SUPPLEMENTARY MATERIAL 2

to Zach, Horna, Leuschner and Zimmermann: "Patterns of wood carbon dioxide efflux across a 2,000-m elevation transect in an Andean moist forest"

S 2 Description of extrapolation

After measurements of R_S and R_R, data were combined with stand structural parameters to extrapolate surface area-based rates of R_S and R_R to the forest stand. We assumed that (1) our measurements of CO_2 efflux over a selection of representative species reflected the CO_2 efflux for all species at the respective elevation level and (2) surface area-based rates of R_S and R_R were similar within organ and species.

Stand structural parameters

In the study plots, where stem and root efflux was measured, a forest inventory survey with 80 marked canopy trees was previously conducted (Moser 2008). The 80 trees per stand covered an area of 827 m², 343 m² and 96 m² at 1,050 m, 1,890 m and 3,050 m, respectively. All trees were identified at the species level. As long as they reached the canopy, trees with a diameter at breast height (DBH) < 5 cm were included. The trees chosen for efflux measurements were among these canopy trees (see S 1). All trees were equipped with manual dendrometer tapes (DBH). Tree height was measured using a Vertex III Forestor tree height meter (Haglöf, Langsele, Sweden). For each canopy tree, we calculated the total stem surface area from tree height and diameter data assuming a cone-shaped bole surface area. We used total tree height as a measure for bole length from the base to the canopy top and assumed base diameter being equal to DBH. This model has successfully been applied for estimating the stem surface area of neotropical montane forest tree species in Puerto Rico (Harris et al. 2008). For each elevation plot, we calculated the stem area index (i.e., SAI) as the cumulative bark surface area of all canopy trees divided by the plot ground area:

(1) $$SAI = \frac{1}{A_G}\sum_{i=1}^{n}\left(r * \sqrt{r^2 + h^2}\right) * \Pi = \frac{1}{A_G}\sum_{i=1}^{n} A_{Si}$$

with A_G being the plot ground area (m²), r being the radius at breast height (m), h the tree height (m) and A_{Si} is the stem surface area of tree i (m^2).

Scaling stem CO_2 efflux

For each plot, we averaged rates of R_S of all measured trees and of the four measurement campaigns combined over the course of the year for extrapolating stand-level stem C efflux (R_{Smean}). We found R_S to be highly variable among trees and in most cases only weakly correlated with air and tissue temperature (Zach et al. in revision), which did not allow for establishing a temperature response function to account for abiotic factors controlling wood CO_2 efflux throughout the year.

Several studies calculating stand-level CO_2 efflux in temperate (Strobel 2004; Gansert 2002; Gries 2004) and tropical forests (Ryan et al. 1994; Meir and Grace 2002; Nepstad et al. 2002; Cavaleri et al. 2006) distinguished different diameter size classes prior to up-scaling. Because there were no significant relationships between basal area and R_S of the measured trees at any of our sites (data not shown), we did not separate DBH size-classes. Instead, we assumed that rates of R_S per surface area were constant across tree diameter size classes for extrapolating R_S to the stand. Ryan et al. (1994) found stem diameter to explain only 20% of the variability in R_S of one single tropical lowland tree species. In a tropical mountain forest comparable to our sites, stem diameter explained less than 15% of total variation in R_S of several tree species combined (Harris et al. 2008).

Carbon efflux for each tree stem was calculated assuming a cone-shaped stem (Harris et al. 2008) as it was applied for the SAI (equation (1)). We calculated totals of C efflux for each canopy tree within the study plots. Single-tree efflux totals were then summed. The cumulative vertical stand C flux was projected to the ground area by dividing the total site area:

$$E_c = \left(\left[\sum_{i=1}^{n} \left(R_{Smean} * A_{Si} \right) \right] * A_G^{-1} \right) * 365 days \qquad (2)$$

with E_c being the cumulative annual stem C efflux (g C m^{-2} ground area y^{-1}) of a plot with n trees. R_{Smean} is the mean annual C efflux from n trees measured over different seasons and expressed on a daily basis (g C m² surface area d^{-1}); A_{Si} is the stem surface area of tree i (m^2) assuming a cone shape (equation (1)) and A_G being the plot ground area (m²). Up-scaling did not include estimates of branch or leaf CO_2 efflux.

Estimates of coarse root total C efflux were based on mean annual rates of R_R (µmol C m^{-2} surface area s^{-1}) and the standing coarse root biomass stock (g C m^{-2} ground area y^{-1}; Moser 2008). Surface area efflux rates were first expressed on a volume basis (µmol C m^{-3} wood volume s^{-1}) based on the wood biomass volume enclosed in the measurement chamber. Volume-based efflux rates were then converted to biomass (µmol C g^{-1} biomass s^{-1}) using specific wood gravity (g cm^{-3}) as determined for the measured roots (data not shown). Coarse root C efflux is extrapolated to the year (g C g^{-1} biomass y^{-1}) and then multiplied by the standing coarse root biomass stock to derive the annual stand C efflux of the coarse root biomass (g C m^{-2} ground area y^{-1}). Coarse root biomass was assumed to consist by 50% of C and ash-free matter to represent 99.3% of the biomass (Ryan et al. 1994; Meir and Grace 2002).

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