatively poorly understood biome functions, and secondly to aid modellers seeking to predict the impacts of climate change on carbon uptake and release by tropical rainforests.

We conducted field measurements at two contrasting rainforest locations in tropical South America: Tambopata in lowland Peru, near the Andean Mountains, and Paracou in French Guiana, on the eastern edge of the continent, close to the Atlantic Ocean. These two locations differ strongly in terms of soil fertility and the availability of nitrogen (N) and phosphorus (P); preliminary data showed that leaf N contents are on average approximately twice as high in the Peruvian plots, and levels of leaf P are about three times as high. At each site, we examined a wide range of species that differed in many plant functional traits and used this information to examine for differences in the fundamental relationships between the rate of photosynthesis (light- and CO2-saturated; Amax) and the rates of leaf respiration in both the light (Rlight) and dark (Rdark).

We present photosynthesis and respiration data collected from more than 200 trees belonging to over 100 species, investigating how the relationship between the two fluxes differed with soil fertility, both within and between the Peruvian and French Guianan sites. As expected, the results identified strong positive correlations between Amax and Rdark. However, the slope and intercept of the relationships were not constant between sites of differing fertility, indicating the key role that nutrient availability may play in controlling the carbon balance of tropical forests; this will be investigated further using leaf nutrient content data. Furthermore, rates of leaf respiration at any given temperature were lower in the light than in darkness (i.e. light inhibited leaf respiration). This has important implications for estimating gross primary productivity (GPP) from net ecosystem exchange and standard rates of night-time respiration. Our results suggest GPP may be overestimated by such calculations.

In summary, our study is amongst the first to investigate how nutrient availability affects the carbon balance of tropical trees by looking at a wide range of species at sites of contrasting fertility. The relationships observed will be extremely valuable to the modelling community in terms of increasing our understanding of spatial patterns of plant growth in the Amazon.