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Supplementary material

Appendix 1

MCMC algorithm for fitting crown allometry and small adult growth and mortality rates

We estimated parameters and credible intervals (CIs) of models of crown diameter, individual tree growth and annual mortality (described below) using an adaptive MCMC Metropolis algorithm (Lee 1997; Gelman, Roberts & Gilks 1999). We fitted several different functional forms for each model and compared them using the Akaike information criterion (Akaike, 1974). The MCMC algorithm compares parameter values using the log-likelihood of the data given the model. At each iteration the algorithm selects a parameter to alter and recalculates the likelihood. If the new parameter improves the likelihood then it is accepted by the algorithm. If not, it is accepted with probability of the ratio of the new and old likelihoods. In this way it returns not only a best-fit value for each parameter given the data but also estimates its distribution. The algorithm has two periods: burn-in and sampling. During the burn-in period the algorithm alters the search range ("jumping distance") of each parameter value to achieve an optimal acceptance ratio of 25% (Gelman, Roberts & Gilks 1999). After the burn-in period, the jumping distance is fixed (separately for each parameter). During sampling parameter values are recorded every 100 iterations and the resulting parameter samples are taken as samples from the posterior distribution of each parameter. The resulting samples are then used to calculate mean and 95% confidence intervals for each parameter. We used uniform priors on all parameters, setting bounds much wider than expected parameter values, so that the MCMC algorithm needed to refer to the log-likelihood only (at U[-250, 250]). We used normalised mean annual temperature and mean annual precipitation values (taken from Gonzalo Jiménez, 2008). All models were fitted using an adaptive Metropolis algorithm written in C. Convergence was checked using the Geweke diagnostic statistic (Geweke 1992), using a sampling period of 500,000 iterations of the algorithm and testing means of the initial 10% and final 50% of the chain.

Competitive environment: crown diameter allometry and calculation of crown metric CAI

We expected recruitment to be positively correlated with conspecific adult density (potential parent trees) and negatively with aboveground competition for light, so we generated metrics to describe these factors, choosing crown area to represent both. For each plot we defined two values to represent conspecifics adult density and aboveground competition for light; the crown cover of adults of all species of interest (CAI_{sp}, m^2/ha) and of all adults on the plot (CAI_{all}), using species-specific crown width allometric equations derived from data collected from the second inventory. We calculated CAI_{all} and CAI_{sp} for all plots in both inventories, to quantify change in canopy area over time.

We parameterised models of crown diameter (CD) as a function of stem size (DBH) and climate for each species in order to calculate the crown area of adults in each plot, both in total and of each species individually, and checked convergence using the Geweke diagnostic statistic (Geweke 1992). We used a subset of the IFN2 database in which two measurements of crown diameter were recorded for around four trees of particular silvicultural interest in each plot. The number of measurements for each species is shown in Table S1. We parameterised DBH-CD equations using adaptive MCMC for the 30 species with more than 50 trees measurements in the data (in total >200,000 measurements), which accounted for >90% of the data. We tested a set of models (see Table S2 for functional forms tested) for crown diameter as a function of stem size and climate and selected the best model as the best for the most species and data (model 10, see Table S2).

For each tree we used these functions to use to calculate the total crown area of all taller trees in each plot, CAI_h, and the crown area of all conspecifics, CAI_{sp} in the plot. We also calculated the crown area of all trees in each plot, CAI_{all}. Observed and predicted crown diameters are shown for each of the 30 fitted species in Fig. S1. For species lacking allometric data we estimated the crown diameter-stem diameter relationship by either using the allometric equation of the single most closely related species or by averaging the allometric parameters of all the most closely related species if there was more than one at the closest distance (determined according to a phylogenetic tree created using the software Phylomatic, Webb & Donoghue 2005, see Table S3).

Construction of priors for growth and mortality functions

To construct priors for the growth and mortality functions within the ABC algorithm we fitted models to data of small trees from the Spanish Forest Inventory. We selected plots that had been measured in both the second (IFN2) and third (IFN3) inventories and fitted models to trees that had stem diameter (DBH) < 10 cm in the IFN2, excluding individuals whose mortality was human induced. We fitted models to 16 species with >100 individual stems for both growth and mortality. All models were species specific, with parameters fitted separately for each species.

Growth and mortality rates of trees are strongly size dependent, with growth increasing and mortality decreasing with size (e.g. Kunstler et al., 2009; Lines et al., 2010; Coomes et al., 2012). We compared three candidate models for growth and three candidate models for mortality using initial stem size (DBH_1) and competition measured as crown area of all taller trees, CAIh, in the plot (see Tables S4 and S5 for the model functional forms). For both growth and mortality, we tested a constant rate model, a size dependent model and a size and competition dependent model. We tested whether the effect of competition was important for growth using a functional form from Coomes et al. (2012) and a simple linear model for mortality. We modelled annual growth by fitting a model for the stem diameter measured in the IFN3 (DBH_2) as a function of the initial stem diameter measured in the IFN2 (DBH_1) and the growth rate using:

$$DBH_2 \sim N(DBH_1 + tGR, \omega_0^2) \qquad \text{(eqn S1)}$$

where GR is the predicted annual growth rate, t is the time interval (average 9 years) and ω0 is the standard deviation, estimated by the model.

We modelled the annual probability of mortality using a logistic function:

$$P(\text{mortality}) = 1/\left(1 + \exp\left(-k\right)\right) \qquad \text{(eqn S2)}$$

with corresponding likelihood:

$$\text{likelihood of data given model} = \begin{cases} [1 - P(\text{mortality})]^t & \text{if tree survived} \\ 1 - [1 - P(\text{mortality})]^t & \text{if tree died} \end{cases}$$

We compared a set of models with different functional for k and selected the best fit model according to AIC (see Tables S4 and S5, for model functional forms and AIC scores for growth and mortality respectively).

Model fit results of growth and mortality model MCMC parameterisation

We compared three models for both annual growth and annual mortality rates (Tables S4 and S5), and checked convergence using the Geweke diagnostic statistic (Geweke 1992). We calculated AIC values to compare models for each species individually. For both growth and mortality the best fit models for all species included the effects of both stem size and competition (model 2 in Tables S4 and S5), so we used these functional forms in the recruitment model. Individual species' parameter values and their corresponding 95% CIs for these two models are shown in Table S6 and S7. Predicted and observed values for DBH_2, fitted using model 2 in Table S4, are shown in Fig. S2. Predicted and observed values for annual mortality rate, fitted using model 2 in Table S5, are shown in Fig. S3. Predicted growth and mortality rates for each species plotted against DBH and against the range of values of CAI_{all} in which it is found are shown in Fig. 3.

Table A1 Amount of field data for each species used to estimate DBH-crown diameter allometric equations.

Species Name	**Count**
Abies alba	631
Abies pinsapo	63
Castanea sativa	4659
Chamaecyparis lawsoniana	177
Eucalyptus camaldulensis	1972
Eucalyptus globules	7127
Eucalyptus nitens	143
Fagus sylvatica	10292
Larix spp.	409
Picea abies	59
Pinus halepensis	30046
Pinus nigra	18455
Pinus pinaster	38086
Pinus pinea	8970
Pinus radiata	6609
Pinus sylvestris	28093
Pinus uncinata	2720
Platanus spp.	115
Populus alba	97
Populus nigra	1817
Pseudotsuga menziesii	172
Quercus canariensis	417
Quercus faginea	7845
Quercus ilex	36945
Quercus petraea	3660
Quercus pyrenaica	11832
Quercus robur	7958
Quercus rubra	304
Quercus suber	8693
Robinia pseudoacacia	214

Table A2 Tested models of crown diameter (CD) as a function of stem size (DBH), drought length (DL), average annual temperature (AvT) and annual precipitation (PA), and the number of parameters in each model. Parameters fitted are denoted p0-p6. Average temperature and annual precipitation were normalised to aid convergence (using annual precipitation mean = 862, standard deviation = 378, average temperature mean = 12, standard deviation = 3). The number of parameters of each model, its AIC score, rank, and the number of species and percentage of the data for which it was the best model are shown. The model selected for use is shown in bold.

Model	**Description**	**# parameters**	**AIC**	**AIC rank**	**# species' best model**	**% data best model**
0	CD ~ N(p_1+p_2DBH, p_0)	3	5593348	11	1	0.07
1	CD ~ N(p_2+p_3DBH, p_0+p_1DBH)	4	5481178	7	5	16.92
2	CD ~ N(p_1+p2DBH+p3DL, p_0)	4	5584746	8	0	0.00
3	CD~N(p_2+p_3DBH+p_4DL,p_0+p_1DBH)	5	5472071	3	0	0.00
4	CD~N(p_1+p_2DBH+p_3AvT,p_0)	4	5588356	9	0	0.00
5	CD~N(p_2+p_3DBH+p_4AvT,p_0+p_1DBH)	5	5474664	5	2	1.98
6	CD~N(p_1+p_2DBH +p_3PA,p_0)	4	5590359	10	0	0.00
7	CD~N(p_2+p_3DBH+p_4PA, p_0+p_1DBH)	5	5478742	6	4	3.34
8	CD~N(p_2+p_3DBH+p_4DL+p_5AvT, p_0+p_1DBH)	6	5466517	2	2	2.90
9	CD~N(p_2+p_3DBH+p_4PA+p_5AvT, p_0+p_1DBH)	6	5472122	4	5	19.92
10	**CD~N(p_2+p_3DBH+p_4PA+p_5AvT+p_6DL, p_0+p_1DBH)**	7	5464760	1	12	54.87

Table A3 IFN species code, species genus and family, the number of plots the species was found in, and the code of the species' crown diameter allometric equations used to calculate crown area for the species (in bold if the species had its own equation), assigned using nearest phylogenetic neighbour or neighbours, if there was more than one at the closest distance. If more than one species' code is listed then the average of those species' parameters was used. For 93% of the data we were able to use crown diameter equations fitted to the individual species' crown measurements.

IFN code	Species	Family	#Plots	IFN code(s) of species' allometric equation used to fit crown area.
31	*Abies alba*	Pinaceae	293	31
32	*Abies pinsapo*	Pinaceae	42	32
7	*Acacia spp.*	Mimosaceae	37	92
76	*Acer campestre*	Aceraceae	902	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72, 79,92
54	*Alnus glutinosa*	Betulaceae	618	41,42,43,44,45,46,47,48,71,72
88	*Apollonias barbujana*	Lauraceae	4	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72,79, 92
68	*Arbutus unedo*	Ericaceae	743	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72,92
73	*Betula spp.*	Betulaceae	1424	41,42,43,44,45,46,47,48,71,72
91	*Buxus sempervirens*	Buxaceae	29	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72,92
98	*Carpinus betulus*	Coryloideae	5	41,42,43,44,45,46,47,48,71,72
72	*Castanea sativa*	Fagaceae	2396	72
17	*Cedrus atlantica*	Pinaceae	17	21,22,23,24,25,26,28,31,32,33,34,35
13	*Celtis australis*	Ulmaceae	18	41,42,43,44,45,46,47,48,71,72
67	*Ceratonia siliqua*	Fabaceae	218	92
18	*Chamaecyparis lawsoniana*	Cupressaceae	76	18
9	*Cornus sanguinea*	Cornaceae	1	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72,92
74	*Corylus avellana*	Betulaceae	433	41,42,43,44,45,46,47,48,71,72
15	*Crataegus spp.*	Rosaceae	328	41,42,43,44,45,46,47,48,71,72
36	*Cupressus sempervirens*	Cupressaceae	71	18
83	*Erica arborea*	Ericaceae	183	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72,92
62	*Eucalyptus camaldulensis*	Myrtaceae	691	62
61	*Eucalyptus globulus*	Myrtaceae	3006	61
64	*Eucalyptus nitens*	Myrtaceae	69	64
5	*Euonymus europaeus*	Celastraceae	1	51,58
71	*Fagus sylvatica*	Fagaceae	3549	71
3	*Frangula alnus*	Rhamnaceae	7	41,42,43,44,45,46,47,48,71,72
55	*Fraxinus angustifolia*	Oleaceae	761	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72,92
1	*Heberdenia bahamensis*	Myrsinaceae	2	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72,79, 92

65	*Ilex aquifolium*	Aquifoliaceae	446	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72,92
82	*Ilex canariensis*	Aquifoliaceae	114	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72,92
75	*Juglans regia*	Juglandaceae	98	41,42,43,44,45,46,47,48,71,72
37	*Juniperus communis*	Cupressaceae	832	18
39	*Juniperus phoenicea*	Cupressaceae	203	18
38	*Juniperus thurifera*	Cupressaceae	1588	18
35	*Larix spp.*	Pinaceae	173	35
94	*Laurus nobilis*	Lauraceae	139	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72,79,92
12	*Malus sylvestris*	Rosaceae	32	41,42,43,44,45,46,47,48,71,72
81	*Myrica faya*	Myricaceae	202	41,42,43,44,45,46,47,48,71,72
87	*Ocotea phoetens*	Lauraceae	2	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72,79,92
66	*Olea europaea*	Oleaceae	743	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72,92
63	*Other/unknown eucalyptus species*	Myrtaceae	1	61,62,64
89	*Other/unknown laurel species*	Lauraceae	6	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72,79,92
29	*Other/unknown pine species*	Pinaceae	7	21,22,23,24,25,26,28
59	*Other/unknown riparian species*	Unknown (Angiosperm Average)	6	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72,79,92
90	*Other/unknown small trees*	Unknown (Angiosperm Average)	1	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72,79,92
99	*Other/unknown species*	Unknown (Angiosperm Average)	252	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72,79,92
84	*Persea indica*	Lauraceae	43	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72,79,92
8	*Phillyrea latifolia*	Oleaceae	96	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72,92
69	*Phoenix spp.*	Arecaceae	12	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72,79,92
86	*Picconia excelsa*	Oleaceae	16	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72,92
33	*Picea abies*	Pinaceae	34	33
27	*Pinus canariensis*	Pinaceae	1448	23,24,26
24	*Pinus halepensis*	Pinaceae	10893	24
25	*Pinus nigra*	Pinaceae	6988	25
26	*Pinus pinaster*	Pinaceae	12372	26
23	*Pinus pinea*	Pinaceae	3288	23
28	*Pinus radiata*	Pinaceae	2368	28
21	*Pinus sylvestris*	Pinaceae	9221	21
22	*Pinus uncinata*	Pinaceae	929	22
93	*Pistacia terebinthus*	Anacardiaceae	39	61,62,64
79	*Platanus hispanica*	Platanaceae	72	79

51	*Populus alba*	Salicaceae	51	51
58	*Populus nigra*	Salicaceae	658	58
52	*Populus tremula*	Salicaceae	158	51,58
95	*Prunus spp.*	Rosaceae	324	41,42,43,44,45,46,47,48,71,72
34	*Pseudotsuga menziesii*	Pinaceae	80	34
16	*Pyrus spp.*	Rosaceae	30	41,42,43,44,45,46,47,48,71,72
47	*Quercus canariensis*	Fagaceae	220	47
44	*Quercus faginea*	Fagaceae	4373	44
45	*Quercus ilex*	Fagaceae	15714	45
42	*Quercus petraea*	Fagaceae	1695	42
43	*Quercus pyrenaica*	Fagaceae	4596	43
41	*Quercus robur*	Fagaceae	3821	41
48	*Quercus rubra*	Fagaceae	154	48
46	*Quercus suber*	Fagaceae	3537	46
4	*Rhamnus alaternus*	Rhamnaceae	11	41,42,43,44,45,46,47,48,71,72
96	*Rhus coriaria*	Anacardiaceae	4	61,62,64
92	*Robinia pseudoacacia*	Fabaceae	145	92
57	*Salix spp.*	Salicaceae	702	51,58
97	*Sambucus nigra*	Adoxaceae	47	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72, 92
78	*Sorbus spp.*	Rosaceae	492	41,42,43,44,45,46,47,48,71,72
53	*Tamarix spp.*	Tamaricaceae	7	41,42,43,44,45,46,47,48,51,58,61,62,64,71,72,92
14	*Taxus baccata*	Taxaceae	49	18
77	*Tilia spp.*	Malvaceae	123	61,62,64
56	*Ulmus minor*	Ulmaceae	246	41,42,43,44,45,46,47,48,71,72

Table A4 Set of species-specific growth models tested with corresponding maximum log-likelihoods and AICs, and the number of species for which each model was the best fit (according to the AIC) out of the thirteen in the analysis. Model 2 (shown in bold) provided the best fit for the largest number of species, and was therefore chosen.

Model number	Annual growth (GR in equation S1)	Max log likelihood	# parameters	AIC	# of species' best model
0	GR=ω_1	-54844.0	2	109740	0
1	GR= ω_1DBH	-54880.9	2	109813	0
2	GR=ω_1DBH /(1+ $\omega_2 CAI_h$)	-52217.5	3	104513	13

Table A5 Set of species-specific mortality models tested, with corresponding maximum log-likelihoods and AICs, and the number of species for which each model was the best fit (according to the AIC) out of the thirteen in the analysis. Model 2 (shown in bold) provided the best fit for the largest number of species, and was therefore chosen.

Model number	Annual probability of mortality P(mortality)=1/(1+exp(-k)) (equation S2)	Max log likelihood	# of parameters	AIC	# of species' best model
0	k=τ_0	-13147.1	1	26346.3	0
1	k=τ_0 +τ_1DBH	-13127.5	2	26306.9	0
2	k=τ_0 +τ_1DBH +τ_2 CAI_h	-12467.3	3	25012.6	13

Table A6 Parameter values and 95% confidence intervals for the chosen models for growth (equation S1) for each of the thirteen species in the analysis (model 2 in table S4). Parameters ω_1 and ω_2 formed prior mean values for parameters p_3 and p_4 in eqn 7 (main manuscript).

Species	ω_0	ω_1	ω_2
Fagus sylvatica	1.44 (1.39, 1.50)	0.0470 (0.0428, 0.0515)	0.000188 (0.000157, 0.000223)
Juniperus thurifera	1.32 (1.25, 1.40)	0.0215 (0.0191, 0.0241)	0.000311 (0.000176, 0.000475)
Pinus halepensis	2.10 (2.05, 2.15)	0.0387 (0.0369, 0.0405)	0.000180 (0.000154, 0.000207)
Pinus nigra	1.92 (1.88, 1.97)	0.0561 (0.0539, 0.0584)	0.000307 (0.000279, 0.000336)
Pinus pinaster	2.43 (2.43, 2.43)	0.0934 (0.0934, 0.0934)	0.000427 (0.000427, 0.000427)
Pinus pinea	2.52 (2.36, 2.69)	0.0670 (0.0600, 0.0747)	0.000279 (0.000205, 0.000366)
Pinus sylvestris	2.28 (2.24, 2.33)	0.0642 (0.0618, 0.0667)	0.000225 (0.000206, 0.000246)
Pinus uncinata	1.86 (1.75, 1.98)	0.0554 (0.0485, 0.0627)	0.000348 (0.000261, 0.000448)
Quercus faginea	1.10 (1.07, 1.13)	0.0203 (0.0195, 0.0212)	0.000084 (0.000069, 0.000101)
Quercus ilex	1.50 (1.48, 1.52)	0.0186 (0.0181, 0.0191)	0.000046 (0.000038, 0.000055)
Quercus petraea	1.98 (1.98, 1.98)	0.0364 (0.0364, 0.0364)	0.000201 (0.000201, 0.000201)
Quercus pyrenaica	1.42 (1.38, 1.45)	0.0268 (0.0257, 0.0280)	0.000133 (0.000115, 0.000151)
Quercus suber	1.58 (1.49, 1.69)	0.0347 (0.0287, 0.0414)	0.000228 (0.000136, 0.000339)

Table A7 Parameter values and 95% confidence intervals for the chosen models for mortality (equation S2) for each of the thirteen species in the analysis (model 2 in table S5). Parameters formed prior mean values for p_5, p_6 and p_7 in eqn 8 (main manuscript).

Species	τ_0	τ_1	τ_2
Fagus sylvatica	-3.645 (-5.460,-1.573)	-0.2528 (-0.4939,-0.0478)	0.000083 (0.000058,0.000106)
Juniperus thurifera	-2.973 (-5.782,-0.282)	-0.3757 (-0.6969,-0.0454)	0.000245 (0.000099,0.000371)
Pinus halepensis	-3.645 (-4.555,-2.653)	-0.1316 (-0.2457,-0.0273)	0.000158 (0.000131,0.000185)
Pinus nigra	-2.409 (-2.409,-2.409)	-0.3210 (-0.3210,-0.3210)	0.000076 (0.000076,0.000076)
Pinus pinaster	-3.028 (-3.817,-2.152)	-0.1128 (-0.2138,-0.0244)	0.000170 (0.000150,0.000189)
Pinus pinea	-2.243 (-3.786,-0.583)	-0.2087 (-0.3996,-0.0320)	0.000069 (0.000019,0.000120)
Pinus sylvestris	-4.743 (-5.352,-3.945)	-0.0726 (-0.1628,-0.0071)	0.000155 (0.000140,0.000170)
Pinus uncinata	-2.803 (-2.803,-2.803)	-0.1333 (-0.1333,-0.1333)	0.000175 (0.000175,0.000175)
Quercus faginea	-4.557 (-5.342,-3.337)	-0.0896 (-0.2312,-0.0053)	0.000086 (0.000053,0.000116)
Quercus ilex	-4.896 (-5.240,-4.357)	-0.0400 (-0.1027,-0.0021)	0.000079 (0.000062,0.000095)
Quercus petraea	-4.812 (-6.669,-1.669)	-0.2020 (-0.5699,-0.0126)	0.000198 (0.000140,0.000255)
Quercus pyrenaica	-3.933 (-4.577,-3.078)	-0.0820 (-0.1819,-0.0096)	0.000105 (0.000090,0.000120)
Quercus suber	-3.124 (-5.033,-0.849)	-0.2281 (-0.4831,-0.0199)	0.000141 (0.000071,0.000205)

Table A8 Functional forms tested for the juvenile existence model, where P(existence)=logistic(k). Here AVT = average annual temperature (°C), AP = annual precipitation (mm/year) and DL = drought length(months). (See main manuscript eqn 4).

Model	Number of parameters	Functional form
0	7	$k = a_0 + a_1 a_2 AVT - a_2 AVT^2 + \ a_3 a_4 AP - a_4 AP^2 + a_5 a_6 DL - a_6 DL^2$
1	3	$k = a_0 + a_1 a_2 AVT - a_2 AVT^2$
2	3	$k = a_0 + a_1 a_2 AP - a_2 AP^2$
3	3	$k = a_0 + a_1 a_2 DL - a_2 DL^2$
4	5	$k = a_0 + a_1 a_2 AVT - a_2 AVT^2 + \ a_3 a_4 AP - a_4 AP^2$
5	5	$k = a_0 + a_1 a_2 AVT - a_2 AVT^2 + \ a_3 a_4 DL - a_4 DL^2$
6	5	$k = a_0 + a_1 a_2 AP - a_2 AP^2 + \ a_3 a_4 DL - a_4 DL^2$

Table A9 Number of parameters and AIC for all juvenile existence model forms (table S8). Lowest values (best fit model) for each species are shown in bold. Model 0 (main manuscript eqn 4) was chosen as it was judged the best for all but one species.

Model	0	1	2	3	4	5	6
Number of parameters	7	3	3	3	5	5	5
Species							
P. sylvestris	**10202.5**	11689.9	12091.7	11398.9	10949.8	10813.4	10606.4
P. uncinata	**1794.8**	1869.7	3339.1	3182.2	1835.5	1833.6	3025.3
P. pinea	**1156.3**	1172.0	1251.6	1273.3	1158.9	1181.3	1251.6
P. halepensis	**9656.1**	10291.3	10787.4	11651.1	9817.0	10343.6	10708.5
P. nigra	**9861.9**	11080.1	11099.2	11112.7	10054.0	10664.0	10314.5
P. pinaster	**5029.3**	5259.2	5387.2	5205.2	5216.6	5136.8	5099.3
J. thurifera	**2524.1**	2967.5	3090.1	2849.6	2658.9	2635.3	2748.9
Q. petraea	762.6	836.0	809.4	772.6	801.5	776.1	**758.8**
Q. pyrenaica	**1866.4**	1940.8	1903.6	1927.0	1878.7	1923.0	1867.4
Q. faginea	**3075.7**	3244.0	3290.3	3324.3	3084.4	3224.3	3177.9
Q. ilex	**7924.6**	8376.4	8224.8	8560.4	7997.8	8298.8	8206.2
Q. suber	**1209.9**	1653.0	1677.9	1822.4	1447.7	1315.9	1643.8
F. sylvatica	**2391.2**	2682.2	2673.0	2550.6	2481.3	2439.9	2509.1

Table A10. Fitted parameter values (top) and standard deviations (bottom) for model 0 (see table S8), the chosen juvenile existence model.

	Posterior mean parameter value						
Species	a_0	a_1	a_2	a_3	a_4	a_5	a_6
P. sylvestris	-11.006	14.941	0.066	1.809	7.201	0.196	0.742
P. uncinata	-8.774	8.293	0.251	2.070	3.923	0.100	33.458
P. pinea	-36.531	32.838	0.113	1.077	4.156	1.347	0.186
P. halepensis	-30.870	30.143	0.133	0.241	4.350	0.052	0.120
P. nigra	-34.680	22.591	0.170	1.613	16.366	2.173	0.474
P. pinaster	-31.254	23.524	0.121	1.944	9.578	5.264	0.373
J. thurifera	-14.663	7.377	0.059	1.259	22.042	4.102	1.033
Q. petraea	-15.001	23.703	0.014	2.039	7.571	0.289	1.116
Q. pyrenaica	-16.825	18.828	0.024	2.155	8.116	3.254	0.313
Q. faginea	-33.643	22.715	0.180	1.628	9.944	0.691	0.151
Q. ilex	-20.592	30.710	0.054	1.565	8.600	0.102	0.095
Q. suber	-61.827	38.086	0.111	1.631	32.422	1.045	0.471
F. sylvatica	-21.784	17.370	0.141	2.792	4.062	0.361	1.829

	Posterior parameter standard deviation						
Species	a_0	a_1	a_2	a_3	a_4	a_5	a_6
P. sylvestris	0.392	0.382	0.004	0.024	0.439	0.082	0.049
P. uncinata	1.956	0.555	0.022	0.409	0.981	0.042	30.239
P. pinea	3.301	0.565	0.010	0.196	2.914	0.813	0.039
P. halepensis	1.180	0.314	0.006	0.043	0.258	0.044	0.008
P. nigra	1.101	0.143	0.009	0.013	0.583	0.097	0.039
P. pinaster	0.877	0.332	0.003	0.364	0.176	0.178	0.037
J. thurifera	0.922	2.341	0.011	0.040	3.623	0.167	0.129
Q. petraea	1.847	6.846	0.010	0.368	1.517	0.174	0.313
Q. pyrenaica	1.219	4.541	0.007	0.057	0.875	0.403	0.080
Q. faginea	0.950	0.224	0.007	0.044	0.885	0.394	0.037
Q. ilex	0.756	0.495	0.003	0.021	0.506	0.109	0.010
Q. suber	1.071	0.550	0.003	0.027	1.658	0.370	0.062
F. sylvatica	0.988	0.340	0.011	0.080	0.536	0.187	0.444

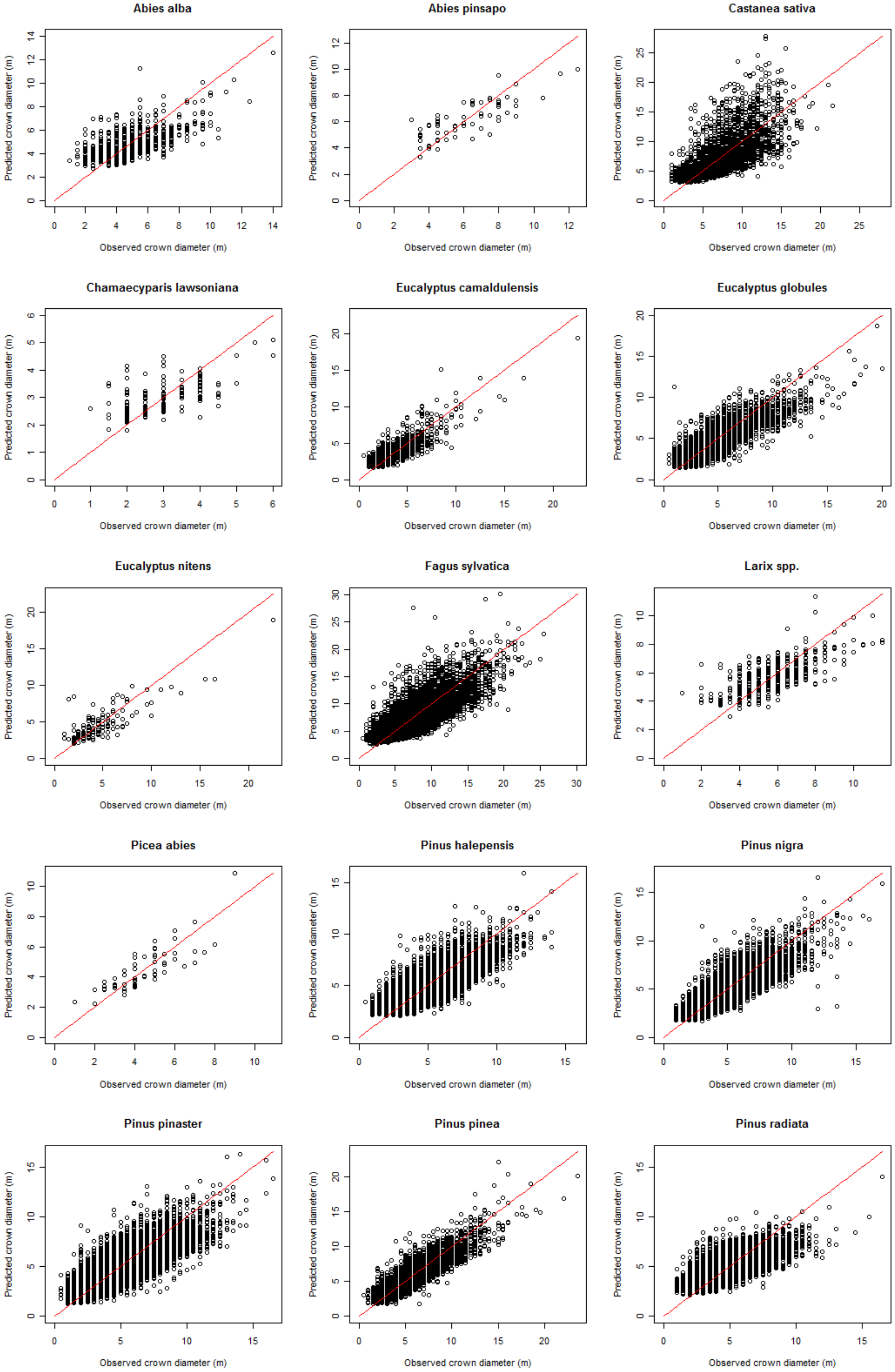
Table A11 Mean and 95% credible interval of juvenile growth and mortality parameters (eqn 6 and 7) fitted by the ABC-SMC-AW method. Values for the recruitment parameters (eqn 5) are given in the main text.

Species	p_3	p_4	p_5	p_6	p_7
P. sylvestris	0.598 (0.343, 0.838)	2.247E-04 (1.329E-04, 3.098E-04)	-4.518 (-5.423, -3.537)	-0.077 (-0.112, -0.043)	1.126E-04 (4.189E-05, 1.841E-04)
P. uncinata	0.447 (0.282, 0.603)	3.122E-04 (1.845E-04, 4.370E-04)	-2.837 (-3.536, -2.237)	-0.192 (-0.192, -0.070)	1.615E-04 (9.611E-05, 2.259E-04)
P. pinea	0.356 (0.162, 0.576)	2.666E-04 (1.531E-04, 3.797E-04)	-2.901 (-3.599, -2.199)	-0.286 (-0.286, -0.162)	6.678E-05 (3.364E-05, 9.778E-05)
P. halepensis	0.343 (0.309, 0.379)	1.837E-04 (1.637E-04, 2.033E-04)	-3.668 (-4.049, -3.256)	-0.149 (-0.149, -0.118)	1.566E-04 (1.381E-04, 1.752E-04)
P. nigra	0.398 (0.248, 0.565)	2.942E-04 (1.628E-04, 4.358E-04)	-2.060 (-2.544, -1.587)	-0.447 (-0.447, -0.190)	1.040E-04 (7.225E-05, 1.364E-04)
P. pinaster	0.781 (0.446, 1.103)	4.551E-04 (2.810E-04, 6.326E-04)	-3.280 (-4.208, -2.474)	-0.158 (-0.158, -0.064)	1.595E-04 (9.098E-05, 2.344E-04)
J. thurifera	0.132 (0.073, 0.213)	2.913E-04 (1.827E-04, 4.001E-04)	-3.170 (-3.816, -2.541)	-0.529 (-0.529, -0.238)	2.466E-04 (1.300E-04, 3.624E-04)
Q. petraea	0.309 (0.182, 0.431)	2.162E-04 (1.347E-04, 2.967E-04)	-5.763 (-6.978, -4.407)	-0.289 (-0.289, -0.119)	2.019E-04 (1.130E-04, 2.852E-04)
Q. pyrenaica	0.226 (0.141, 0.312)	1.360E-04 (8.809E-05, 1.857E-04)	-5.115 (-6.052, -4.142)	-0.108 (-0.108, -0.054)	9.944E-05 (5.926E-05, 1.393E-04)
Q. faginea	0.208 (0.149, 0.265)	8.268E-05 (5.124E-05, 1.147E-04)	-4.720 (-6.917, -2.829)	-0.125 (-0.125, -0.032)	7.001E-05 (2.837E-05, 1.114E-04)
Q. ilex	0.170 (0.120, 0.215)	4.524E-05 (3.080E-05, 6.070E-05)	-4.452 (-6.055, -3.360)	-0.052 (-0.052, -0.030)	7.485E-05 (4.729E-05, 1.032E-04)
Q. suber	0.248 (0.141, 0.366)	2.334E-04 (1.285E-04, 3.310E-04)	-3.165 (-3.980, -2.490)	-0.331 (-0.331, -0.146)	1.428E-04 (8.702E-05, 1.967E-04)
F. sylvatica	0.422 (0.269, 0.572)	1.845E-04 (1.015E-04, 2.689E-04)	-3.504 (-4.747, -2.330)	-0.392 (-0.392, -0.157)	7.740E-05 (4.025E-05, 1.168E-04)

Table A12 Species average climatic conditions, calculated at the centre of the central 90% of their climatic ranges, and the average competitive conditions in the second forest inventory (average CAI_{sp} and CAI_{all} in IFN2) from all plots used in the juvenile analysis.

Species	Average annual temperature (°C)	Average annual precipitation (mm/year)	Average drought length (months)	Average CAI_{sp}	Average CAI_{all}
P. sylvestris	9.35	1022.33	0.76	0.21	0.40
P. uncinata	6.40	1233.13	0.00	0.16	0.32
P. pinea	13.80	678.53	1.91	0.08	0.16
P. halepensis	13.80	621.20	2.06	0.14	0.26
P. nigra	10.85	812.00	1.30	0.15	0.29
P. pinaster	12.20	860.30	1.60	0.12	0.24
J. thurifera	10.56	699.60	1.96	0.05	0.09
Q. petraea	10.80	1018.40	0.67	0.14	0.29
Q. pyrenaica	11.70	976.60	1.36	0.18	0.35
Q. faginea	11.40	870.60	1.33	0.12	0.24
Q. ilex	12.75	803.00	1.93	0.13	0.25
Q. suber	14.65	784.20	1.92	0.12	0.23
F. sylvatica	9.25	1271.50	0.38	0.34	0.64

Figure A1 Observed (black dots) and predicted (red line) crown diameters for each of the 30 species for which we had >50 measurements in the dataset.



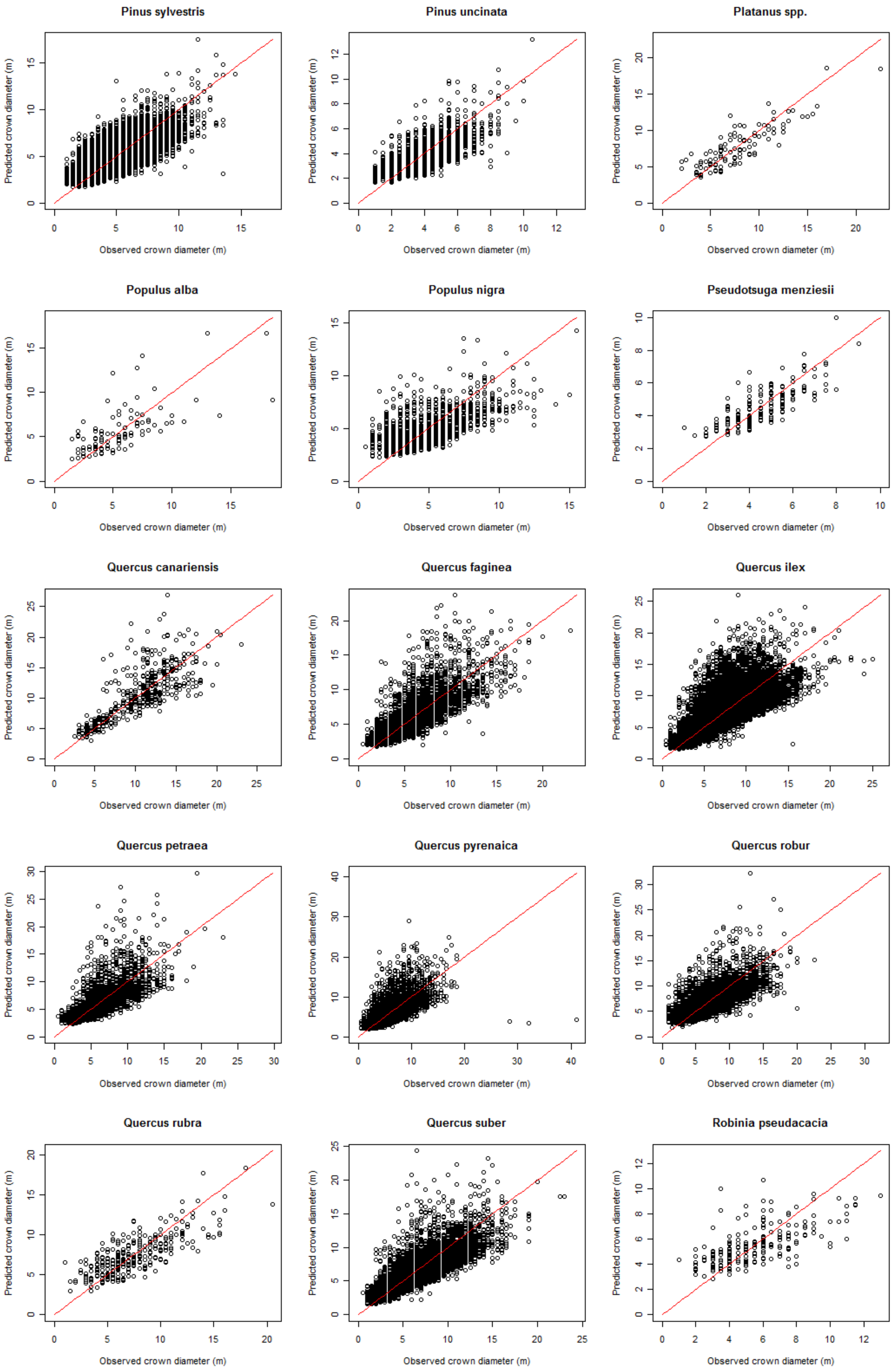

Pinus sylvestris
Pinus uncinata
Platanus spp.
Populus alba
Populus nigra
Pseudotsuga menziesii
Quercus canariensis
Quercus faginea
Quercus ilex
Quercus petraea
Quercus pyrenaica
Quercus robur
Quercus rubra
Quercus suber
Robinia pseudacacia
Predicted crown diameter (m)
Observed crown diameter (m)

Figure A2 Predicted and observed diameters fitted using the chosen growth model (model 2 in table S4). Growth was predicted separately for each species using initial stem size (DBH_1) and CAI_{all}, and final observed diameter (DBH_2) is shown against predicted final diameter ($pDBH_2$). The one to one relationship is shown by the red line.

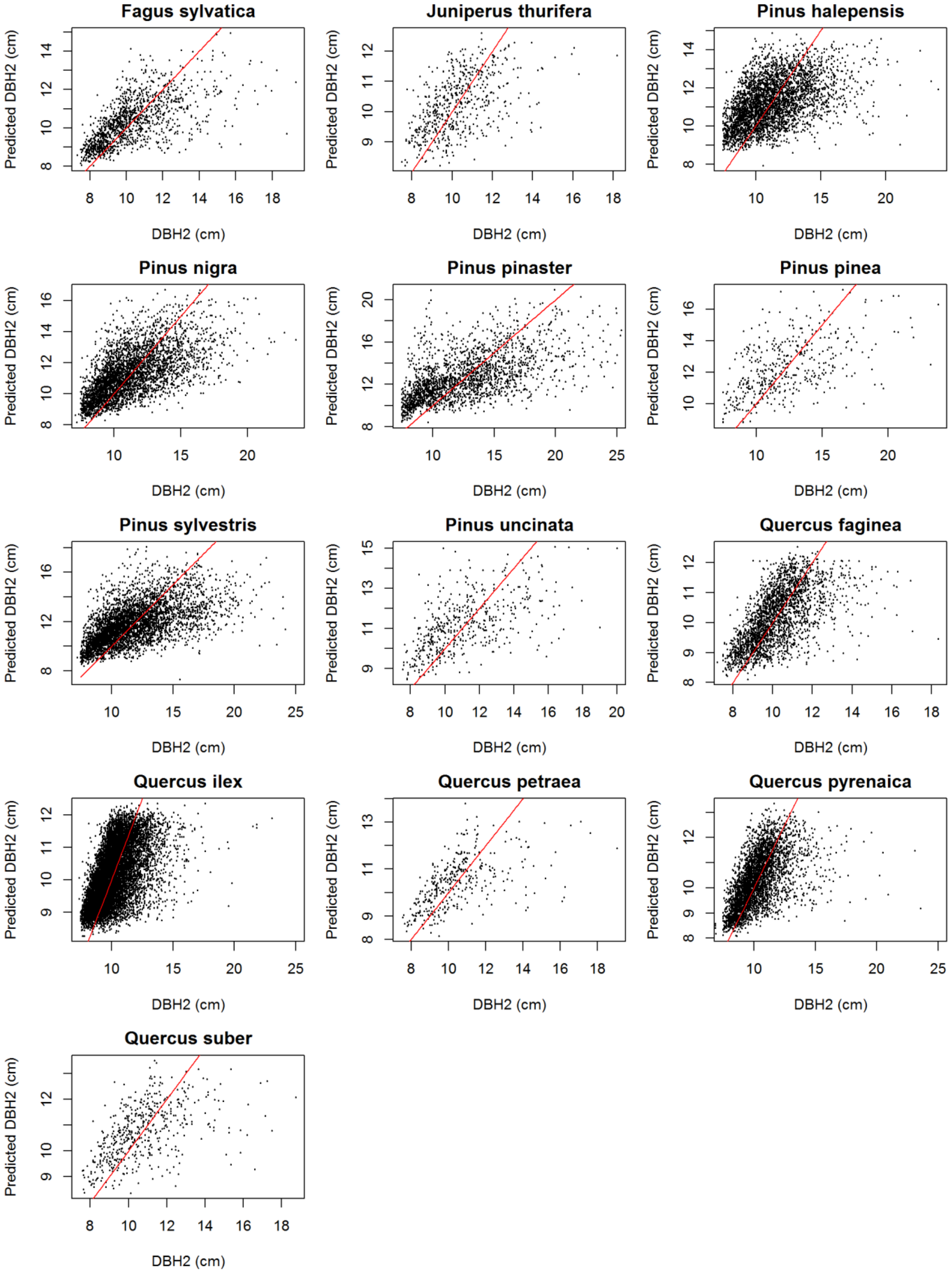


Figure A3 Predicted and observed annual mortality fitted using the chosen mortality model (model 2 in table S5). Mortality was predicted separately for each species using *CAI*$_{all}$, and average rates for each species are shown with their 95% credible intervals. The one to one relationship is shown by the red line.

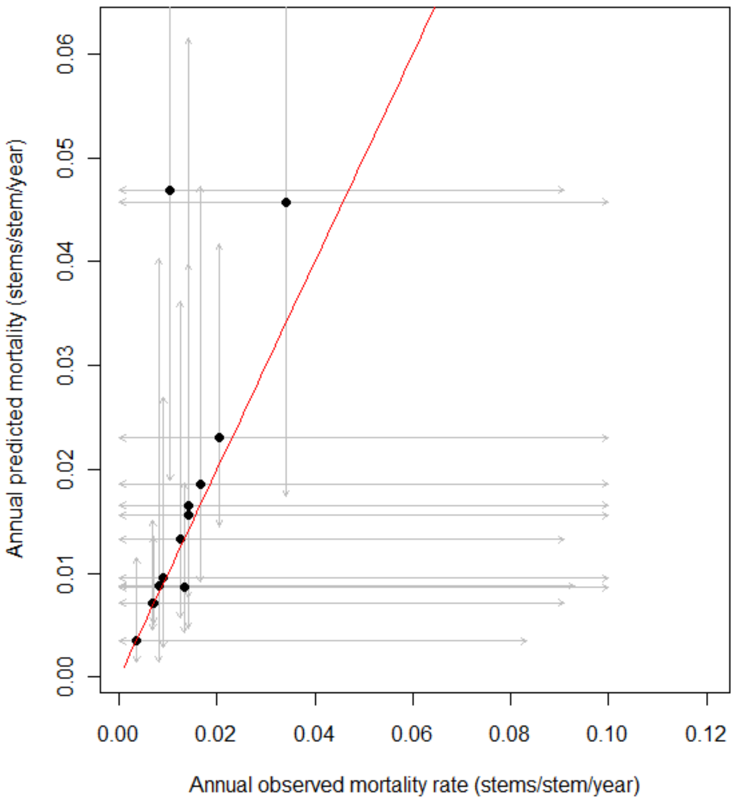
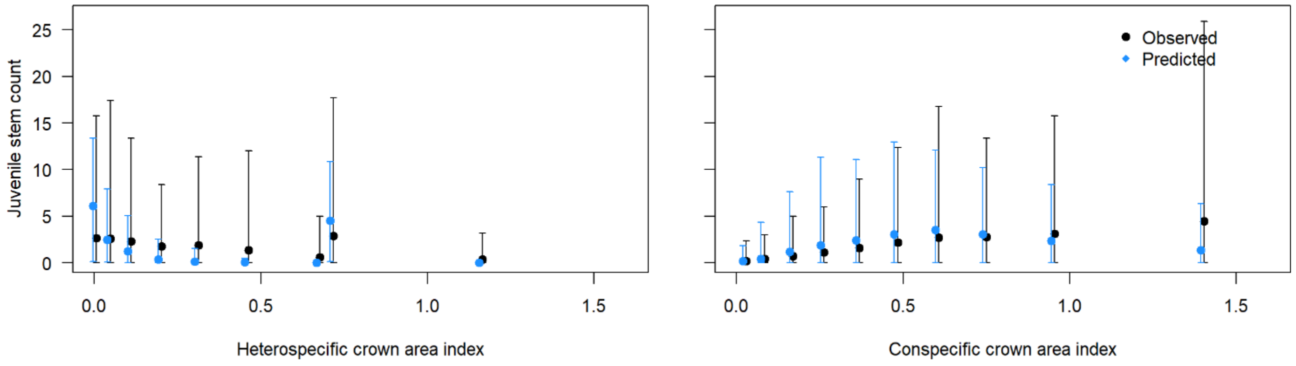
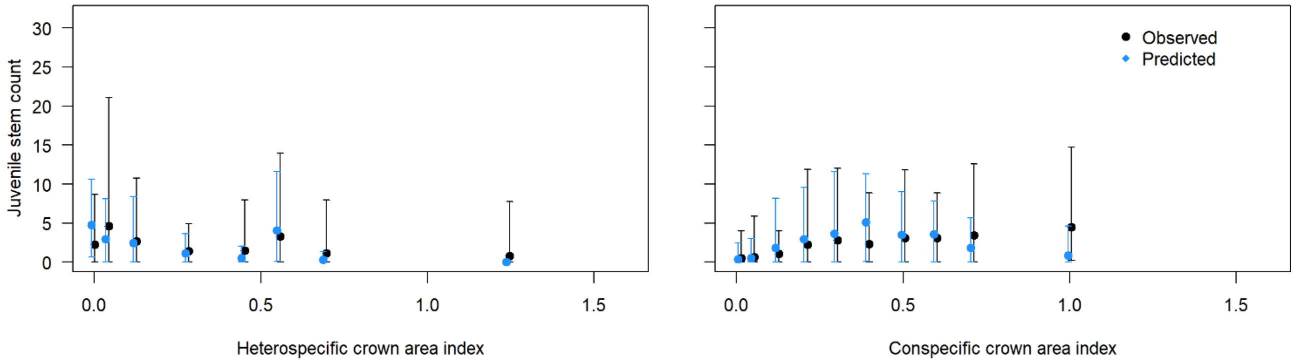


Figure A4 Model predicted (blue) versus observed (black) juvenile stem counts, with data and predictions shown along conspecific and heterospecific crown area index (*CAI_{sp}* and *CAI_{all} - CAI_{sp}* in eqn 5 in the main manuscript). Both model and data are binned into even sized groups representing 10% of the plots, except where bins overlapped (for species with high numbers of monospecific plots), where bins are combined, with model predictions (blue) offset by 0.01 to the left for visual clarity. Error bars represent 95% range of observations and predictions.

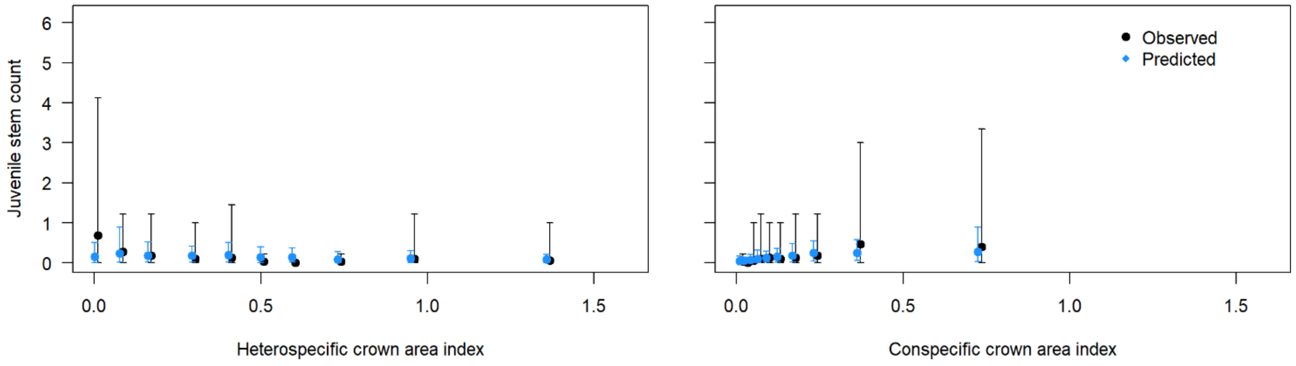
P. sylvestris

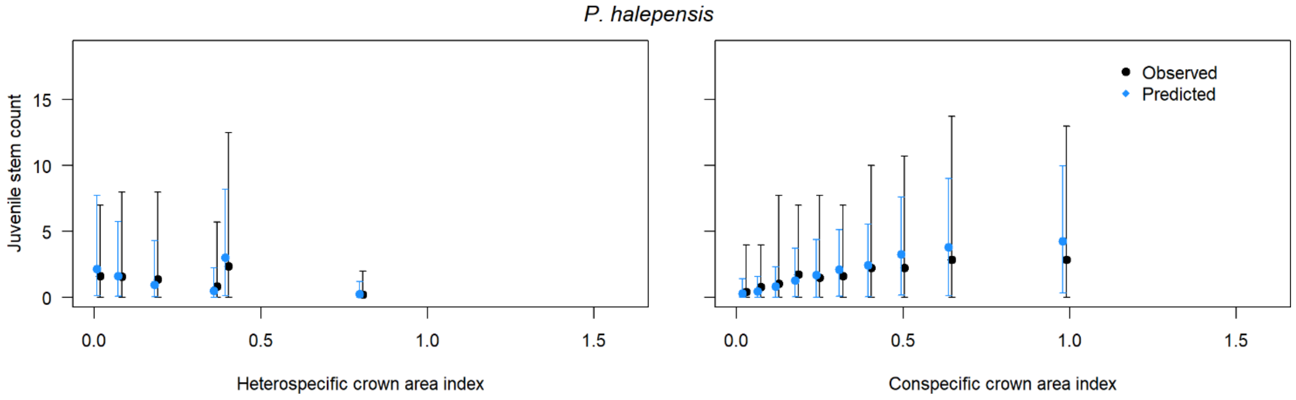


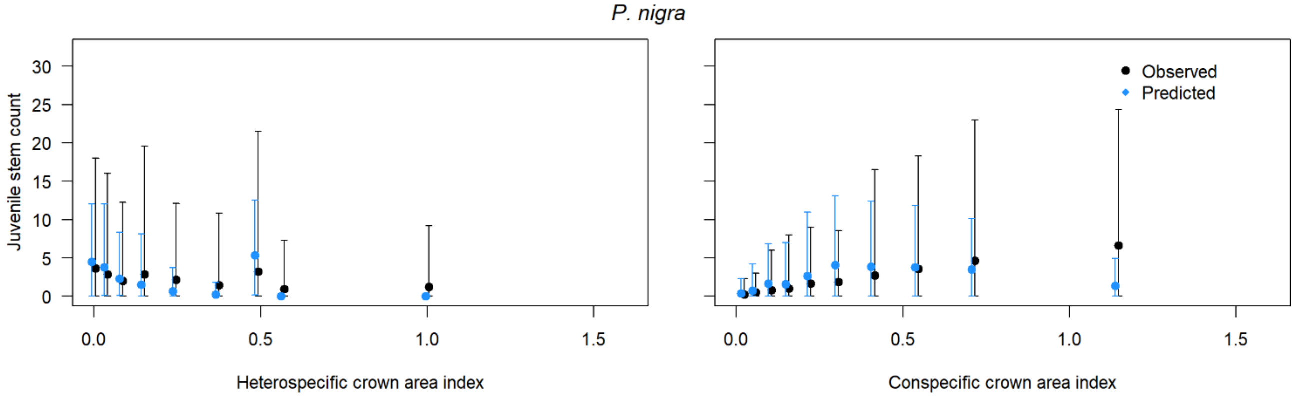
P. uncinata

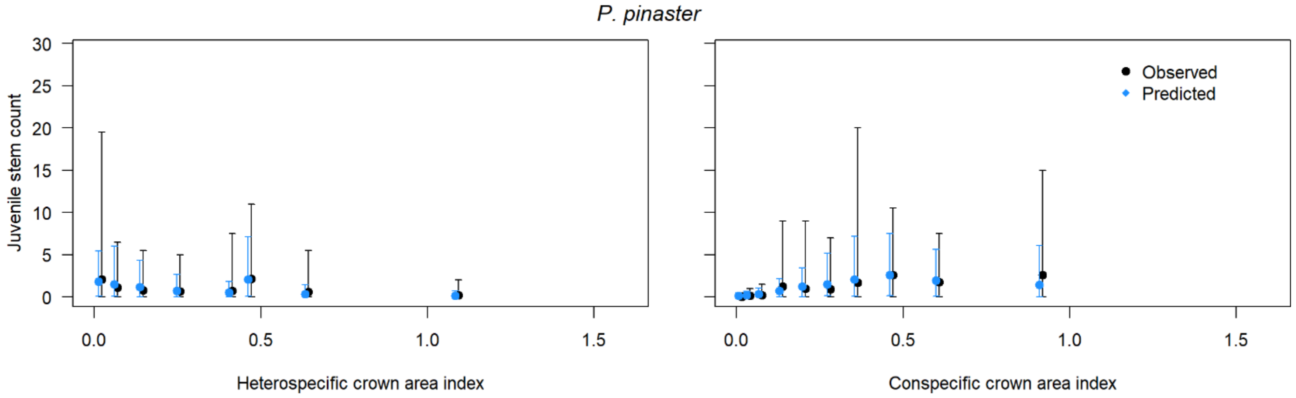


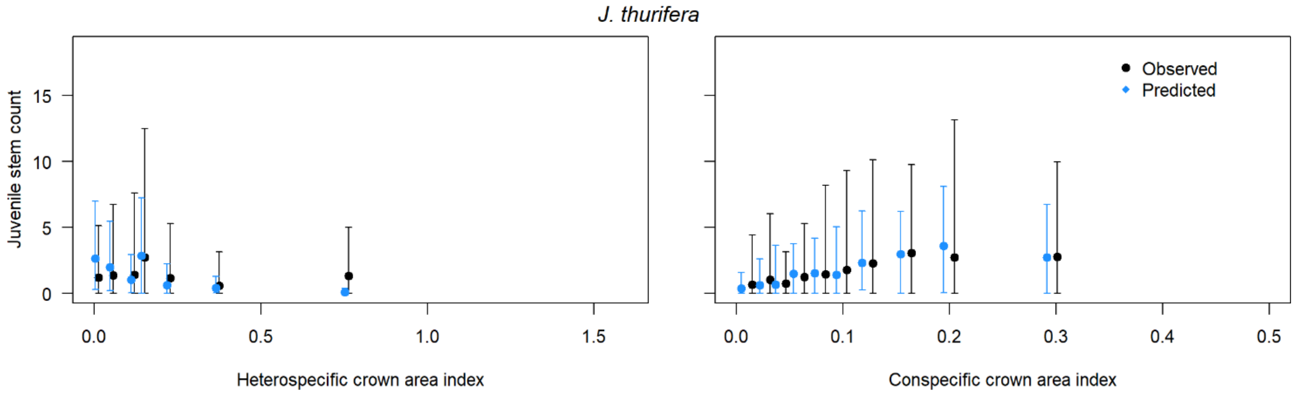
P. pinea

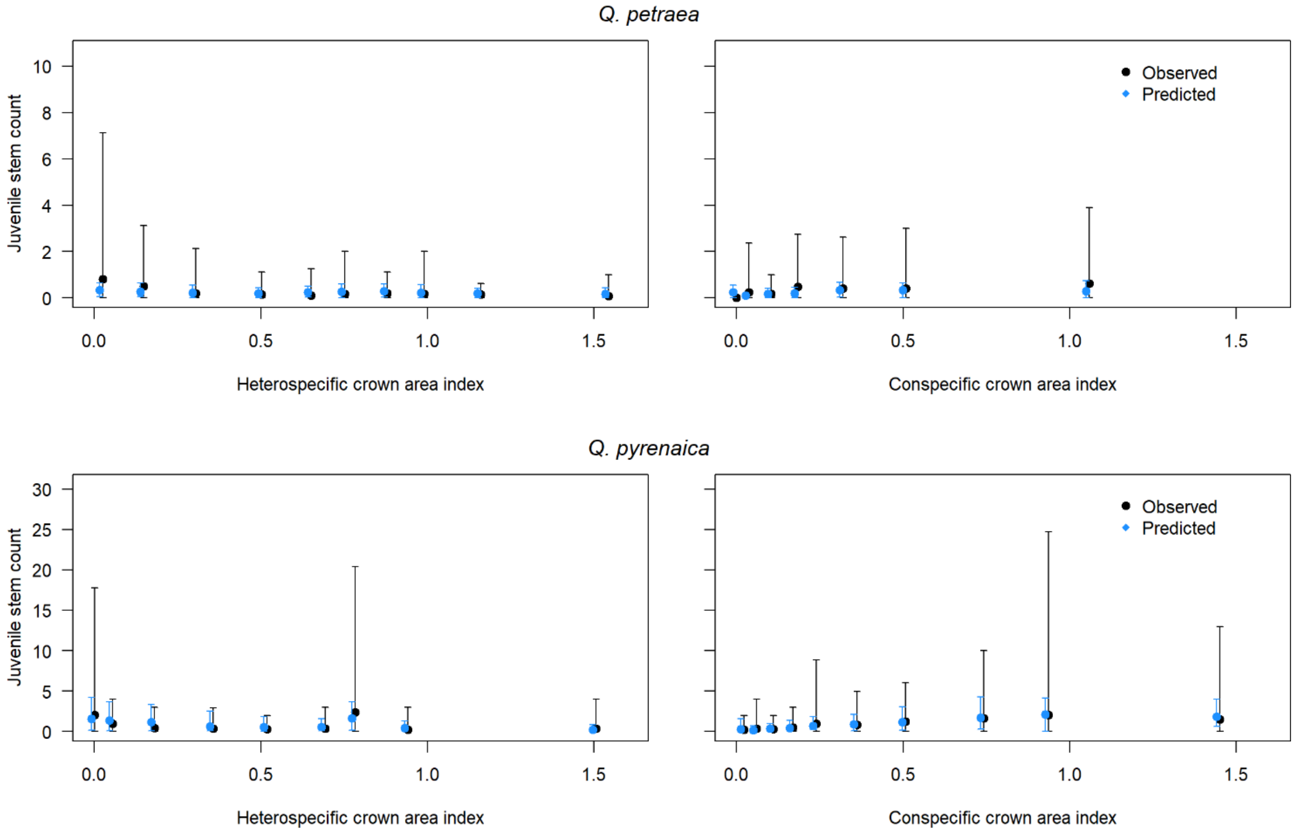


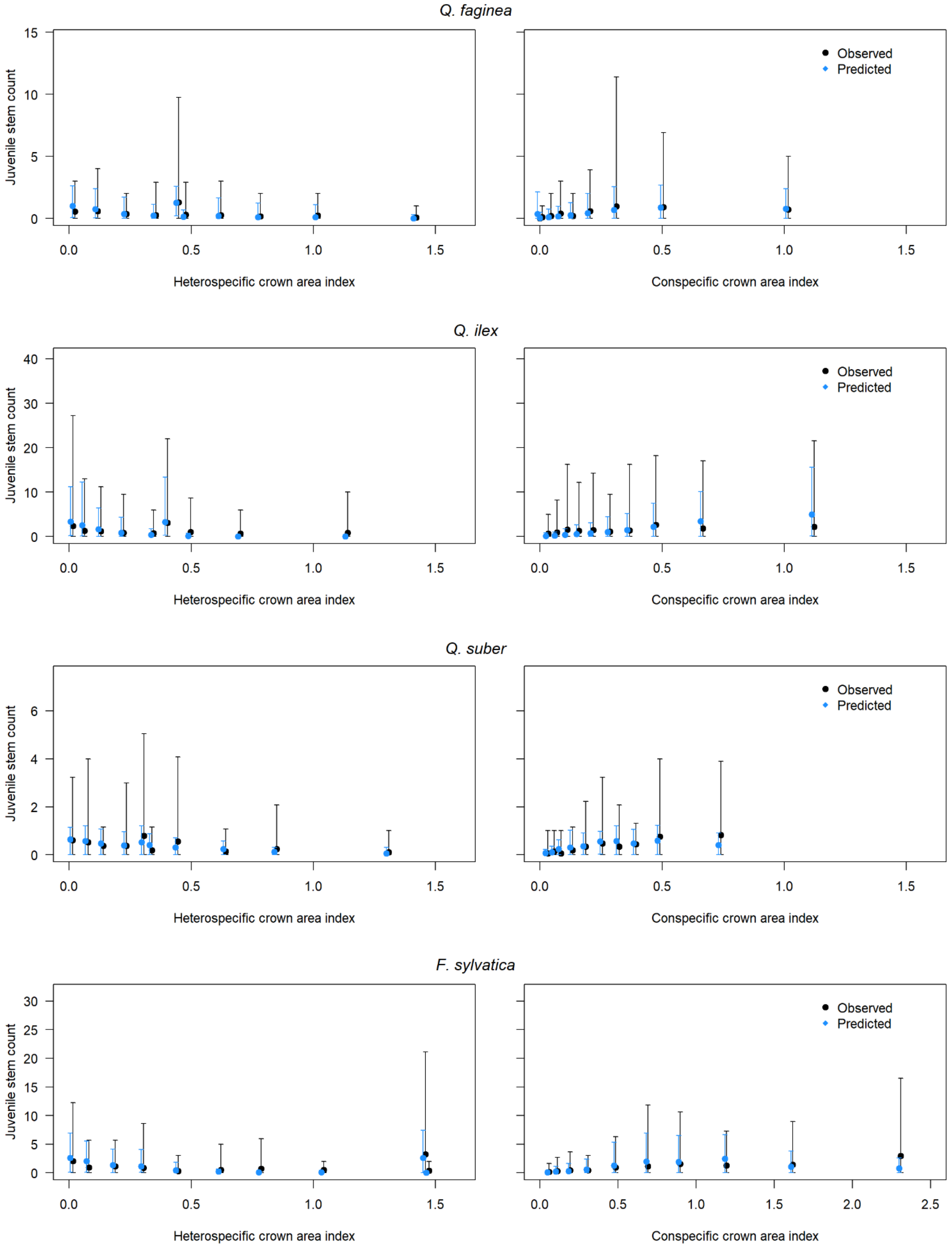

P. halepensis
Juvenile stem count
0
5
10
15
0.0
0.5
1.0
1.5
Heterospecific crown area index
Conspecific crown area index
● Observed
● Predicted


P. nigra
Juvenile stem count
0
5
10
15
20
25
30
0.0
0.5
1.0
1.5
Heterospecific crown area index
Conspecific crown area index
● Observed
● Predicted


P. pinaster
Juvenile stem count
0
5
10
15
20
25
30
0.0
0.5
1.0
1.5
Heterospecific crown area index
Conspecific crown area index
● Observed
● Predicted


J. thurifera
Juvenile stem count
0
5
10
15
0.0
0.5
1.0
1.5
0.0
0.1
0.2
0.3
0.4
0.5
Heterospecific crown area index
Conspecific crown area index
● Observed
● Predicted


Q. petraea
Juvenile stem count
0
2
4
6
8
10
0.0
0.5
1.0
1.5
Heterospecific crown area index
Conspecific crown area index
● Observed
◆ Predicted
Q. pyrenaica
Juvenile stem count
0
5
10
15
20
25
30
0.0
0.5
1.0
1.5
Heterospecific crown area index
Conspecific crown area index
● Observed
◆ Predicted


Q. faginea
Juvenile stem count
0
5
10
15
0.0
0.5
1.0
1.5
Heterospecific crown area index
Conspecific crown area index
● Observed
◆ Predicted
Q. ilex
Juvenile stem count
0
10
20
30
40
0.0
0.5
1.0
1.5
Heterospecific crown area index
Conspecific crown area index
● Observed
◆ Predicted
Q. suber
Juvenile stem count
0
2
4
6
0.0
0.5
1.0
1.5
Heterospecific crown area index
Conspecific crown area index
● Observed
◆ Predicted
F. sylvatica
Juvenile stem count
0
5
10
15
20
25
30
0.0
0.5
1.0
1.5
2.0
2.5
Heterospecific crown area index
Conspecific crown area index
● Observed
◆ Predicted