Supplementary

TEXT S1. Additional equations of photosynthesis and respiration

A_{net} was modelled as:

$$A_{net} = min(A_c, A_J) - R_{day} \quad \text{(S1)}$$

where A_c is the gross photosynthetic rate limited by carboxylation rate, while A_J is the photosynthetic rate limited by electron transport rate; R_{day} is the light respiration rate in absence of photorespiration (μmol m^{-2} s^{-1}).

A_c is calculated as a function of maximum carboxylation capacity (V_{cmax}; μmol m^{-2} s^{-1}) and intercellular CO_2 concentration (C_i):

$$A_c = V_{cmax} \frac{C_i - \Gamma^*}{K_c(1+\frac{O_i}{K_O})+C_i} \quad \text{(S2)}$$

where K_c and K_o are the Michaelis–Menten coefficients of Rubisco activity for CO_2 and O_2, respectively (μmol mol^{-1} and mmol mol^{-1}, respectively), and Γ* is the CO_2 compensation point in the absence of mitochondrial respiration (μmol mol^{-1}); O_i is intercellular O_2 concentration (mmol mol^{-1}). The K_c, K_o, and Γ* are temperature dependent following Bernacchi et al. (2001).

A_J is calculated according to:

$$A_J = \frac{J}{4}\frac{C_i - \Gamma^*}{C_i + \Gamma^*} \quad \text{(S3)}$$

where J is the electron transport rate calculated by solving:

$$\theta_J \cdot J^2 - (a_{abs} \cdot \alpha_J \cdot Q_L + J_{max}) \cdot J + a_{abs} \cdot \alpha_J \cdot Q_L \cdot J_{max} = 0 \quad \text{(S4)}$$

where θ_J describes the curvature electron transport rate (unitless); α_J is the quantum yield (μmol μmol^{-1}); Q_L is the PAR incident on the leaf; a_{abs} is the absorptance of PAR (1 minus leaf reflectance and transmittance; fraction); J_{max} is the maximum electron transport rate at the given temperature (μmol m^{-2} s^{-1}). Both J_{max} and V_{cmax} depend on leaf temperature and are modelled using a peaked Arrhenius function:

$$k_T = k_{25} \cdot \exp(E_a \frac{T_k - 298.15}{298.15 \cdot R_{gas} \cdot T_k}) \cdot (1 + \frac{\exp(298.15 \cdot \Delta S - H_d)}{298.15 \cdot R_{gas}})/(1 + \frac{\exp(T_k \cdot \Delta S - H_d)}{T_k \cdot R_{gas}}) \quad \text{(S5)}$$

where k_t is the value of J_{max} or V_{cmax} at a given temperature (μmol m^{-2} s^{-1}); k_{25} is the value of J_{max} or V_{cmax} at 25 ºC; μmol m^{-2} s^{-1}); T_k is the leaf temperature in Kelvin; E_a is the activation energy which describes the rate of increase of k_t to temperature (J mol^{-1}); H_d is the deactivation energy which describe the rate of decrease of k_t to temperature (J mol^{-1}); ΔS is known as the entropy factor (J mol^{-1} K^{-1}); R_{gas} is the gas constant (J mol^{-1} K^{-1}).

The model also assumes R_{day} to be a fixed fraction (0.7) of R_{dark} (dark respiration rate; μmol m^{-2} s^{-1}), and uses an Arrhenius temperature response function:

$$R_{dark} = R_{dark.25} \cdot \exp(kT \cdot (T_{leaf} - 25)) \quad \text{(S6)}$$

where k_T is the sensitivity of R_{dark} to temperature (ºC^{-1}); and T_{leaf} is the leaf temperature (ºC). MAESPA calculates the leaf temperature that closes the energy balance iteratively (Medlyn et al., 2007).

The light response parameters α_J and θ_J of J were fitted to light response curves measured *in situ*. We assumed that α_J is related to quantum yield of photosynthesis (α):

$$\alpha_J = 4 \cdot \alpha \cdot \frac{C_i + 2 \cdot \Gamma^*}{C_i - \Gamma^*} \quad \text{(S7)}$$

A linear model was fitted to the measured photosynthesis fluxes and absorbed PAR from the initial part of the light response curves (< 100 µmol m^{-2} s^{-1}) and the fitted slope was assumed to be α. This slope was converted to α_J using Eqn. S7. The curvature of J (θ_J) was assumed to be the same as photosynthesis and thus could be estimated by fitting the following quadratic relationship:

$$A_{net} = \frac{a_{abs} \cdot \alpha \cdot Q_L + A_{max} - \sqrt{(a_{abs} \cdot \alpha \cdot Q_L + A_{max})^2 - 4 \cdot a_{abs} \cdot \alpha \cdot Q_L \cdot A_{max} \cdot \theta_J}}{2 \cdot \theta_J} + R_{day} \quad \text{(S8)}$$

where $A_{\max}$ is the maximum of A, Q_L is the incident PAR and a_{abs} is the absorptance, which was calculated to be 0.825, by subtracting the fractions of reflectance (0.082) and transmittance (0.093). Eqn. S8 was fitted to the full light response curves using non-linear least squared method to obtain the values of $A_{\max}$ and θ_J, assuming α from above. Since the fitting is not significantly different in the ambient and elevated data, this study used one θ_J value fitted to all the data.

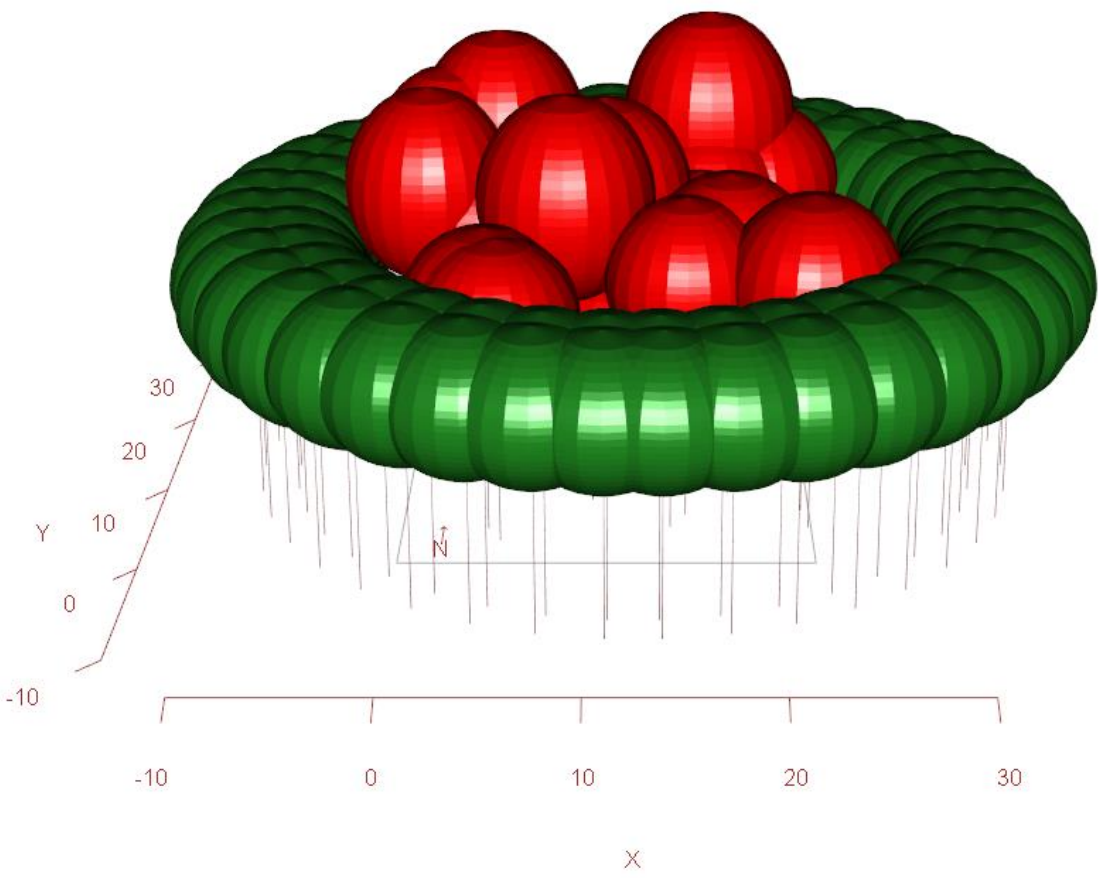

Figure S1. Example of tree stand as represented in MAESPA. The figure shows the trees in ring 1 (red) and the surrounding trees outside the ring (green). Other rings look similar with realistic tree locations and sizes.

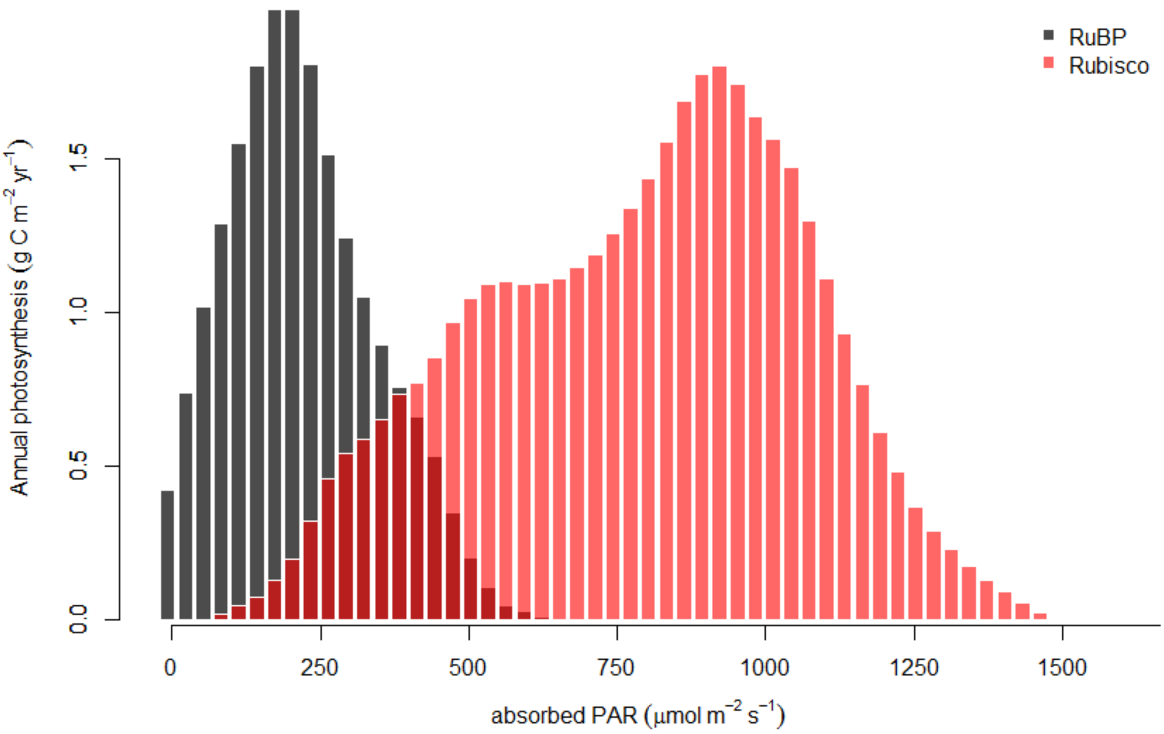

Figure S2. Distribution of average annual photosynthesis limited by Rubisco activity and RuBP-regeneration in bins of absorbed PAR (25 $\mu mol\ m^{-2}\ s^{-1}$), as calculated by MAESPA for all rings during 2013. This figure is produced with a θ_J of 0.85 and a J:V ratio of 2, which represents the assumptions inmost models.