Supplementary Text 3: Using the power model as null model

1 MECHANISTIC COMPONENT

All variables that characterize the forest structure, such as tree density, basal area, biomass, mean diameter, or the number of trees in different diameter classes, can be computed from the two-parameter power distribution of tree diameters, as indicated in Table S1.

Table S1. Expression of the plot attributes when the diameter distribution at plot level is modeled by a power distribution with parameter z, given by: $N(z-1)x^{-z}/(x_0^{1-z}-x_1^{1-z})$, where x is tree diameter and x_0 is the minimum diameter for inventory (a constant imposed by the sampling design of the forest inventory). The power distribution is truncated to an upper limit x_1 so that the moments of the distributions are defined for all values of $z>1$. f is the biomass allometric equation that predicts the aboveground biomass of a tree from its diameter x and wood density ρ.

Plot attribute	Notation	Expression
Density of trees	N	N
Basal area	G	$N\frac{\pi}{4}\frac{z-1}{z-3}\frac{x_0^{3-z}-x_1^{3-z}}{x_0^{1-z}-x_1^{1-z}}$ *
Mean diameter	D	$\frac{z-1}{z-2}\frac{x_0^{2-z}-x_1^{2-z}}{x_0^{1-z}-x_1^{1-z}}$ †
Equivalent diameter	E	$(\frac{4}{\pi}G/N)^{0.5}$
Density of tree in class $[a,b[$	N_{ab}	$N\frac{a^{1-z}-b^{1-z}}{x_0^{1-z}-x_1^{1-z}}$
Aboveground biomass	B	$N\frac{z-1}{x_0^{1-z}-x_1^{1-z}}\int_{x_0}^{x_1}f(x,\rho)\,x^{-z}\mathrm{d}x$
Proportion of biomass of trees with dbh $\geq c$	P	$\frac{N}{B}\frac{z-1}{x_0^{1-z}-x_1^{1-z}}\int_{c}^{x_1}f(x,\rho)\,x^{-z}\mathrm{d}x$

$*$ or $N\frac{\pi}{2}x_0^2x_1^2(x_1^2-x_0^2)^{-1}\ln(x_1/x_0)$ for $z=3$.
† or $x_0x_1(x_1-x_0)^{-1}\ln(x_1/x_0)$ for $z=2$.

2 CORRELATION BETWEEN BIOMASS AND BASAL AREA

Pearson's correlation coefficient between modeled biomass and modeled basal area according to the power null model was 0.86 (Figure S1B). The correlation between the deviations of biomass and basal area to the predictions equaled 0.80 and was significantly different from zero (p-value < 0.001). When excluding the data from the Oyan and Ngouha2 sites, the correlation between modeled biomass and basal area was 0.87. The correlation between the deviations of biomass and basal area to the power model then equaled -0.23 and was not significantly different from zero at 5% confidence level, even if very close to significance (p-value = 0.05).

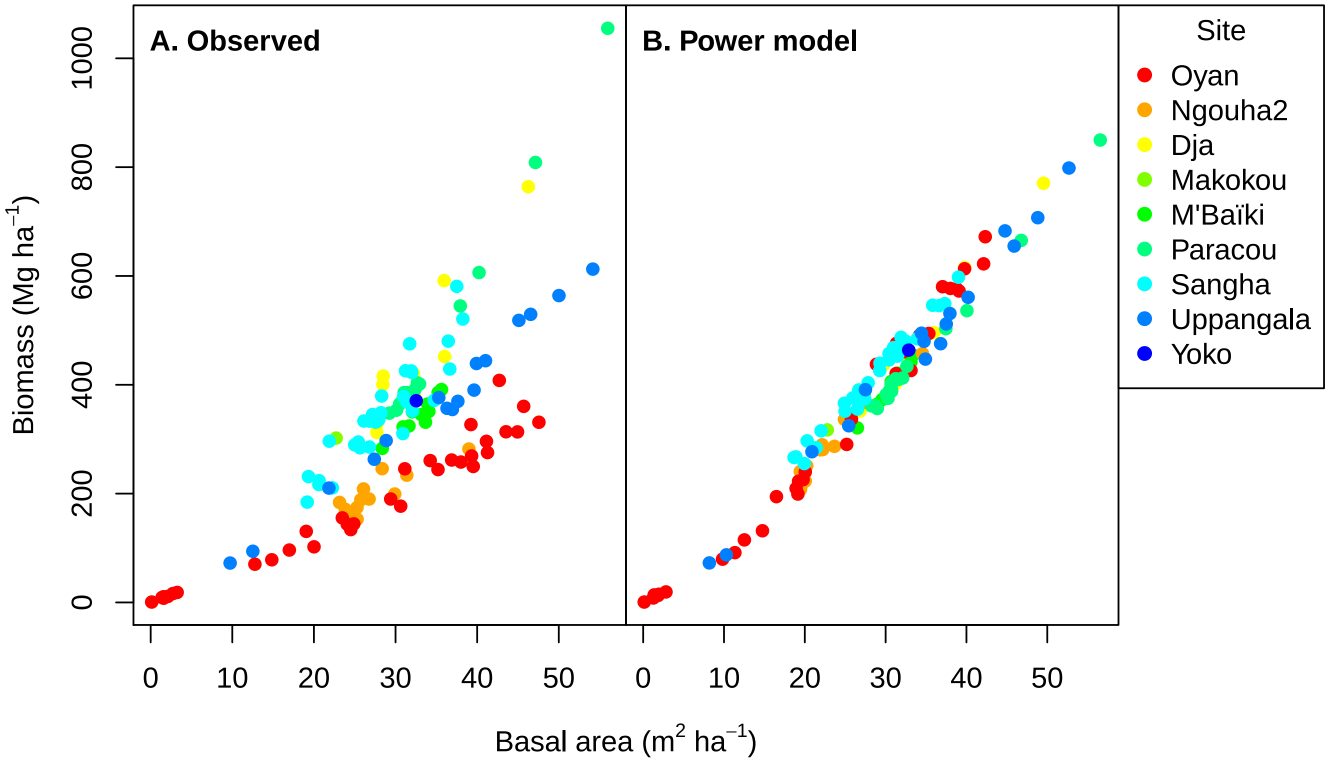

Figure S1. Aboveground biomass versus basal area for 133 forest stands at 9 sites as (A) observed, (B) modeled by the power null model. The different colors correspond to the different sites as shown in the legend.

3 ORDINATION OF PLOTS BASED ON STRUCTURAL VARIABLES

The power null model performed a little less well than the exponential model in rendering the overall pattern of observed data (Figure S2A and B). The sum of the first two eigenvalues for the power model equaled 8.7. The matrix of deviations $\mathbf{D}$ showed a similar pattern to that obtained with the exponential model (sum of first two eigenvalues = 7.8, p-value < 0.001), with a reversal of the direction of the first axis of the PCA (Figure S2C, D).

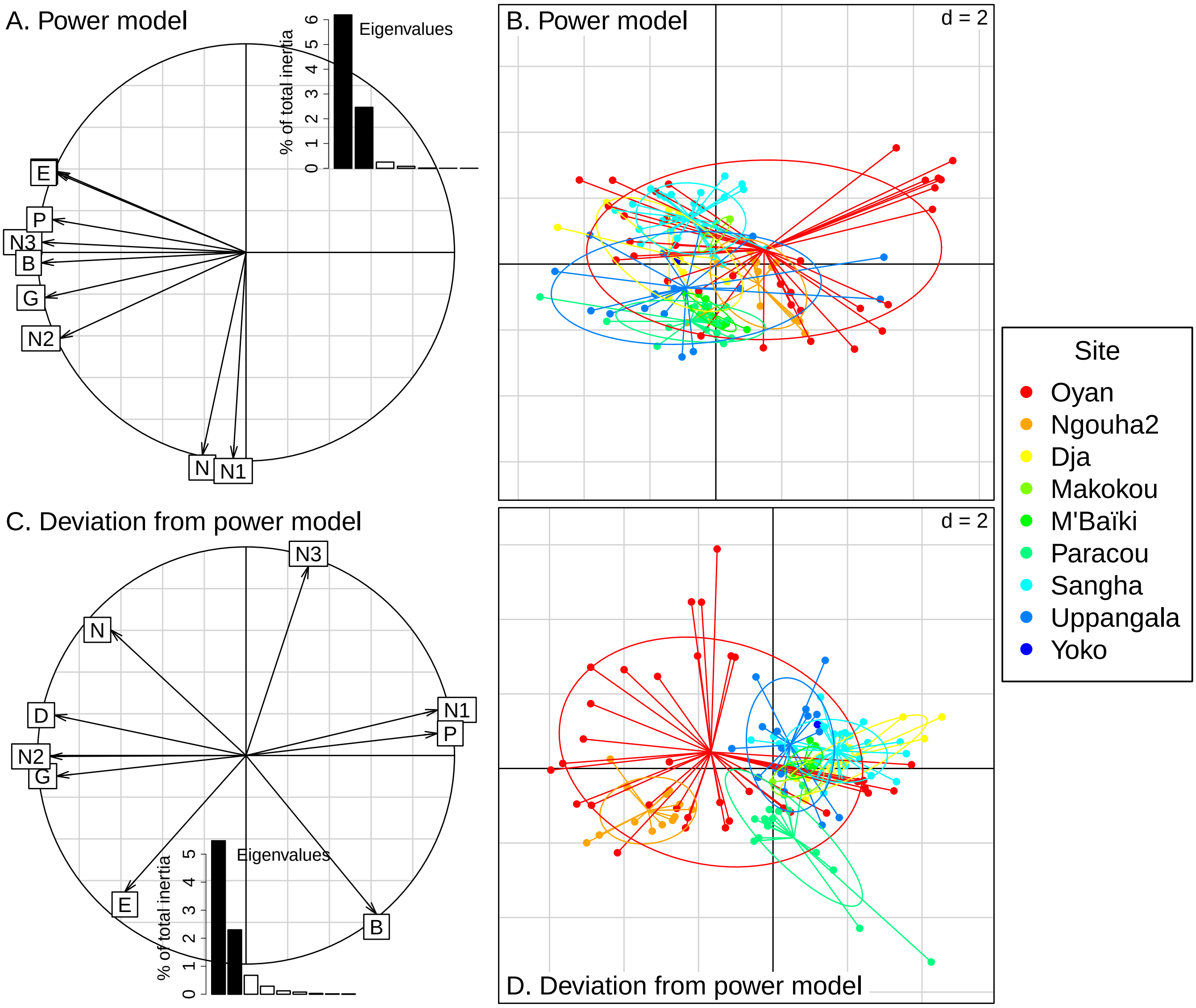

Figure S2. Principal component analysis (PCA) of structural characteristics of 133 forest plots at 9 sites. The PCA is performed either on the modeled data using the power model (A, B), or on the deviations of observations to the predictions of the power model (C, D). (A, C): correlation circle between the first two axes of the PCA and structural characteristics (N = density of trees, G = basal area, D = mean diameter, E = equivalent diameter, N_1 = density of trees with dbh < 30 cm, N_2 = density of trees with dbh in the range 30-60 cm, N_3 = density of trees with dbh ≥ 60, B = aboveground biomass, and P = proportion of biomass represented by trees with dbh ≥ 60 cm). The insets show the eigenvalues of the PCA. (B, D): projection of the forest plots on the first two axes of the PCA. Each dot corresponds to a plot with the color indicating the site. Lines and ellipses highlight the dispersion of the plots of each site.

4 ORDINATION OF PLOTS BASED ON COUNTS IN DBH CLASSES

The PCA of modeled data was similar with the power model (Figure S3A, B) than with the exponential model. The sum of the first two eigenvalues for the power model equaled 11.0. There was a significant pattern left in the deviations of observations from the power model (sum of the first two eigenvalues = 5.5, p-value < 0.001). The PCA of the deviations from the power model succeeded less well than the exponential model in separating the forest sites (Figure S3C, D).

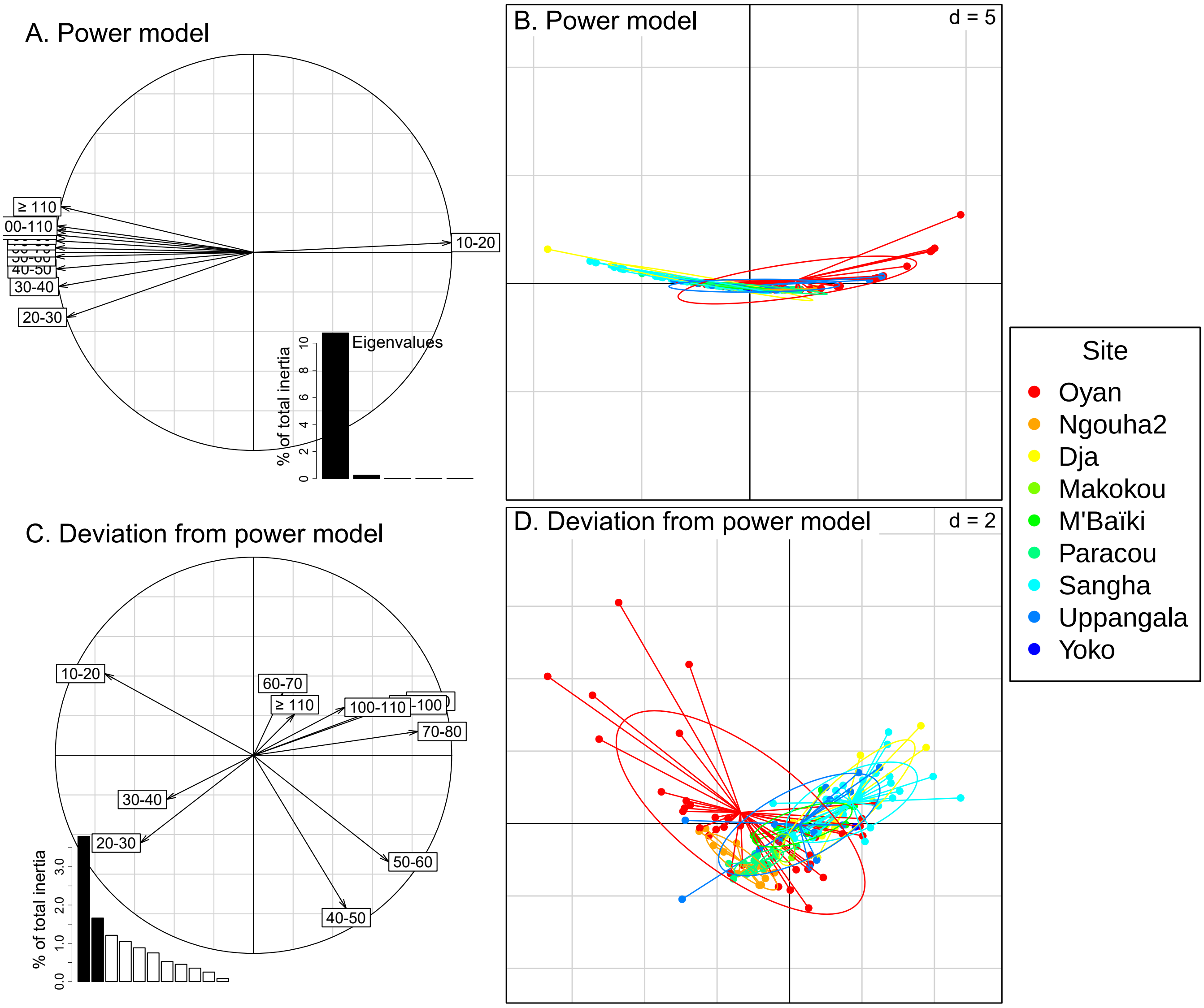

Figure S3. Principal component analysis (PCA) of the chord-transformed abundances of stems per dbh class in 133 forest plots at 9 sites. The PCA is performed either on the modeled abundances using the power model (A, B), or on the deviations of observations to the predictions of the power model (C, D). (A, C): correlation circle between the first two axes of the PCA and the chord-transformed abundances in the dbh classes (from 10-20 cm for the first dbh class to ≥ 110 cm for the 11th dbh class). The insets show the eigenvalues of the PCA. (B, D): projection of the forest plots on the first two axes of the PCA. Each dot corresponds to a plot with the color indicating the site. Lines and ellipses highlight the dispersion of the plots of each site.