Supporting Information

Contrasting growth trajectories but convergent size-dependent survival of enrichment-planted seedlings in logged and old-growth forests

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1 Climber cutting

Three of the Sabah Biodiversity Experiment plots included in this study received a complete climber cutting treatment as part of a different experiment (plots numbered 5, 11 and 14), where all lianas $\geq$ 10 cm in height were cut at the base in 2011 and 2014. [1]

Including the climber cutting treatment as a fixed effect in our growth and survival models did not change our results.

[1] O'Brien, M. J. et al. Positive effects of liana cutting on seedlings are reduced during El Niño-induced drought. Journal of Applied Ecology 56, 891–901 (2019). doi: 10.1111/1365-2664.13335

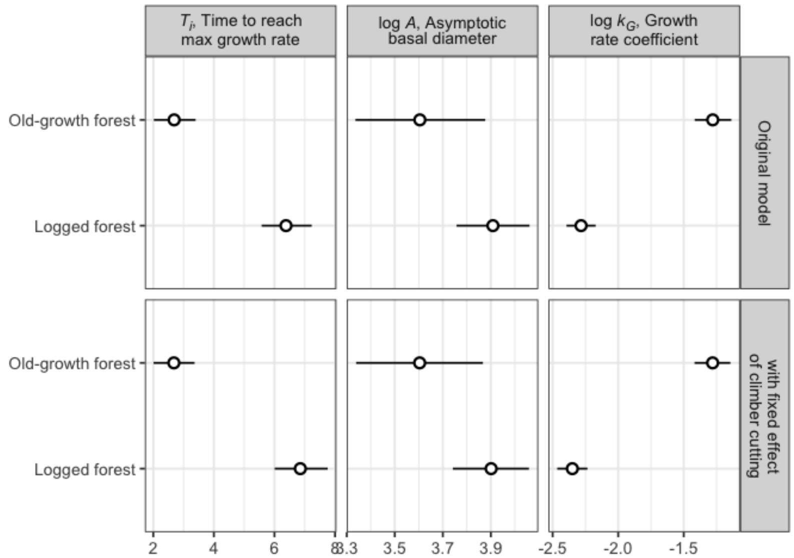

Figure 1: Comparison of parameter estimates for the growth model with and without a fixed effect of climber cutting. Facet columns indicate the parameters of the growth function with estimates for the old-growth and logged forest types on the y axis. Facet rows show results from the original model presented in the main text, and a model with the addition of a fixed effect for climber cutting treatment. Point shows the median of the posterior distribution with lines dentoting the 95% credible interval.

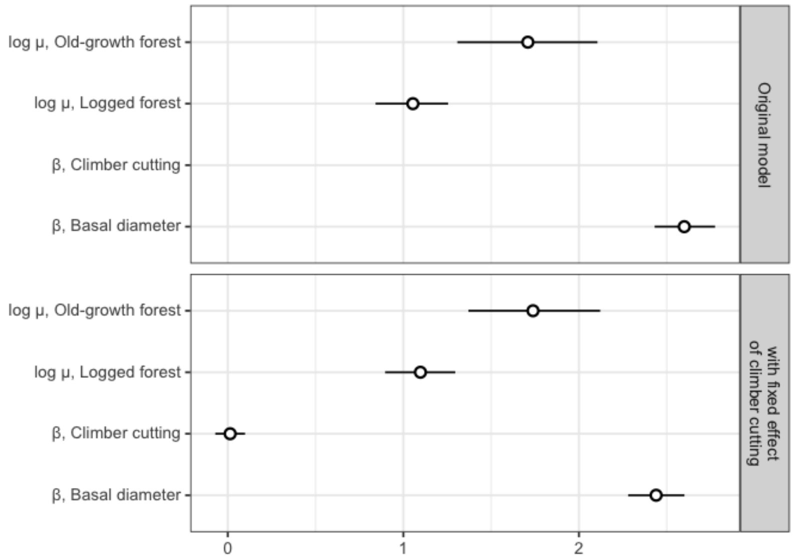

Figure 2: Comparison of parameters from survival models with and without a fixed effect of climber cutting. Facet rows show results from the original model presented in the main text, and a model with the addition of a fixed effect for climber cutting treatment. Point shows the median of the posterior distribution with lines dentoting the 95% credible interval.

2 Species taxonomy

In the main text we use species names which are consistent with prior publications involving the Sabah Biodiversity Experiment. Here, we list the current accepted names for reference. Species names were matched to a static copy of The World Flora Online (WFO) v.2024.12 zenodo.14538251 using the function `WFO.match` from the R package {WorldFlora}. The function `WFO.one` was then used to find one unique matching name for each submitted name. using the argument `priority = "Accepted"`, it first limits candidates to accepted names, with a possible second step of eliminating accepted names that are synonyms.

Table 1: Taxonomy of species included in the study

Original name	New accepted name	WFO ID	Authorship
Dipterocarpus conformis	Dipterocarpus conformis	wfo-0000651311	Slooten
Dryobalanops lanceolata	Dryobalanops lanceolata	wfo-0000657521	Burck

Original name	New accepted name	WFO ID	Authorship
Hopea sangal	Hopea sangal	wfo-0000724645	Korth.
Parashorea malaanonan	Parashorea malaanonan	wfo-0000396696	(Blanco) Merr.
Parashorea tomentella	Parashorea tomentella	wfo-0000396691	(Symington) Meijer
Shorea argentifolia	Rubroshorea argentifolia	wfo-1000050969	(Symington) P.S.Ashton & J.Heck.
Shorea beccariana	Rubroshorea beccariana	wfo-1000050992	(Burck) P.S.Ashton & J.Heck.
Shorea faguetiana	Richetia faguetiana	wfo-1000051017	(F.Heim) P.S.Ashton & J.Heck.
Shorea gibbosa	Richetia gibbosa	wfo-1000051019	(Brandis) P.S.Ashton & J.Heck.
Shorea johorensis	Rubroshorea johorensis	wfo-1000050945	(Foxw.) P.S.Ashton & J.Heck.
Shorea leprosula	Rubroshorea leprosula	wfo-1000050975	(Miq.) P.S.Ashton & J.Heck.
Shorea macrophylla	Rubroshorea macrophylla	wfo-1000050993	(de Vriese) P.S.Ashton & J.Heck.
Shorea macroptera	Rubroshorea macroptera	wfo-1000050964	(Dyer) P.S.Ashton & J.Heck.
Shorea ovalis	Rubroshorea ovalis	wfo-1000051055	(Korth.) P.S.Ashton & J.Heck.
Shorea parvifolia	Rubroshorea ovata	wfo-1000050977	(Dyer ex Brandis) P.S.Ashton & J.Heck.

3 Survival analysis of logged forest seedlings in their first census

57% of all individuals were never recorded as alive (5,868 out of 10,272) i.e., they died in the period between planting and their first census. This occurs exclusively in the logged forest since unlike in the old-growth forest, diameter measurements were not taken at the time of planting.

We excluded these individuals from the main analysis since they lack data both on size and exact age, hence the seedlings cannot be directly compared. For the first cohort of seedlings planted into the logged forest, between 18 and 20 months elapsed between planting and censusing, in that time 70% of seedlings died (5,034 out of 7,222). For the second cohort (replacing dead seedlings from cohort one), between 7 and 28 months elapsed between planting and censusing, and 30% died (834 out of 2,746).

Nevertheless, this data might provide some insight on which species are more likely to survive over these time periods, and we present a simple analysis here.

Survival of seedlings from cohort one and two were assessed in separate models with identical formulae. We fit the models in the `R` package `brms` with a Bernoulli response distribution, where zero indicated the seedling was dead in it's first census and one indicated it was alive. The predictor was a fixed effect of species. We use a regularising prior of `normal(0, 2)`, a common choice for Bernoulli models. Results are presented in Figure 3 and Figure 4.

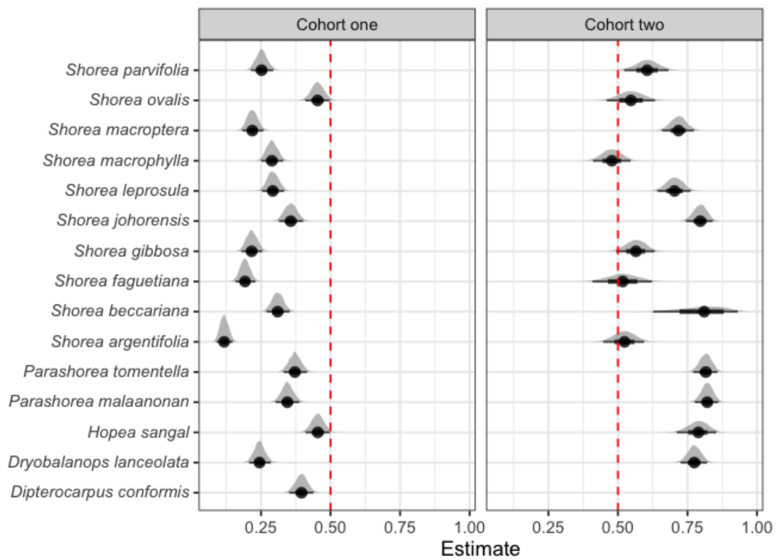

Figure 3: Posterior estimates of survival probability in the time period between planting and the first census of cohort one and two seedlings in the logged forest. The posterior median is represented by a point with the line showing the 66% and 95% credible interval. The dashed red line shows where the likelihood of survival is 50%. No *Dipterocarpus conformis* seedlings were planted in the second cohort due to insufficient avalibility.

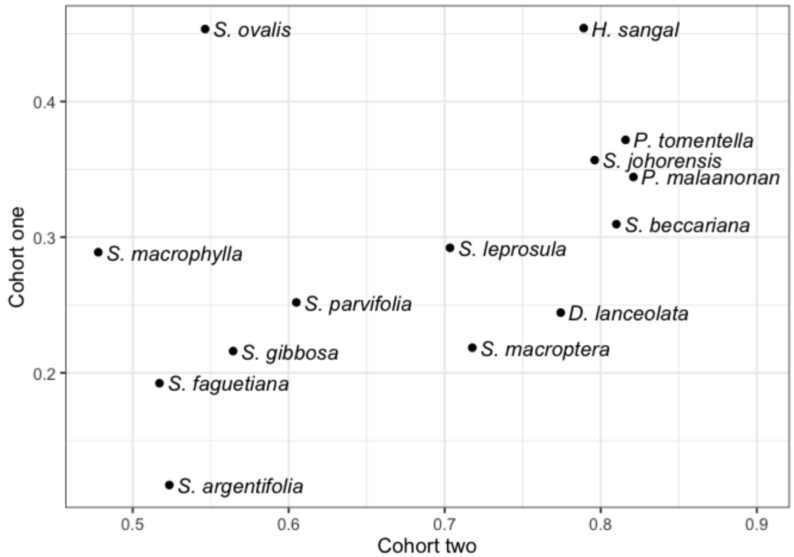

Figure 4: Median posterior estimates of survival probability for seedlings in cohort one (y axis) and two (x axis) in the time period between planting and their first census.

4 Estimating missing values of basal diameter

There are 190 missing values of basal diameter in our data (0.73% of all records for living trees). For these missing values, we estimated basal diameter from diameter at breast height using a known allometric equation, [2]

$$d_{h2} = \frac{D_{h1}}{exp(b_1 h1 - h2)}$$

where d_{h2} is the estimated diameter (mm) at height h_2 (m), D_{h1} is the known diameter (mm) at height h_1 (m), and b_1 is a taper parameter.

We chose the value for our taper parameter $b_1 = 3.91$ by optimising on trees where we had diameter measurements both at the base and at breast height, to find the value which gave the lowest Root Mean Squared Error.

[2]Cushman, K. C. et al. Improving estimates of biomass change in buttressed trees using tree taper models. Methods in Ecology and Evolution 5, 573–582 (2014). doi: 10.1111/2041-210X.12187

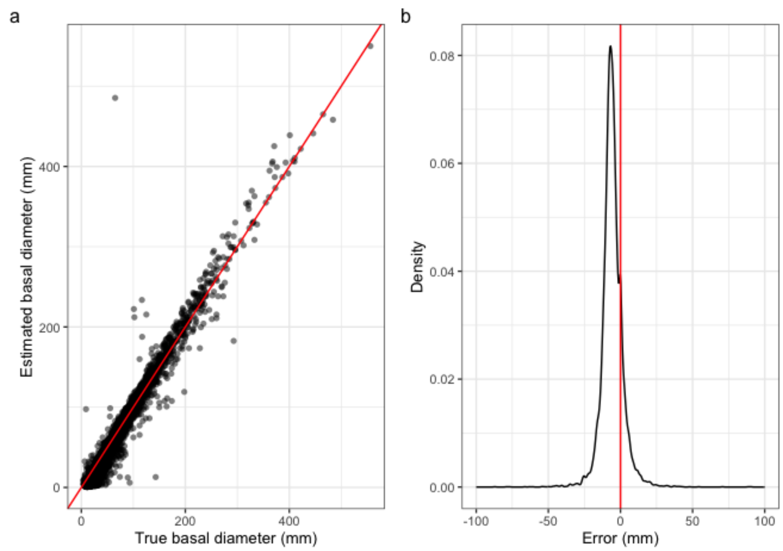

Figure 5: In (a), estimated values of basal diameter are plotted against their true values. The red line indicates where the estimate is equal to the true value. (b) Shows the distribution of the error around zero (red line).

5 Prior choice

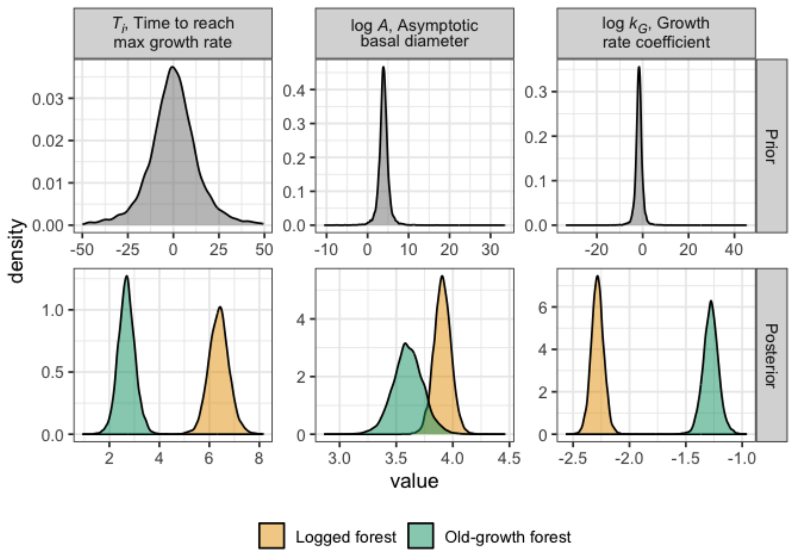

Figure 6: Prior and posterior distributions for the growth model on the link scale. Facet columns indicate parameters estimated by the model. Facet rows indicate the prior and posterior distributions. Note that the same priors were set for both forest types, and that axes are not preserved across panels.

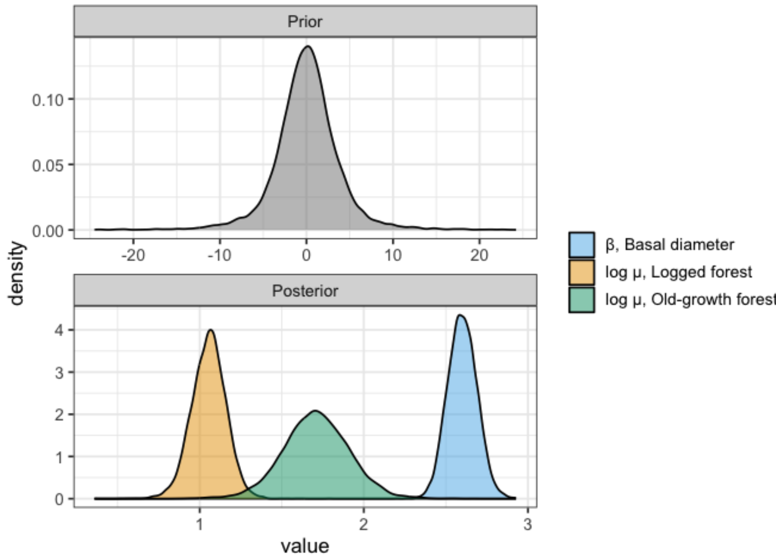

Figure 7: Prior and posterior distributions for the survival model on the link scale. Prior and posterior distributions are displayed in separate panels and colours indicate parameters estimated by the model. Note that the same prior was set across all the population-level parameters, and that axes are not preserved across panels.

6 Growth curves over time

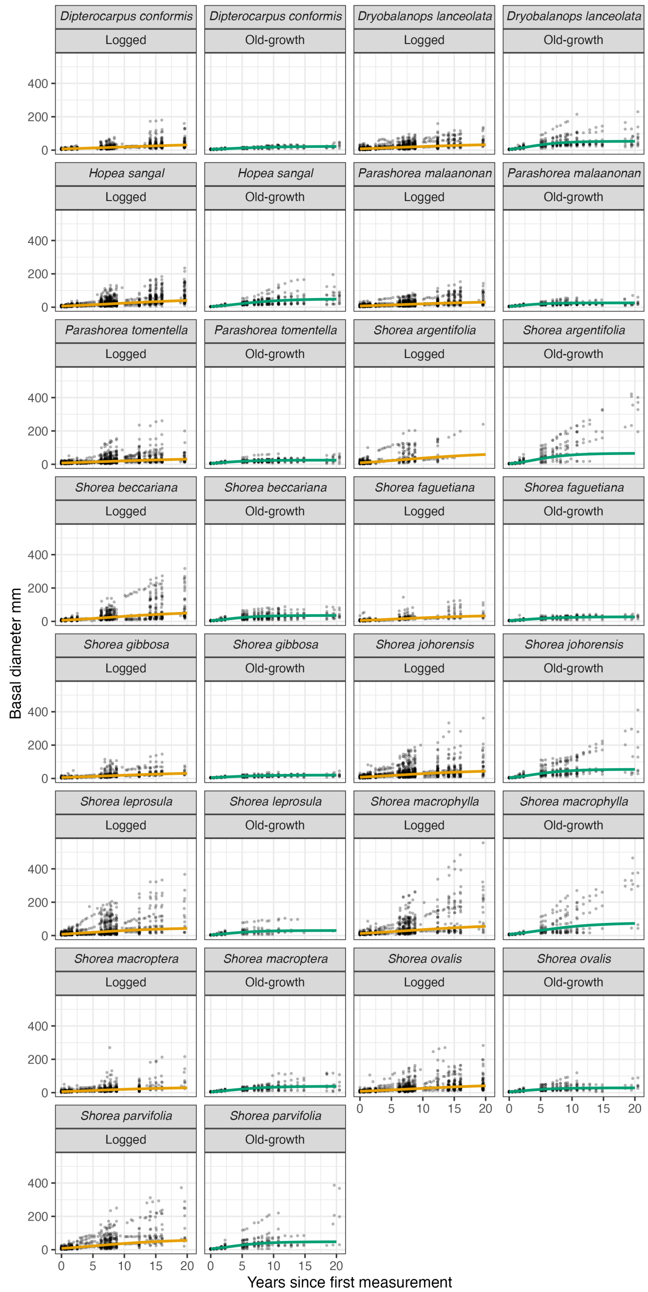

Figure 8: Basal diameter measurements for all seedlings over time (black points). Coloured lines show posterior predictions for a typical seedling of each of the 15 species in the old-growth (green) and logged (yellow) forest.

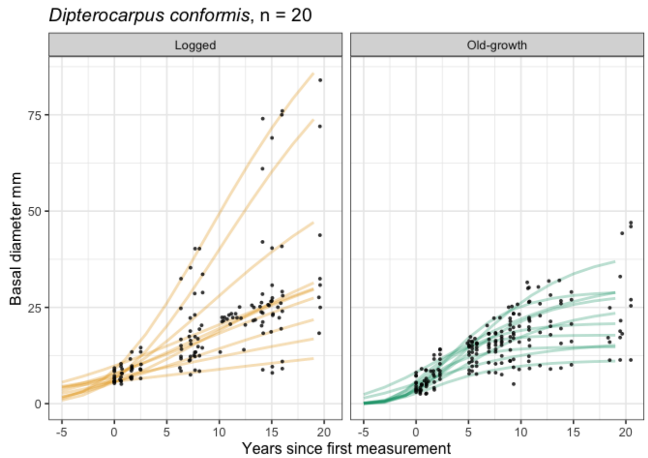

Figure 9: Basal diameter measurements for 20 randomly selected *Dipterocarpus conformis* seedlings over time (black points). Coloured lines show posterior predictions for individuals in the old-growth (green) and logged (yellow) forest.

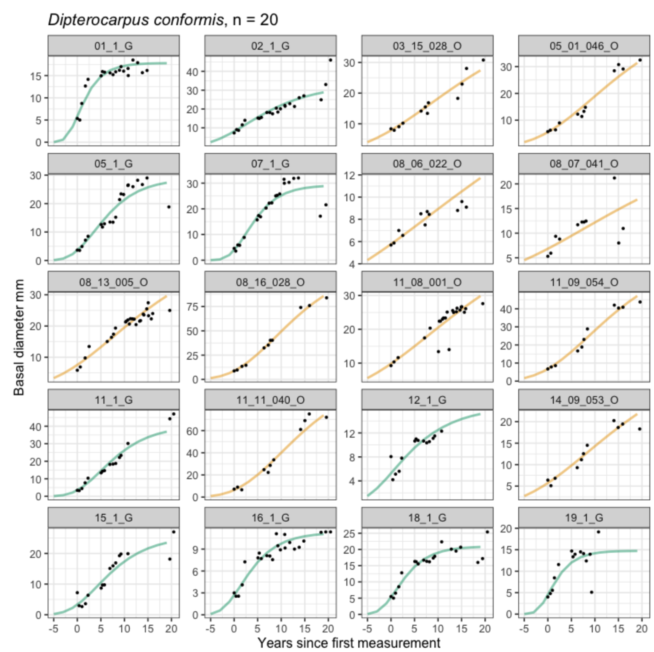

Figure 10: Basal diameter measurements for 20 randomly selected *Dipterocarpus conformis* seedlings over time (black points). These are the same individuals which are shown in Figure 9 above. Coloured lines show posterior predictions for individuals in the old-growth (green) and logged (yellow) forest. Note that the y-axis scale varies between panels.

7 Posterior predictive checks

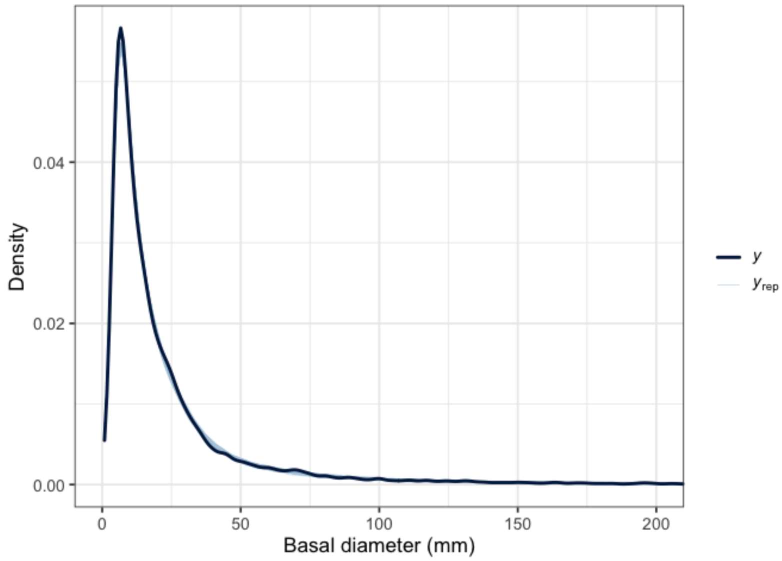

Figure 11: Posterior predictive check for the growth model, where the observed data is in dark blue (y) and 50 draws from the posterior distribution are in light blue ($yrep$).

Table 2: Posterior estimates of fixed effects from the growth model on the response scale

Parameter	Forest type	Posterior median	l-95% CI	u-95% CI	Rhat	Bulk effective sample size	Tail effective sample size
A	Logged	49.825	42.829	58.028	1.001	5614.307	6642.914
A	Old-growth	36.758	28.108	48.255	1.000	7817.899	6747.319
k_G/e	Logged	3.751	3.356	4.192	1.000	6115.659	6917.982
k_G/e	Old-growth	10.239	8.926	11.800	1.000	9874.542	6836.225
T_i	Logged	6.380	5.576	7.229	1.000	6780.500	6621.473
T_i	Old-growth	2.689	2.021	3.397	1.000	9540.742	7616.194

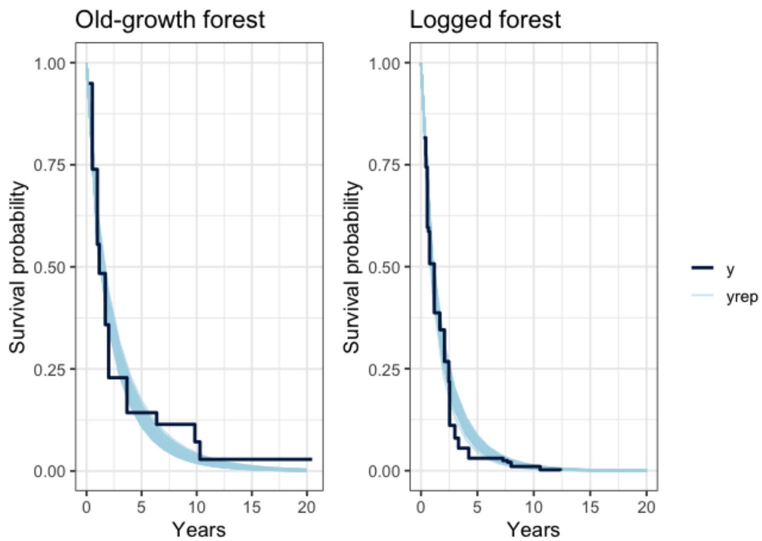

Figure 12: Posterior predictive check for the survival model, where the observed data is in dark blue (y) and 50 draws from the posterior distribution are in light blue (*yrep*). Conditional Kaplan-Meier curves, represented by y, were estimated for seedlings at representive values of basal diameter (the 0.25, 0.5 and 0.75 quartiles +/- the standard distribution multiplied by 0.01). Posterior preditions (*yrep*), were made for seedlings of these exact sizes (the 0.25, 0.5 and 0.75 quartiles).

Table 3: Posterior estimates of population-level effects from the survival model. The mean of the Weibull distribution, μ, has been back-transformed to the response scale (years).

Parameter	Posterior median	l-95% CI	u-95% CI	Rhat	Bulk effective sample size	Tail effective sample size
μ, Logged forest	2.877	2.320	3.507	1.001	2090.704	3589.735
μ, Old-growth forest	5.518	3.696	8.213	1.000	2583.691	4432.720
β, Basal diameter	2.599	2.432	2.775	1.000	10644.645	7872.663