**Supplementary material**

**Statistical approach to obtain the best model.**

**Legend for variables used.**

Canopy: Canopy openness

aD: Average of diameter (Tree + Palm)

aH: Average of heigh (Tree + Palm)

cvD: Coefficient of variation of diameter

cvH: Coefficient of variation of height

d\_ha: Density /hectare (Tree + Palm)

g\_ha: Basal area/hectare (Tree + Palm)

AGB: Above ground biomass

**Table S3**: Correlation among variables and selection of non collinear variables according to Borcard et al. (2011).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Canopy | *aD* | *aH* | *cvD* | *cvH* | *d\_ha* | *g\_ha* | *AGBtree* | *AGBpalm* | *AGBshrub* | *AGBT* | GVIF | *Selected* | final GVIF |
| Canopy | 1.00 |  |  |  |  |  |  |  |  |  |  | 4.93E+00 | Canopy | 3.41027 |
| aD | 0.13 | 1.00 |  |  |  |  |  |  |  |  |  | *2.26E+00* | aD | 1.542466 |
| aH | -0.28 | 0.04 | 1.00 |  |  |  |  |  |  |  |  | 9.90E+00 |  |  |
| cvD | -0.42 | 0.12 | 0.26 | 1.00 |  |  |  |  |  |  |  | 1.23E+01 | cvD | 1.669949 |
| cvH | 0.08 | -0.05 | **0.72** | 0.02 | 1.00 |  |  |  |  |  |  | 3.33E+00 | cvH | 2.990595 |
| d\_ha | -0.23 | -0.44 | 0.07 | -0.06 | 0.11 | 1.00 |  |  |  |  |  | 3.72E+00 | d\_ha | 2.512646 |
| g\_ha | -0.70 | 0.16 | 0.56 | **0.75** | 0.20 | 0.01 | 1.00 |  |  |  |  | 8.01E+01 |  |  |
| AGBtree | -0.41 | -0.11 | **0.78** | 0.40 | 0.65 | 0.44 | 0.62 | 1.00 |  |  |  | 1.45E+09 | AGBtree | 4.779901 |
| AGBpalm | -0.39 | 0.44 | 0.38 | 0.26 | 0.05 | -0.50 | 0.64 | 0.05 | 1.00 |  |  | 5.33E+08 | AGBpalm | 2.713494 |
| AGBshrub | -0.48 | -0.18 | -0.17 | 0.16 | -0.37 | 0.15 | 0.25 | -0.09 | 0.00 | 1.00 |  | 3.35E+08 | AGBshrub | 1.666453 |
| AGBT | -0.70 | 0.06 | **0.75** | 0.50 | 0.40 | 0.17 | **0.90** | **0.79** | 0.52 | 0.31 | 1.00 | 2.28E+09 |  |  |

**Butterfly Richness**

*Formula after collinearity cleaning*

glm(Richness ~ Canopy + aD + cvD + cvH + d\_ha + AGBtree + AGBpalm + AGBshrub, family = poisson, data=data)

**Table S4**: Full generalized linear model and linear mixed-effect models output of the butterfly richness.

|  |  |  |
| --- | --- | --- |
| Full model | Weight | AIC |
| Richness ~ Canopy + aD + cvD + cvH + d\_ha + AGBtree + AGBpalm + AGBshrub | - | 131 |
| Richness ~ Canopy + aD + cvD + cvH + d\_ha + AGBtree + AGBpalm + AGBshrub | Plot | 133 |
| Richness ~ Canopy + aD + cvD + cvH + d\_ha + AGBtree + AGBpalm + AGBshrub | fCanopy | 133 |

f Canopy: A categoric variable for canopy openness grouping class<28% or >28%.

**Table S5**: Full generalized linear model output of the butterfly richness and coefficients contributions.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Estimate | Std. | Error | z | value | Pr(>|z|) |
| (Intercept) | 1.89E+00 | 6.70E-01 | 2.819 | 0.00481 | \*\* |
| Canopy | 1.50E-02 | 7.97E-03 | 1.882 | 0.05982 | . |
| aD | 7.31E-03 | 1.81E-02 | 0.404 | 0.68593 |  |
| cvD | 3.07E-03 | 4.68E-03 | 0.656 | 0.51168 |  |
| cvH | 8.86E-03 | 1.00E-02 | 0.882 | 0.37772 |  |
| d\_ha | 2.64E-04 | 5.31E-04 | 0.497 | 0.61906 |  |
| AGBtree | -6.50E-04 | 1.31E-03 | -0.497 | 0.6194 |  |
| AGBpalm | 1.21E-05 | 1.59E-03 | 0.008 | 0.99396 |  |
| AGBshrub | 1.88E-03 | 1.64E-03 | 1.147 | 0.25132 |  |
| Null deviance: 30.9 on 18 degrees of freedom | | | | | |
| Residual deviance: 21.0 on 10 degrees of freedom | | | | | |
| Overdispersion = 2.1. | | | | | |
| AIC: 131.3 (r2 = 0.3) | | | | | |

**Table S6**: Reduced generalized linear model output of the butterfly richness after drop.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Coefficients | Estimate | Std. | Error | Value | Pr(>|z|) |
| (Intercept) | 2.733863 | 0.128309 | 21.307 | <0.001 | \*\*\* |
| Canopy | 0.011787 | 0.004258 | 2.768 | 0.00563 | \*\* |
| Null deviance: 30.90 on 18 degrees of freedom | | | | | |
| Residual deviance: 23.56 on 17 degrees of freedom | | | | | |
| AIC: 119.86 | | | | | |
| Overdispersion =1.39 | | | | | |
| r2 = 0.24 | | | | |  |

**Butterfly Richness (Margalef index)**

*Formula after collinearity cleaning*

lm(d ~ Canopy + aD + cvD + cvH + d\_ha + AGBtree + AGBpalm + AGBshrub)

**Table S7**: Full linear model output of the butterfly richness via Margalef index.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Estimate | Std. | Error | t | Pr(>|t|) |
| (Intercept) | -0.08534 | 3.112935 | -0.027 | 0.979 |
| Canopy | 0.026417 | 0.036169 | 0.73 | 0.482 |
| aD | 0.052685 | 0.079716 | 0.661 | 0.524 |
| cvD | 0.026246 | 0.021664 | 1.212 | 0.254 |
| cvH | 0.032128 | 0.046241 | 0.695 | 0.503 |
| d\_ha | 0.001386 | 0.002472 | 0.561 | 0.587 |
| AGBtree | -0.00323 | 0.005873 | -0.55 | 0.594 |
| AGBpalm | -0.00256 | 0.00722 | -0.354 | 0.73 |
| AGBshrub | 0.005462 | 0.007273 | 0.751 | 0.47 |
| Residual standard error: 1.012 on 10 degrees of freedom | | | | |
| AIC = 62.19 | | | | |
| r2 = -0.3145 | | | | |

**Butterfly Abundance**

*Formula after collinearity cleaning*

glm(abundance ~ Canopy + aD + cvD + cvH + d\_ha + AGBtree + AGBpalm + AGBshrub, family = poisson)

**Table S8**: Generalized linear model output of butterfly abundance and vegetation structure. Overdispersion higher than 60 suggest the use of a negative binomial family.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Estimate | Std. | Error | z | Pr(>|z|) |
| (Intercept) | 4.390351 | 0.292058 | 15.032 | 2.00E-16 | \*\*\* |
| Canopy | 0.044741 | 0.003894 | 11.49 | 2.00E-16 | \*\*\* |
| aD | -0.01718 | 0.008627 | -1.992 | 0.04641 | \* |
| cvD | -0.01902 | 0.0021 | -9.056 | 2.00E-16 | \*\*\* |
| cvH | 0.003353 | 0.004349 | 0.771 | 0.44069 |  |
| d\_ha | -0.00037 | 0.000233 | -1.592 | 0.1115 |  |
| AGBtree | 0.001913 | 0.000588 | 3.251 | 0.00115 | \*\* |
| AGBpalm | 0.003027 | 0.000732 | 4.137 | 3.51E-05 | \*\*\* |
| AGBshrub | 0.002246 | 0.000786 | 2.859 | 0.00425 | \*\* |
| Null deviance: 1160.06 on 18 degrees of freedom | | | | | |
| Residual deviance: 343.83 on 10 degrees of freedom | | | | | |
| AIC: 483.5 | | | | | |
| Overdispersion = 64 | | | | | |

*Formula after overdispersion correction*

glm.nb(d ~ Canopy + aD + cvD + cvH + d\_ha + AGBtree + AGBpalm + AGBshrub, data=data)

**Table S9**: Full negative binomial generalized linear model output of butterfly abundance response to the vegetation structure.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Estimate | Std. | Error | z | value | Pr(>|z|) |
| (Intercept) | 4.339133 | 1.2617 | 3.439 | 0.000584 | \*\*\* |
| Canopy | 0.046612 | 0.014762 | 3.157 | 0.001591 | \*\* |
| aD | -0.03469 | 0.032771 | -1.059 | 0.289739 |  |
| cvD | -0.01682 | 0.00883 | -1.905 | 0.056763 | . |
| cvH | 0.011606 | 0.018734 | 0.62 | 0.535563 |  |
| d\_ha | -0.0004 | 0.001003 | -0.4 | 0.689144 |  |
| AGBtree | 0.000886 | 0.002393 | 0.37 | 0.711282 |  |
| AGBpalm | 0.003275 | 0.002931 | 1.117 | 0.263878 |  |
| AGBshrub | 0.003283 | 0.00297 | 1.105 | 0.269037 |  |
| Null deviance: 56.788 on 18 degrees of freedom | | | | | |
| Residual deviance: 19.444 on 10 degrees of freedom | | | | | |
| AIC: 214.72 | | | | | |
| Theta: 6.33 | | | | | |
| Std. Err.: 2.15 | | | | | |
| r2 = 0.60 | | | | | |

**Table S10**: Reduced negative binomial generalized linear model output of butterfly abundance response to the vegetation structure.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Estimate | Std. | Error | z | Pr(>|z|) |
| (Intercept) | 4.892087 | 0.665553 | 7.35 | 1.98E-13 | \*\*\* |
| Canopy | 0.03094 | 0.010513 | 2.943 | 0.00325 | \*\* |
| cvD | -0.017509 | 0.008498 | -2.06 | 0.03936 | \* |
| Null deviance: 44.091 on 18 degrees of freedom | | | | | |
| Residual deviance: 19.630 on 16 degrees of freedom | | | | | |
| AIC: 207.78 | | | | | |
| Theta: 4.85 | | | | | |
| Std. Err.: 1.61 | | | | | |
| r2 = 0.55 | | | | | |

**Butterfly Diversity**

*Formula after collinearity cleaning*

lm(H ~ Canopy + aD + cvD + cvH + d\_ha + AGBtree + AGBpalm + AGBshrub, data=data)

**Table S11**: Full linear model output of the butterfly diversity response to vegetation structure.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Estimate | Std. | Error | t | Pr(>|t|) |
| (Intercept) | 6.54E-01 | 9.96E-01 | 0.657 | 0.525 |
| Canopy | 1.14E-02 | 1.03E-02 | 1.103 | 0.293 |
| aD | 1.63E-02 | 2.53E-02 | 0.645 | 0.532 |
| cvD | 1.33E-02 | 7.23E-03 | 1.839 | 0.093 |
| cvH | 7.98E-03 | 1.53E-02 | 0.52 | 0.613 |
| d\_ha | 1.11E-04 | 8.26E-04 | 0.134 | 0.896 |
| AGBtree | -6.12E-04 | 1.94E-03 | -0.316 | 0.758 |
| AGBpalm | -9.16E-05 | 2.41E-03 | -0.038 | 0.97 |
| AGBshrub | 2.88E-04 | 2.38E-03 | 0.121 | 0.906 |
| Residual standard error: 0.3385 on 11 degrees of freedom | | | | |
| AIC =21.47 | | | | |
| r2 = -0.03679 | | | | |

**Table S12**: Full generalized additive model and generalized additive mixed model output of the butterfly diversity.

|  |  |  |
| --- | --- | --- |
| Full model | Weight | AIC |
| H ~ Canopy + aD + cvD + cvH + d\_ha + AGBtree + AGBpalm + AGBshrub | - | -36.87 |
| H ~ Canopy + aD + cvD + cvH + d\_ha + AGBtree + AGBpalm + AGBshrub | Plot | 22.49 |
| H ~ Canopy + aD + cvD + cvH + d\_ha + AGBtree + AGBpalm + AGBshrub | fCanopy | 29.10 |

**Table S13**: Full generalized additive model output of the butterfly diversity and coefficient contributions.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | edf | Ref.df | F | p-value |
| s(Canopy) | 7.86E-01 | 3 | 1.217 | **0.028742** |
| s(aD) | 1.15E+00 | 3 | 6.921 | **0.002761** |
| s(cvD) | 3.00E+00 | 3 | 16.18 | **0.00132** |
| s(cvH) | 2.85E+00 | 3 | 8.474 | **0.010111** |
| s(d\_ha) | 2.61E+00 | 3 | 34.244 | **0.000175** |
| s(AGBtree) | 2.62E+00 | 3 | 14.736 | **0.001641** |
| s(AGBpalm) | 3.18E-09 | 3 | 0 | 0.893249 |
| s(AGBshrub) | 7.68E-10 | 3 | 0 | 0.8878 |
| r2 = 0.94 | | | | |

Gráfico de dispersão

Descrição gerada automaticamente

**Figure S1**: Relation of canopy openness (bubbles=canopy openness) and tree density with the Shannon-Wiener Index.