Estimating Tree Growth Models from Complex Forest Monitoring Data: Appendix G

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Appendix G: Examples of simpler models

To test the robustness of the parameter estimates for basal area and topographic slope, we estimated simpler models omitting other covariates. We tried various combinations of omitting significant or not significant covariates, and checked the two observation error priors which give the most different observation error estimates to see if these different priors affected other parameter estimates. When a covariate was included, both the main effect and the interaction was included, and likewise when it was removed from the model. The models we used are shown in Table G1, which indicates which variables were included or omitted. See Table G2 for point estimates (means) of parameters in different models; see figures G1-G5 for posteriors for selected cases.

Table G1: Which variables are omitted or included in simpler models. TD = tree diameter; BA = basal area; TS = topographic slope; SE = soil effects; WD = annual water deficit; E = elevation, I = Insolation; OEP = Observation Error Prior: UPNZ (uniform prior, no zero allowed - the prior used in the main paper), UPZ (uniform prior, zero allowed), GP (gamma prior with equal shape and rate). Model 6 differs from Model 5 in that Model 6 has had its year random effects removed.

Model Number	TD	BA	TS	SE	WD	E	I	OEP
Model 1	X	X	X	X	X	X	X	UPNZ
Model 2	X	X	X	X				UPZ
Model 3	X	X	X	X				GP
Model 4	X	X		X			X	UPZ
Model 5	X	X	X	X	X			UPZ
Model 6*	X	X	X	X	X			UPZ

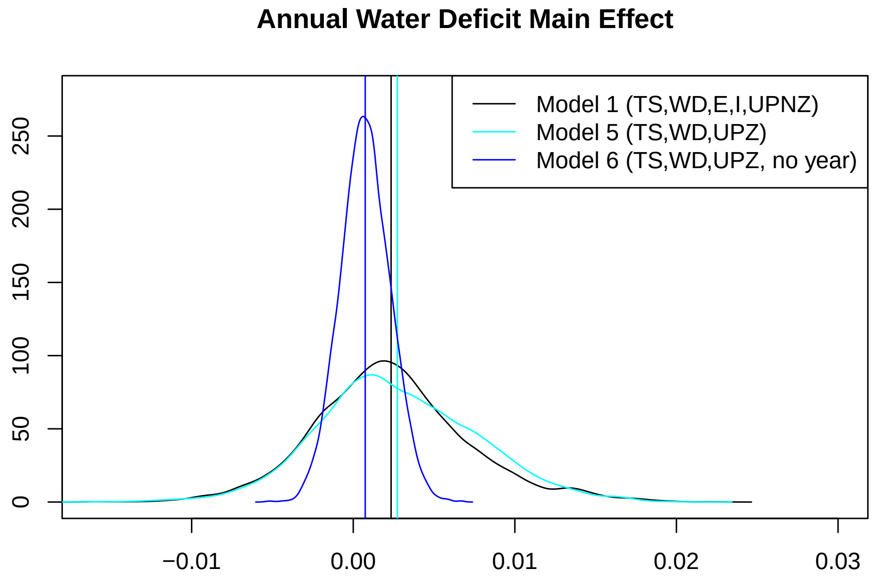
Table G2: Parameter point estimates (means) for model parameters from different models. "X" indicates that variable is not in the model. Most estimates are stable across models; see Figures G1 - G5 for posteriors for some nodes which shift considerably when other variables are removed from the model.

Parameter	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Plot Intercept Effect	0.006	0.006	0.006	0.006	0.006	0.006
Plot Slope Effect	0.005	0.005	0.005	0.005	0.005	0.005
Tree Intercept Effect	0.007	0.007	0.007	0.007	0.007	0.006
Tree Slope Effect	0.001	0.001	0.001	0.001	0.001	0.001
Comp. Intercept Effect	0.006	0.006	0.007	0.008	0.006	0.006
Comp. Slope Effect	0.002	0.002	0.002	0.002	0.002	0.002
Year Intercept Effect	0.012	0.108	0.104	0.1	0.012	X
Year Slope Effect	0.006	0.006	0.005	0.005	0.006	X
Cohassett Main Effect	0.031	0.029	0.034	0.029	0.031	0.033
Cohassett-Size Int.	1.013	1.013	1.013	1.013	1.013	1.013
Basal Area Main Effect	-0.009	-0.01	-0.01	-0.009	-0.009	-0.008
Basal Area-Size Int.	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
Insolation Main Effect	-0.001	X	X	0	X	X
Insolation-Size Int.	0.001	X	X	0	X	X
Top. Slope Main Effect	-0.002	-0.002	-0.002	X	-0.002	-0.002
Top. Slope-Size Int.	0.001	0	0	X	0	0
Water Def. Main Effect	0.002	X	X	X	0.003	0.001
Water Def.-Size Int.	0.001	X	X	X	-0.001	0.001
Elevation Main Effect	0	X	X	X	X	X
Elevation-Size Int.	-0.001	X	X	X	X	X
Obs. Error	0.005	0.003	0.013	0.002	0.003	0.004
Residual Error	0.019	0.019	0.018	0.019	0.019	0.024

Note that all models contain Tree Size, Basal Area, and Soil Effects, and are omitted from figure legends below. In general, parameter estimates are quite robust. Comparing models 2 and 3 (same covariates, different prior for observation error) shows that the changes in priors for observation error do not affect other parameter estimates (Figs. G2, G3, and G4). While some parameters show some shifts when others are removed, the significance of the estimates is not changed, and the shifts are typically quite small (don't change the point estimate much). For example, when comparing model 2 (with topographic slope included and insolation excluded) and model 4 (insolation included and topographic slope excluded) with model 1 which includes them both (Figs. G4 and G5), topographic slope remains significant when insolation is removed and insolation remains not significant when topographic slope is removed; it did not take up the variation unaccounted for by the removal of topographic slope.

The only exception was the tradeoff between annual water deficit and intercept year effects: when annual deficit was removed from the model (Models 2, 3, and 4 as compared with 1 and 5), the year intercept value was consistently an order of magnitude higher. So even though the annual deficit does not appear significant (overlaps zero), it clearly has explanatory power (Fig G2). In Model 6 we omitted the year random effects, and annual deficit still did not become significant though its estimate was shifted slightly and improved in precision (the posteriors were less broad; compare with Model 5 (Fig. G1). All other estimates are unaffected by the removal of other covariates in the simplified models we examined.

All results in these figures are on the standardized unitless scale.



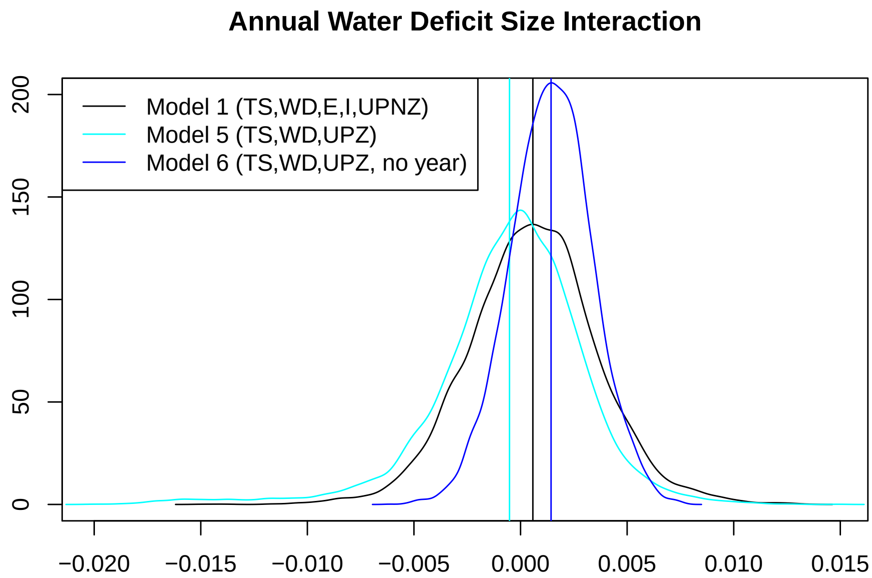
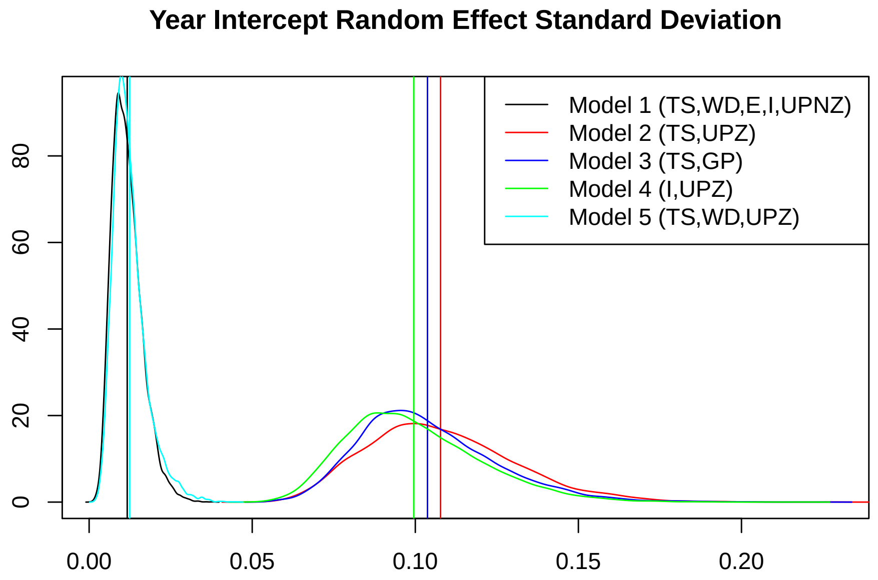


Figure G1: Removing year random effects $\sigma_{\alpha,w}$ and $\sigma_{\beta,w}$ tightens up the estimates for annual water deficit and shifts them slightly; however, annual deficit does not take up significant explanatory power (still overlaps zero). (Upper) Main effect for annual water deficit γ^{def}. (Lower) Interaction between size and annual water deficit κ^{def}.
TS = topographic slope;WD = annual water deficit; E = elevation, I = Insolation; Observation Error Prior: UPNZ (uniform prior, no zero allowed - the prior used in the main paper), UPZ (uniform prior, zero allowed), GP (gamma prior with equal shape and rate).



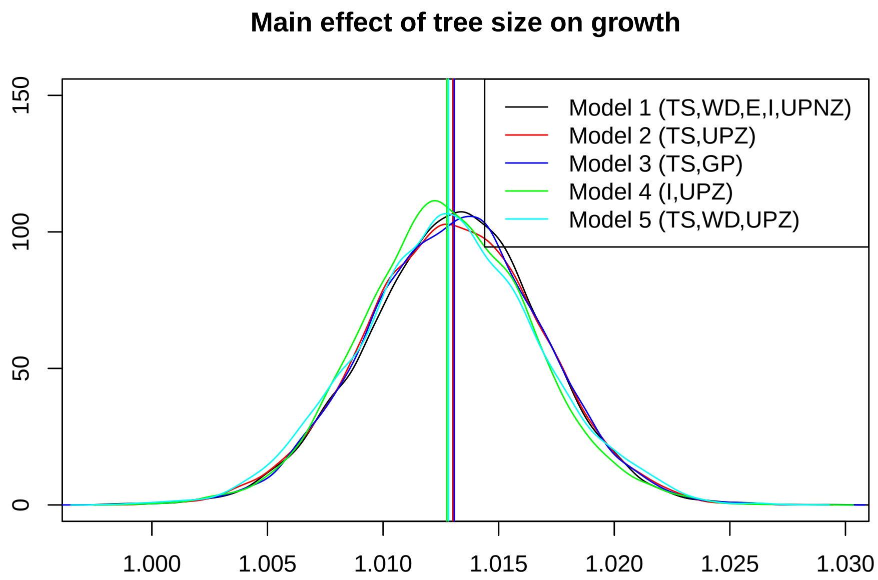
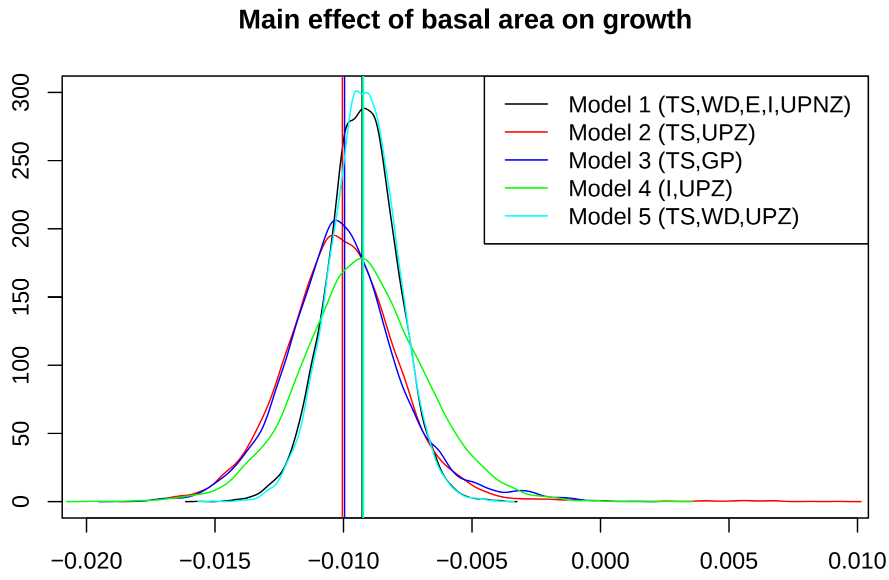


Figure G2: (Upper) The models which lack annual water deficit all have a higher estimate for the year intercept random effect standard deviation $\sigma_{\alpha,w}$. Though annual water deficit's parameters overlapped zero significantly, at least the main effect γ^{def} does seem to have some explanatory power, because the random effect is taking up some variation from it. The year random effect is still significantly separated from zero when annual deficit is in the model, implying that there is other year-to-year variation that annual deficit does not account for. (Lower) An example of a parameter which is unchanged regardless of other covariates are included or not: the tree size main effect for Cohassett soil κ^C.
TS = topographic slope; WD = annual water deficit; E = elevation, I = Insolation; Observation Error Prior: UPNZ (uniform prior, no zero allowed - the prior used in the main paper), UPZ (uniform prior, zero allowed), GP (gamma prior with equal shape and rate).



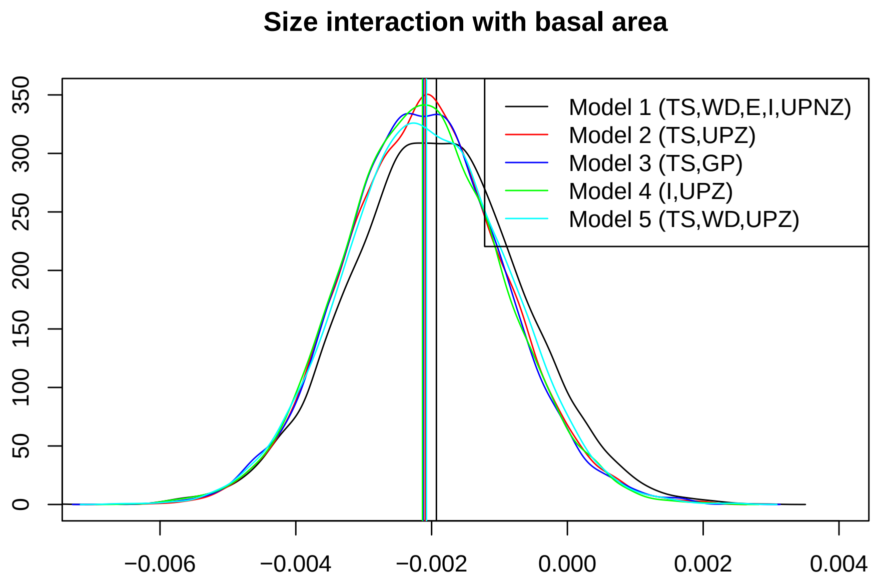
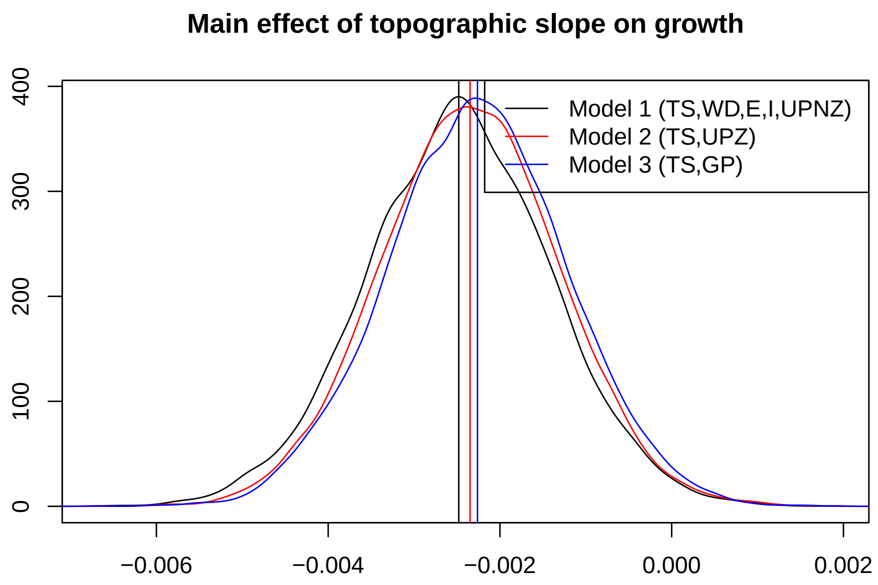


Figure G3: For basal area, the removal of other covariates does not change the parameter estimates much. (Upper) The main effect of basal area on tree growth γ^{ba} is affected only slightly by the removal of various other covariates. Differences in means for different models are no larger than 0.0008 (on the standardized scale). (Lower) There is very little difference in basal area's interaction with size κ^{ba} parameter for models with different covariates included.
TS = topographic slope; WD = annual water deficit; E = elevation, I = Insolation; Observation Error Prior: UPNZ (uniform prior, no zero allowed - the prior used in the main paper), UPZ (uniform prior, zero allowed), GP (gamma prior with equal shape and rate).



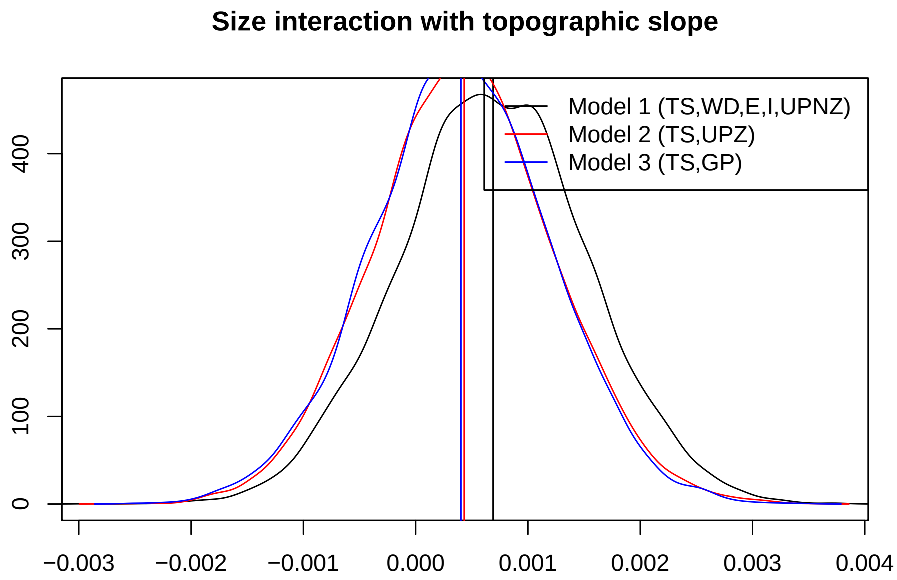
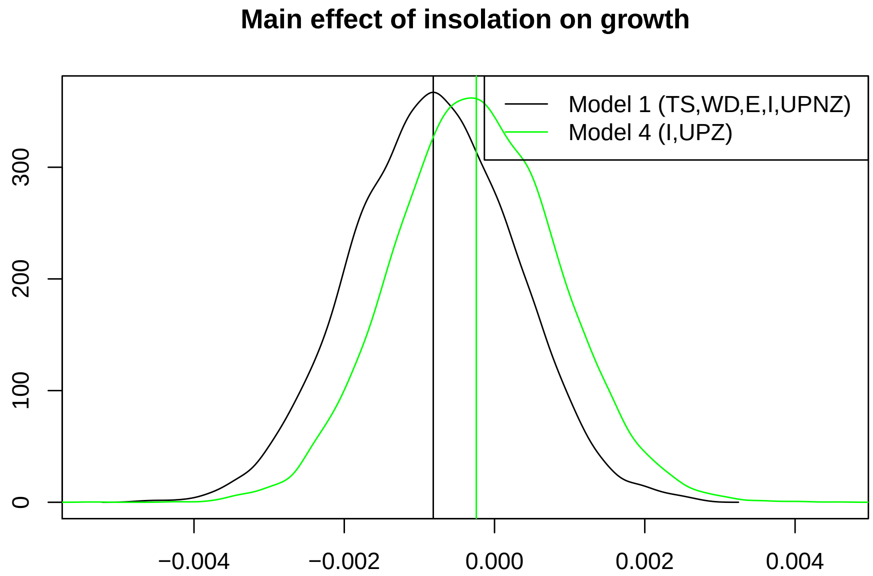


Figure G4: For topographic slope, removal of other parameters does not change parameter estimates much. (Upper) The estimate of the main effect for topographic slope γ^{tslope} is quite robust to both priors used for observation error and to removal of annual deficit,insolation, and elevation. (Lower) The same is true for the interaction of topographic slope with size κ^{tslope}.
TS = topographic slope; WD = annual water deficit; E = elevation, I = Insolation; Observation Error Prior: UPNZ (uniform prior, no zero allowed - the prior used in the main paper), UPZ (uniform prior, zero allowed), GP (gamma prior with equal shape and rate).



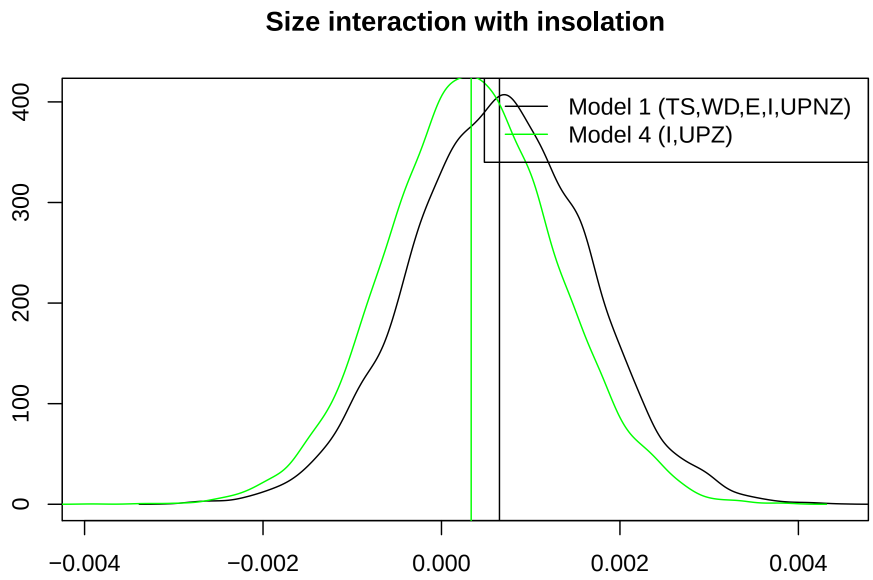


Figure G5: The estimate for insolation parameters is robust to removing other covariates (topographic slope, elevation, annual water deficit); it does not become more significant (less overlap of zero) when it is in the model and topographic slope is not: it doesn't take on explanatory power. (Upper) Main effect of insolation on growth γ^{insol}; (Lower) Interaction of growth with size κ^{insol}.
TS = topographic slope; WD = annual water deficit; E = elevation, I = Insolation; Observation Error Prior: UPNZ (uniform prior, no zero allowed - the prior used in the main paper), UPZ (uniform prior, zero allowed), GP (gamma prior with equal shape and rate).