**Supplementary Information 1:** Plot information including plot codes and area, forest ages and census intervals, and weights attributed to each plot. The weights correspond to the ((cubic root of plot area) + (cubic root of census interval) – 1).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **PlotCode** | **Forest sucessional interval yr** | **Initial census** | **Final census** | **Census interval (yr)** | **Census weight** | **Plot area (ha)** | **Plot weight** |
| 104 | >50 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| 110 | 26-50 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| 1537 | >50 | 2000 | 2009 | 9 | 2.08 | 1 | 1 |
| 1538 | 26-50 | 2000 | 2009 | 9 | 2.08 | 1 | 1 |
| 1539 | >50 | 2000 | 2009 | 9 | 2.08 | 1 | 1 |
| 1540 | >50 | 2000 | 2009 | 9 | 2.08 | 1 | 1 |
| 1541 | >50 | 2000 | 2009 | 9 | 2.08 | 1 | 1 |
| 1542 | 26-50 | 2000 | 2009 | 9 | 2.08 | 1 | 1 |
| 1543 | >50 | 2000 | 2009 | 9 | 2.08 | 1 | 1 |
| 1544 | >50 | 2000 | 2009 | 9 | 2.08 | 1 | 1 |
| 1545 | >50 | 2000 | 2009 | 9 | 2.08 | 1 | 1 |
| 1546 | >50 | 2000 | 2009 | 9 | 2.08 | 1 | 1 |
| 157FL | 26-50 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| 158FL | 26-50 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| 162 | 26-50 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| 25Carbono | >50 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| 36 | 15-25 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| 41MFL | 15-25 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| 80 | 26-50 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| 86 | 26-50 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| AR03 | 15-25 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| av1 | 26-50 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| av2 | 26-50 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| av3 | 26-50 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| BJS | >50 | 2012 | 2016 | 4 | 1.59 | 1 | 1 |
| CA | >50 | 2013 | 2017 | 4 | 1.59 | 1 | 1 |
| CA2A | 15-25 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| CA2M | 26-50 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| CAA3 | 15-25 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| CAF2 | >50 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| CAF3 | >50 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| ENN-01 | >50 | 2014 | 2020 | 6 | 1.82 | 0.12 | 0.49 |
| ENN-02 | >50 | 2014 | 2019 | 6 | 1.79 | 0.12 | 0.49 |
| Epagri | >50 | 2011 | 2015 | 4 | 1.59 | 1 | 1 |
| EW-10 | >50 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| EW31 | 15-25 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| FNC-01 | >50 | 2012 | 2017 | 6 | 1.79 | 1.2 | 1.06 |
| GL1A | 15-25 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| GL3A | 15-25 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| GL3M | 15-25 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| LIX01 | 15-25 | 2010 | 2016 | 6 | 1.82 | 0.06 | 0.39 |
| MFO-01 | >50 | 2014 | 2020 | 6 | 1.83 | 0.12 | 0.49 |
| MN | >50 | 2015 | 2019 | 4 | 1.59 | 1 | 1 |
| Painel | 26-50 | 2014 | 2018 | 4 | 1.59 | 1 | 1 |
| Parnamul | >50 | 2015 | 2019 | 4 | 1.59 | 1 | 1 |
| PB1 | >50 | 2012 | 2016 | 4 | 1.59 | 1 | 1 |
| PB2 | >50 | 2012 | 2016 | 4 | 1.59 | 1 | 1 |
| PNA-01 | >50 | 2014 | 2019 | 6 | 1.78 | 0.12 | 0.49 |
| PNA-02 | >50 | 2014 | 2019 | 6 | 1.77 | 0.12 | 0.49 |
| PNA-03 | >50 | 2014 | 2019 | 6 | 1.78 | 0.12 | 0.49 |
| PRM-01 | >50 | 2014 | 2019 | 5 | 1.76 | 0.12 | 0.49 |
| PRM-02 | >50 | 2014 | 2019 | 5 | 1.76 | 0.12 | 0.49 |
| PRM-03 | >50 | 2014 | 2019 | 5 | 1.74 | 0.12 | 0.49 |
| PSJ2 | 15-25 | 2016 | 2020 | 4 | 1.59 | 0.2 | 0.58 |
| vargem | >50 | 2014 | 2015 | 1 | 1 | 0.96 | 0.99 |

**Supplementary Information 2:** Extended material and methods

*1 Study area and vegetation data*

Concerning the vegetation data, the mean sampled area across 55 plots is 0.36 ha. All plots had at least two censuses across time, and the mean census interval is six years. The vegetation data collection followed the RAINFOR protocols (Phillips et al. 2001).

*2 Carbon estimation*

The equation used to estimate individual biomass is the following (Chave et al. 2014):

Individual biomass = 0.0673 (WD dbh2 H)0.976, where H represents the individual tree height (m), and WD represents the wood density of the species (g cm-3). For the palm *Euterpe edulis*, we tested the relationship of this equation and the species-specific equation provided in Uller et al. 2021 (<https://doi.org/10.1139/cjfr-2020-0215>), which had a correlation of 0.98. Therefore, we used the Chave et al. 2014 equation for all species. Wood density information was obtained from regional (Missio et al. 2017; Oliveira et al. 2019), and global databases (Chave et al. 2009; Zanne et al. 2009). All biomass values were converted into carbon values by multiplying by 0.456 (Martin et al. 2018).

To obtain above-ground wood productivity and carbon loss through mortality, we used the equations 3 and 4 recommended by (Kohyama et al. 2019), see below:

Equation to obtain AGWP

 Equation to obtain carbon loss

Where: T: census interval; B0: total biomass at time t = 0; BT: total biomass at t = T; Bs0: initial biomass at t = 0 for survivors over t = 0 to T.

*3 Biodiversity metrics*

*3.1 Taxonomic diversity*

Taxonomic diversity or species diversity is calculated by considering species abundance distribution in a community (a forest plot, for instance). A common index used to represent taxonomic diversity is the Simpson Index (or Inverse Simpson index), which is sensitive to the dominant species in the community (Magurran and McGill 2010). We selected the Inverse Gini-Simpson index as a taxonomic diversity metric as it is closely related to Rao’s quadratic entropy (Botta‐Dukát 2005).

*3.2 Functional diversity*

Functional traits correspond to morpho-physio-phenological features that influence species fitness (Violle et al. 2007). Their effect may also be scaled-up to community levels, due to functional diversity (FD) metrics, such as Rao’s quadratic entropy (Botta‐Dukát 2005).

Functional diversity often corresponds to the value and range of functional traits of the species present in a community, weighting by their abundance, and represents the niche complementarity hypothesis (Diaz and Cabido 2001). According to this hypothesis, the greater niche complementarity in or across communities provides a better use of resources among coexisting species.

*3.3 Phylogenetic diversity*

Phylogenetic diversity quantifies the diversity of evolutionary lineages in or across communities and is associated with species differences across evolutionary history. For instance, the Mean Pairwise Distance (MPD) is a metric used to quantify phylogenetic dissimilarity among coexisting species (Tucker et al. 2017). Therefore, by assessing the pairwise distance across a group of taxa this metric provides information on the phylogenetic diversity of communities.

*Functions and packages used to conduct data analysis*

1. Above-ground biomass estimation: *AGBChv14* function, available at BiomasaFP package (Sullivan et al. 2020).
2. Taxonomic diversity: This variable was estimated by using the function *diversity*, index = “inv”, from vegan package (Oksanen et al. 2019), and by using a community matrix described by stem density per plot.
3. Functional diversity: We calculated FD (i.e., Rao's quadratic entropy) with the *dbFD* function from FD package (Laliberté et al. 2015), and by using a community matrix described by stem density per plot.
4. Phylogenetic tree construction: *V*.*PhyloMaker* package (Jin and Qian 2019).
5. Phylogenetic diversity: We calculated PD by using the *mpd* function from picante package (Kembel et al. 2010), and a community matrix described by stem density per plot.
6. Linear Mixed Models: *lme* function from nlme package (Pinheiro et al. 2020).
7. Data standardization: function *decostand*, “standardize” method, vegan package (Oksanen et al. 2019).
8. Original data availability: Part of the original data can be requested at ForestPlots.net database (Lopez-Gonzalez et al. 2011; ForestPlots et al. 2021).

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**Supplementary Information 3:** Tree functional traits and ecological function in forest communities

The leaf functional traits were collected by the Plant Ecology Labs (Universidade Federal do Rio Grande do Sul and Universidade Federal do Paraná, Brazil), and Forestry Department (Universidade do Estado de Santa Catarina, Brazil). These data are also available at TRY database, and can be accessed under formal request (Kattge et al. 2020). All data collection followed the standardised protocol developed by Pérez-Harguindeguy et al. (2013), considering the following collection procedures for leaf traits: at least five leaves per plant (to obtain the individual mean), and at least three individuals per species (to obtain species trait value). The leaf area values were calculated from scanned fresh leaves. All simple leaves selected were measured including petioles, and compound leaves had just the leaflet area measured, without rachis. Wood density collection also followed the standardized protocol (Pérez-Harguindeguy et al. 2013), and species values were obtained from plot (Missio et al. 2017) and regional level (Oliveira et al. 2019), and global databases (Zanne et al. 2009; Chave et al. 2014).

|  |  |  |
| --- | --- | --- |
| Functional trait | Ecological function | Reference |
|  |  |  |
| Specific Leaf Area (SLA, cm²/g) | Photosynthetic assimilation; low-cost construction | (Westoby 1998; Poorter et al. 2008) |
| Leaf Dry Matter Content (LDMC, mg/g) | Leaf longevity, forest productivity | (Fortunel et al. 2009; Smart et al. 2017) |
|  |  |  |
| Maximum Height (Hmax, m) | Competitive ability to achieve light resources | (Westoby 1998) |
| Wood Density (WD, g/cm³) | Hydraulic conductance, stem structures, longevity of carbon stocks | (Poorter et al. 2008; Chave et al. 2009)  |

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**Supplementary Information 4:** Diagnosis of the effect of plot size and census interval in forest net carbon change estimate, therefore needing to account these variables as weights in the models.





**Supplementary Information 5**: Results of the generalised least square models among response variable (net carbon change) and predictors (taxonomic, FD, and PD) interacting with forest age. FD = functional diversity; PD = phylogenetic diversity

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Net carbon change ~ (taxonomic + FD + PD) \* interval |  |  |  |  |
|  | Estimate | Std. Error | t value | Pr(>|t|) |
| (Intercept) | 1.83 | 0.55 | 3.33 | 0.00 |
| taxonomic | -0.81 | 0.39 | -2.10 | 0.04 |
| FD | 0.81 | 0.42 | 1.92 | 0.06 |
| PD | -0.53 | 0.76 | -0.70 | 0.49 |
| interval15-25 | 1.27 | 1.44 | 0.88 | 0.38 |
| interval26-50 | 0.64 | 0.79 | 0.81 | 0.42 |
| taxonomic:interval15-25 | 0.02 | 1.30 | 0.02 | 0.99 |
| taxonomic:interval26-50 | 1.20 | 0.83 | 1.46 | 0.15 |
| FD:interval15-25 | 1.66 | 2.17 | 0.77 | 0.45 |
| FD:interval26-50 | -1.70 | 0.82 | -2.08 | 0.04 |
| PD:interval15-25 | -0.12 | 0.99 | -0.12 | 0.91 |
| PD:interval26-50 | 0.82 | 0.91 | 0.90 | 0.37 |
| --- |  |  |  |  |
| Residual standard error: 1.47 on 43 degrees of freedom |  |  |  |  |

**Supplementary Information 6:** Comparison of above-ground wood productivity and carbon loss through mortality in different forest ages across subtropical Brazilian Atlantic Forest.



