Supplementary Material

Tab. S1 - Distribution of trees sampled by species harvested to fit allometric biomass equations in secondary tropical forests of the southeast Yucatán peninsula. (N): number of trees; (DBH range): range in diameter at breast height (cm); (H range): range in total tree height (m); (Class): wood density classification (H is high, I is intermediate, and L is low).

| No | Scientific name | N | DBH range (cm) | H range (m) | Biomass range (kg) | Wood density (g cm⁻³) | Class |
|----|-----------------|---|----------------|-------------|-------------------|----------------------|-------|
|    |                 |   |                |             | Stem             | Branches            | Foliage | Total-tree |                |        |
|    |                 |   |                |             | 0.22-32.12       | 0.08-19.48          | 0.01-2.34 | 0.32-47.70 | 0.80 ± 0.03 | H    |
| 1  | Lonchocarpus rugosus | 13 | 1.4 - 10       | 3.10 - 11.0 |                  |                      |         |            |                |       |
| 2  | Pouteria campechiana | 14 | 1.6 - 9.9      | 2.50 - 11.0 | 0.25-26.90       | 0.08-10.72          | 0.01-2.69 | 0.34-36.85 | 0.79 ± 0.02 | H    |
| 3  | Malmea depressa    | 13 | 1.5 - 10       | 3.10 - 10.0 | 0.23-20.65       | 0.04-9.85           | 0.05-2.51 | 0.32-32.09 | 0.78 ± 0.01 | H    |
| 4  | Pouteria unilocularis | 17 | 1.2 - 10       | 2.90 - 11.30 | 0.20-29.95       | 0.09-25.76          | 0.06-5.33 | 0.35-54.98 | 0.78 ± 0.01 | H    |
| 5  | Chrysophyllum mexicanum | 15 | 1.2 - 9.9      | 2.70 - 12.0 | 0.09-27.63       | 0.08-9.82           | 0.05-3.98 | 0.24-40.68 | 0.77 ± 0.01 | H    |
| 6  | Lonchocarpus xau    | 12 | 1.4 - 9.9      | 2.15 - 10.60| 0.06-28.04       | 0.07-17.04          | 0.04-4.51 | 0.16-46.82 | 0.76 ± 0.02 | H    |
| 7  | Psidium sartorium  | 13 | 1.3 - 9.5      | 2.80 - 13.40| 0.26-32.48       | 0.05-19.29          | 0.02-3.01 | 0.34-52.97 | 0.75 ± 0.02 | H    |
| 8  | Coccoloba diversifolia | 13 | 1.3 - 9.9      | 1.50 - 11.80| 0.08-25.92       | 0.01-15.34          | 0.02-3.55 | 0.12-40.03 | 0.74 ±0.03  | H    |
| 9  | Croton reflexiolius | 15 | 1.3 - 9.8      | 2.80 - 11.20| 0.01-28.91       | 0.06-14.12          | 0.03-3.39 | 0.11-45.58 | 0.72 ± 0.002 | H   |
| 10 | Brosimum alicastrum | 14 | 1.2 - 10       | 2.80 - 11.20| 0.16-24.21       | 0.13-12.43          | 0.09-4.21 | 0.38-40.86 | 0.71 ± 0.02 | H    |
| 11 | Dipholis salicifolia | 18 | 1.1 - 9.9      | 2.50 - 10.70| 0.11-25.12       | 0.03-18.90          | 0.04-2.23 | 0.17-37.43 | 0.69 ± 0.01 | H    |
| 12 | Luehea speciosa    | 12 | 1.4 - 10       | 2.80 - 10.40| 0.16-24.80       | 0.05-10.28          | 0.02-1.94 | 0.23-37.02 | 0.67 ± 0.02 | H    |
| 13 | Guettarda combii   | 17 | 1.2 - 10       | 2.20 - 10.40| 0.03-20.39       | 0.02-16.43          | 0.01-3.38 | 0.15-39.24 | 0.64 ± 0.01 | H    |
| 14 | Swartzia cabensis  | 14 | 1.1 - 8.9      | 2.45 - 11.0 | 0.12-21.10       | 0.04-6.80           | 0.02-1.38 | 0.23-28.11 | 0.63 ± 0.03 | H    |
| 15 | Piscidia piscipula | 15 | 1.2 - 10       | 2.20 - 10.80| 0.11-23.79       | 0.00-15.37          | 0.01-3.17 | 0.15-37.86 | 0.62 ± 0.02 | H    |
| 16 | Zuelania guidoniana | 14 | 1.1 - 10       | 2.20 - 12.20| 0.14-27.05       | 0.04-13.34          | 0.03-2.57 | 0.20-39.67 | 0.62 ± 0.01 | H    |
| 17 | Lysiloma latisiliquum | 15 | 1.3 - 10       | 2.60 - 11.20| 0.14-23.79       | 0.03-12.85          | 0.01-3.46 | 0.20-31.91 | 0.61 ± 0.02 | H    |
| 18 | Licaria campechiana | 16 | 1.4 - 9.9      | 3.20 - 9.60 | 0.19-17.78       | 0.08-19.48          | 0.09-7.86 | 0.36-42.85 | 0.61 ± 0.01 | H    |
| 19 | Vitex gaumeri      | 12 | 1.2 - 10       | 2.75 - 10.60| 0.12-20.10       | 0.02-15.17          | 0.04-5.71 | 0.17-34.05 | 0.52 ± 0.04 | I     |
| 20 | Simarouba glauca   | 14 | 1.4 - 9.8      | 2.80 - 9.90 | 0.20-16.00       | 0.03-11.06          | 0.03-2.68 | 0.20-39.67 | 0.42 ± 0.01 | I     |
| 21 | Bursera simaruba   | 13 | 1.5 - 10       | 3.10 - 10.0 | 0.16-11.95       | 0.02-3.41           | 0.03-0.99 | 0.22-14.80 | 0.29 ± 0.02 | L     |
| 22 | Cecropia peltata   | 12 | 1.1 - 9.9      | 2.20 - 9.0  | 0.04-10.90       | 0.00-6.70           | 0.01-0.84 | 0.05-16.18 | 0.25 ± 0.02 | L     |
Allometric equations to estimate above-ground biomass of small-diameter mixed tree species in secondary tropical forests

**Tab. S2** - Allometric regression models tested for estimating biomass from 22 species with high structural importance in secondary tropical forests. (AGB): above-ground biomass (kg) and can correspond to stem, branch or foliage biomass; ($\beta_0$, $\beta_1$): regression coefficients of the models to be estimated; (ln): natural logarithm function; (DBH): diameter at breast height (cm); (CF): Correction Factor; (H): total tree height (m); ($\rho$): wood density (g cm$^{-3}$) by species. We assumed that the error terms are independent and identically distributed as $\varepsilon \sim N(0,\sigma^2_e)$.

| No | Reference                  | Allometric regression model                                                                 |
|----|----------------------------|---------------------------------------------------------------------------------------------|
| 1  | Hughes et al. (1999)       | $\text{AGB} = \exp[\beta_0 + \beta_1 \ln(DBH^2)](CF/10^6)+\varepsilon_i$                |
| 2  | Ketterings et al. (2001)   | $\text{AGB} = 0.11^\beta_0 \times DBH^{2+\beta_1}+\varepsilon_i$                          |
| 3  | Cairns et al. (2003)       | $\text{AGB} = \exp[-\beta_0 + \beta_1 \ln(DBH^2)+\beta_2/2] + \varepsilon_i$            |
| 4  | Bi et al. (2004)           | $\text{AGB} = \exp[\beta_0 + \beta_1 \ln(DBH^{2})] + \varepsilon_i$                     |
| 5  | Chave et al. (2005)        | $\text{AGB} = \exp[\beta_0 + \beta_1 \ln(\rho \times DBH^{2-H})] + \varepsilon_i$         |
| 6  | Urquiza-Hass et al. (2007) | $\text{AGB} = [\beta_0 + \beta_1 \ln(DBH^{2-H})](\rho/0.72) + \varepsilon_i$            |
| 7  | Chave et al. (2014)        | $\text{AGB} = \beta_0 (\rho \times DBH^{2-H})^{\beta_1} + \varepsilon_i$                  |
| 8  | Soriano-Luna et al. (2015) | $\text{AGB} = \exp(-\beta_0)(DBH^{2-H})^{\beta_1} + \varepsilon_i$                        |
Tab. S3 - Program that can be used to fit a system of biomass estimation equations by tree structural component, stem, branches and foliage, using SAS/ETS®.

Prior to simultaneous fit, models I and II were selected from a set of models:

```plaintext
# Read the biomass_tree data
proc import out=groups.biomass datafile="direction\biomass_tree.csv" run;

# Example of simultaneous fit with model I. where B0 to B5 are regression coefficients of the parameters to be estimated, ρ is the wood density, DBH is diameter at breast height (cm), H = total tree height (m). We use the command resid.component_type to indicate the weights but with the expression included within a square root (sqrt) to correct the heteroscedasticity of the residuals, as indicated in the material and methods section (see Alvarez-Gonzalez et al. 2005). The term iv that appears in the fit command for each parameter indicates that a numerical starting value of the iterative parameter estimation procedure must be included.

proc model data=groups.biomass;
parms B0 B1 B2 B3 B4 B5;
stem=B0*(ρ*DBH**2*H)**B1;
branches=B2*(ρ*DBH**2*H)**B3;
foliage=B4*(ρ*DBH**2*H)**B5;
total=B0*(ρ*DBH**2*H)**B1+B2*(ρ*DBH**2*H)**B3+B4*(ρ*DBH**2*H)**B5;
resid.stem=resid.stem*sqrt(1/(stem+resid.stem));
resid.branches=resid.branches*sqrt(1/branches+resid.branches));
resid.foliage=resid.foliage*sqrt(1/foliage+resid.foliage));
fit stem branches foliage total start=(B0 iv B1 iv B2 iv B3 iv B4 iv B5 iv)/itsur;
out=groups.Model1_simultaneous outest=params outcov;
run;
```
Tab. S4 - Program to fit an equation to estimate the total-tree biomass under an independent approach using SAS®.

```sas
proc model data=groups.biomass;
parms B0 iv B1 iv;
DBH2=1/(DBH**2*H); # weighting function
total=B0*(ρ*DBH**2*H)**B1
fit total/breusch=(1 ρ DBH H) out=groups.Model1_independent;
weight DBH2;
run;
```
Tab. S5 – Goodness-of-fit statistics for the regression models fit to 22 tree species. (AGB): aboveground biomass (kg); (ρ): wood density (g cm⁻³); (β₀, β₁): regression coefficients of the parameters to be estimated; (DBH): diameter at breast height (cm); (H): total tree height (m); (ln): the natural logarithm function; (CF): Correction Factor; (adj-R²): proportion of variance explained by model; (AIC): the Akaike information criterion. We assume that the error terms are independent and identically distributed as ε~N(0,σ²).

| No. | Allometric model                                                                 | RMSE  | R²     | AIC    |
|-----|----------------------------------------------------------------------------------|-------|--------|--------|
| 1   | AGB=β₀(ρˣDBH²ˣH)⁰¹+ε_i                                                         | 11.35 | 0.94   | 1509.81|
| 2   | AGB=exp(-β₀)(DBH²ˣH)⁰¹+ε_i                                                     | 11.15 | 0.93   | 1511.87|
| 3   | AGB=exp[β₀+β₁ln(ρˣDBH²ˣH)]+ε_i                                                | 11.76 | 0.93   | 1520.21|
| 4   | AGB=exp[β₀+β₁ln(DBH²ˣH)]+ε_i                                                   | 13.98 | 0.92   | 1570.87|
| 5   | AGB=exp[-β₀+β₁ln(DBH²⁾+β₂/2]+ε_i                                              | 14.06 | 0.92   | 1572.56|
| 6   | AGB=exp[β₀+β₁ln(DBH²)(CF/10⁶)]+ε_i                                             | 16.64 | 0.91   | 1620.51|
| 7   | AGB=0.11×β₀ DBH²+ε_i                                                           | 17.05 | 0.91   | 1626.69|
| 8   | AGB=[β₀+β₁ln(DBH²ˣH)](ρ/0.72)+ε_i                                              | 11.56 | 0.82   | 1516.91|