Comparison of Four Model Systems

The following notations will be used hereafter.

(Model system 1): using all the data, having two dummy variables, i.e., *Rddummy* and *Branch*;

(Model system 2): using data of analyzed stems without ramicorns, having a dummy variable, i.e., *Rddummy*;

(Model system 3): using data of analyzed stems with a *Rd* less than 1.5, having a dummy variable, i.e., *Branch*;

(Model system 4): using data of the analyzed stems without ramicorns and simultaneously with a *Rd* less than 1.5, having no dummy variable;

(*Branch)*: a dummy variable (Tree with ramicorns when *Branch* equals 1, tree without ramicorns when *Branch* equals 0);

(*Rddummy)*: also a dummy variable (*Rddummy*=1 if *Rd* < 1.5, and 0 otherwise);

(*natural)*: a dummy variables (Natural forest when *natural* equals 1, plantation when *natural* equals 0);

(*bt*), (DBH_{ob}), (*H*), (*h*), (*dib*) and (*vib*): bark thickness, diameter at breast height (1.3 m height from ground) over bark, total tree height; height from ground, diameter under bark at height *h* and stem total volume under bark;

(d^2h): $DBH_o \times DBH_{ob} \times H$;

(*tbt*), ($tDBH_{ob}$), (*tH*), td^2h and (*tvib*): transformed values of *bt*, DBH_{ob}, *H*, d^2h and *vib* by the Box-Cox method;

(*Rd*): relative diameter and equal to dib/DBH_{ib};

(*Rh*): relative height and equal to *h/H*;

(*Rhg*): relative height classes (%);

(*Y*) and (Z_i): calculated according to eqn.8 and eqn.6 in this manuscript;

(R^2): coefficient of determination;

(*RMSE*): root mean square errors;

(*Bias*): mean bias;

(*MAD*): mean absolute deviation;

(a_i), (b_i) and (c_i): model parameters.

Tab. S1 - Summary statistics of four data sets used for modelling.

Model type	Model system	Sample number	Range of age (year)	Range of *Rd*	Range of DBH_{ob}(cm)	Range of *H*(m)	Range of response variable
bt (cm)	1, 3	2358	16-84	0.01- 1.50	3.8-39.9	5.0-21.0	0.0-3.5
	2,4	2059	16-84	0.02- 1.50	3.8-22.6	5.0-18.2	0.0-3.0
vib (m^3)	1	1299	5-84	1.00	0.3-39.9	1.4-21.0	0.00001-0.649
	2	1201	5-84	1.00	0.3-23.1	1.4-18.2	0.00001-0.224
	3	1035	5-84	1.00	1.6-39.9	1.4-21.0	0.0002-0.649
	4	937	5-84	1.00	1.6-23.1	1.4-18.2	0.0002-0.224
dib (cm)	1	12814	5-84	0.01- 12.00	0.3-39.9	1.4-21.0	0.1-41.0
	2	11336	5-84	0.01- 12.00	0.3-23.1	1.4-18.2	0.1-25.5
	3	11419	5-84	0.01- 1.50	1.6-39.9	1.4-21.0	0.1-41.0
	4	9942	5-84	0.01- 1.50	1.6-23.1	1.4-18.2	0.1-25.5

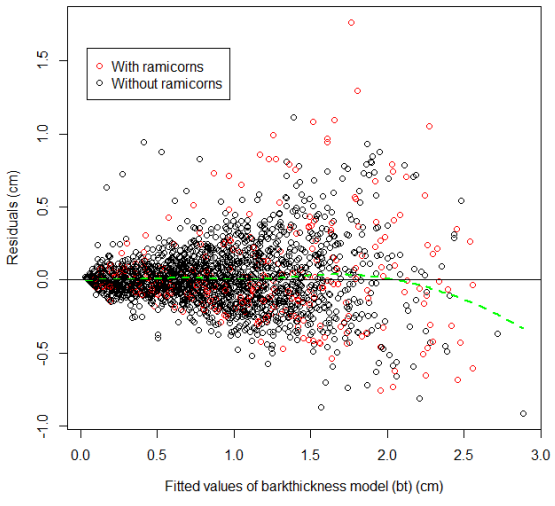
Tab. S2 - Values of fitting statistics for eight models (*tbt*, *tvib*, *Y*, *bt*, *vib* and *dib*).

Models type	Model system	Transformed models		Back-transformed models	
		R^2	*RMSE*	R^2	*RMSE*
bt (cm)	1,3	0.90	0.22	0.86	0.24
	2,4	0.94	0.15	0.92	0.15
vib (m^3)	1	0.99	0.061	0.99	0.006
	2	0.99	0.043	0.99	0.003
	3	0.99	0.066	0.99	0.006
	4	0.99	0.044	0.99	0.003
dib(cm)	1	0.91	0.32	0.97	0.84
	2	0.91	0.32	0.97	0.67
	3	0.95	0.21	0.97	0.80
	4	0.96	0.20	0.98	0.61

Tab. S3 - Results of *tbt* and *bt* models.

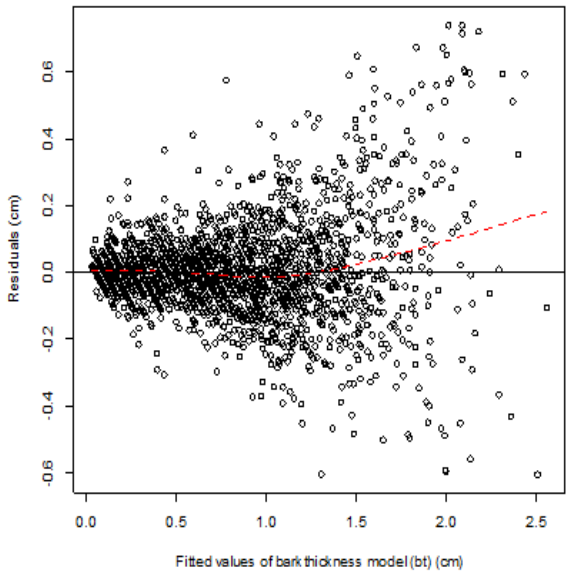
Model system 1, Model system 3

$tbt=a_0+a_1\times Branch\times tdib^5/10^5+a_2\times tdib+a_3\times Rh+a_4\times Rh^2+a_5\times Rh^3+a_6\times natural$



Model system 2, Model system 4

$tbt=a_0+a_1\times tdib^5/10^4+a_2\times tdib^4/10^3+a_3\times tdib^3/10^2+a_4\times tdib+a_5\times Rh+a_6\times Rh^2+a_7\times Rh^3+a_8\times Rh^4+ a_9\times natural$

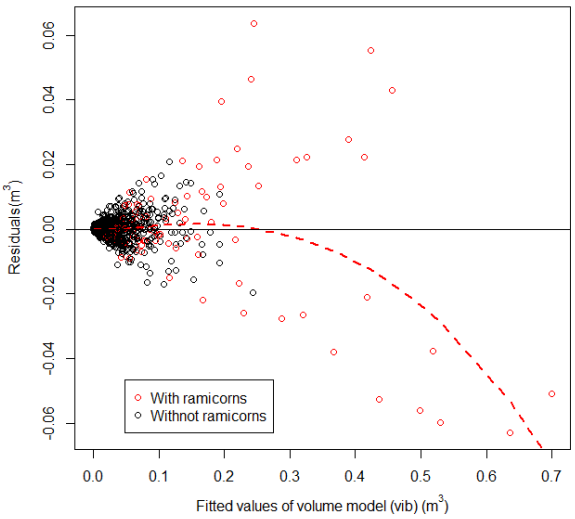


Note: all the data used for fitting *tbt* model are with a *Rd* <1.5, so there is not the variable of *Rddummy* for the *tbt* model in Model system 1 and Model system 2.

Tab. S4 - Results of *tvib* and *vib* models.

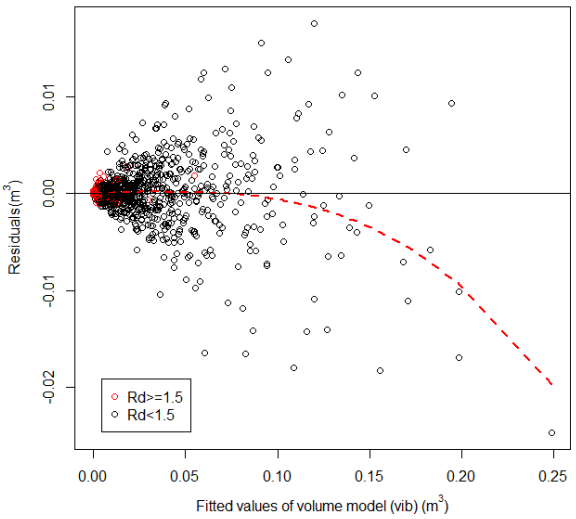
Model system 1

$tvib=b_0+b_1\times tDBHob\times Branch+b_2\times tDBHob+b_3\times Branch+b_4\times tH+b_5\times Rddummy+b_6\times tH\times Rddummy$



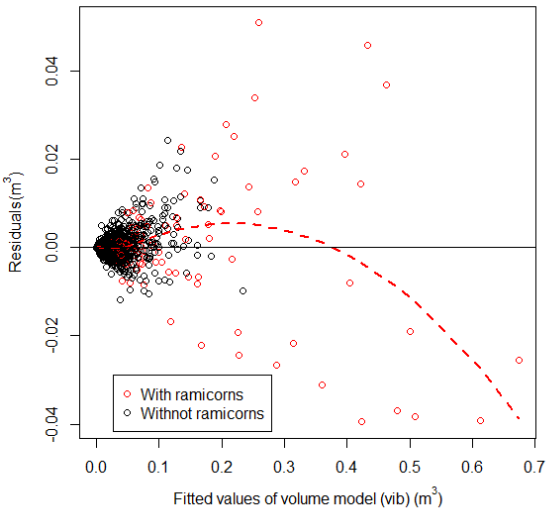
Model system 2

$tvib=b_0+b_1\times Rddummy+b_2\times tH+b_3\times Rddummy\times tH+b_4\times td^2h$



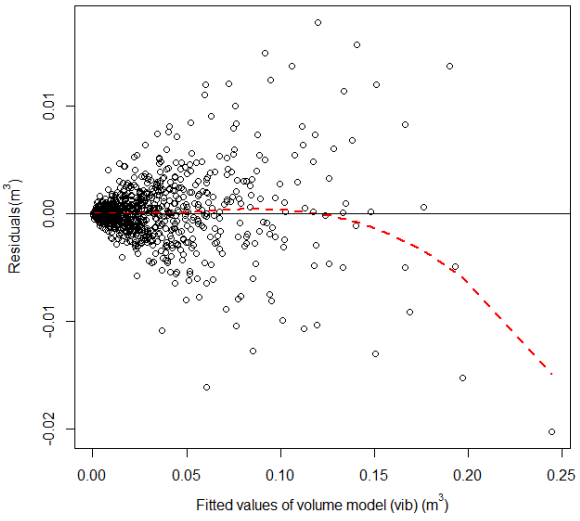
Model system 3

$tvib=b_0+b_1\times tDBHob\times Branch+b_2\times tDBHob+b_3\times Branch+b_4\times tH$



Model system 4

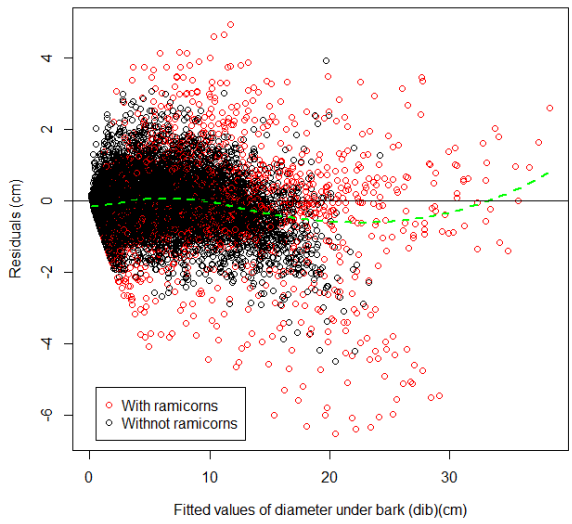
$tvib=b_0+b_1\times td^2\ h+b_2\times tH$



Tab. S5 - Results of *Y* and *dib* models.

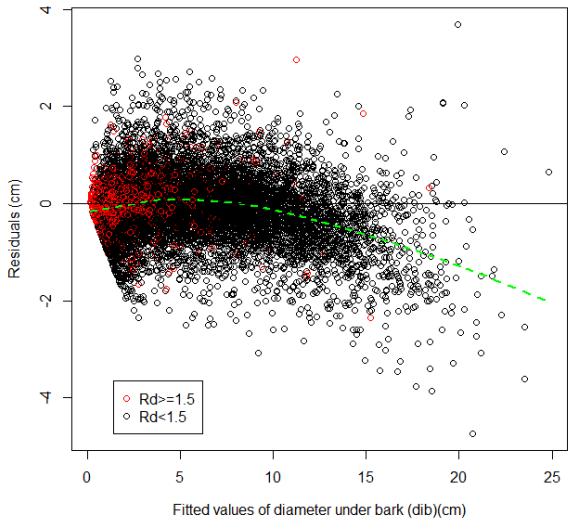
Model system 1

$Y=c_3\times Z_3+c_4\times Z_4+c_5\times(Rddummy+Branch+1)\times Z_5+c_6\times Z_6+(8\times(1-(c_3/4)-(c_4/5)-((c_5\times(Rddummy+Branch+1))/6)-(c_6/7)))\times Z_7$



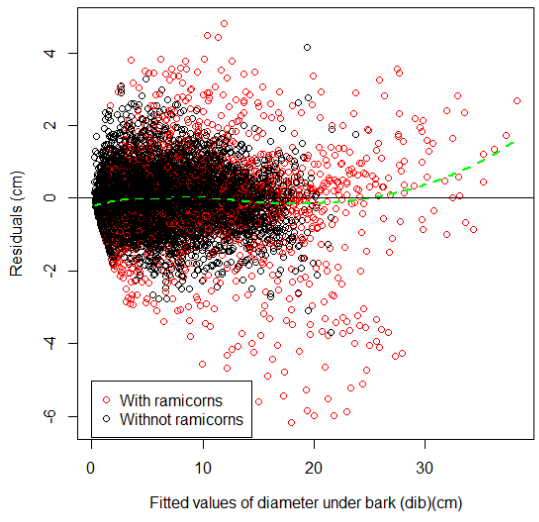
Model system 2

$Y=c_3\times Z_3+c_4\times Z_4+c_5\times Z_5+c_6\times(Rddummy+1)\times Z_6+(8\times(1-(c_3/4)-(c_4/5)-(c_5/6)-(c_6\times(Rddummy+1)/7)))\times Z_7$



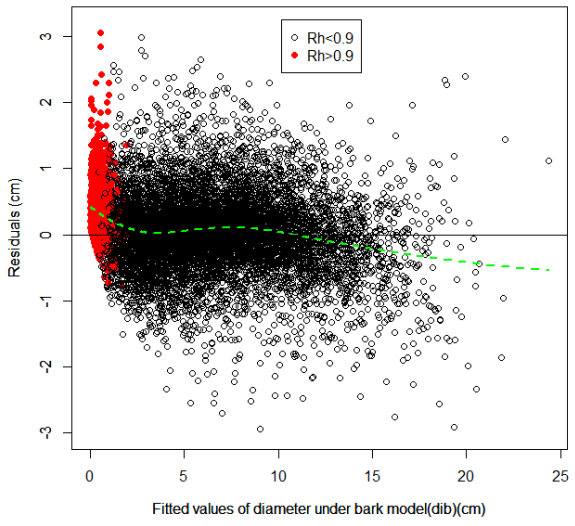
Model system 3

$Y=c_3\times Z_3+c_4\times(Branch+1)\times Z_4+c_5\times Z_5+c_6\times Z_6+(8\times(1-(c_3/4)-(c_4\times(Branch+1)/5)-(c_5/6)-(c_6/7)))\times Z_7$



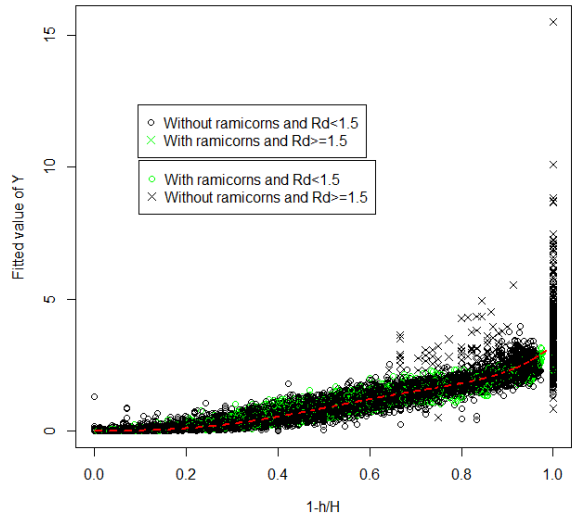
Model system 4

$Y=c_3\times Z_3+c_4\times Z_4+c_5\times Z_5+c_6\times Z_6+(8\times(1-(c_3/4)-(c_4/5)-(c_5/6)-(c_6/7)))\times Z_7$

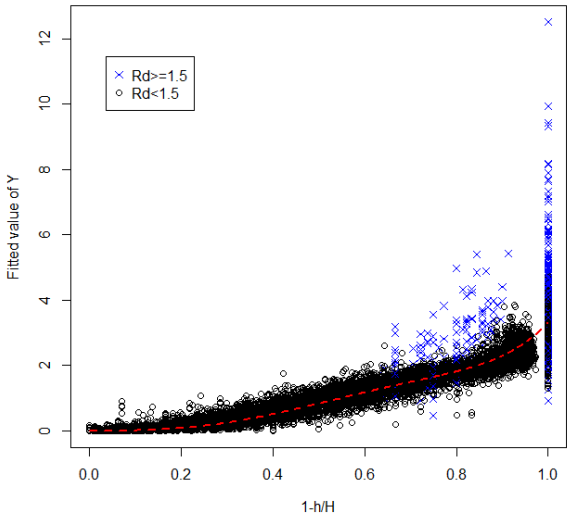


Tab. S6 - The estimated taper function (red dotted curve) and the basic taper data for each system.

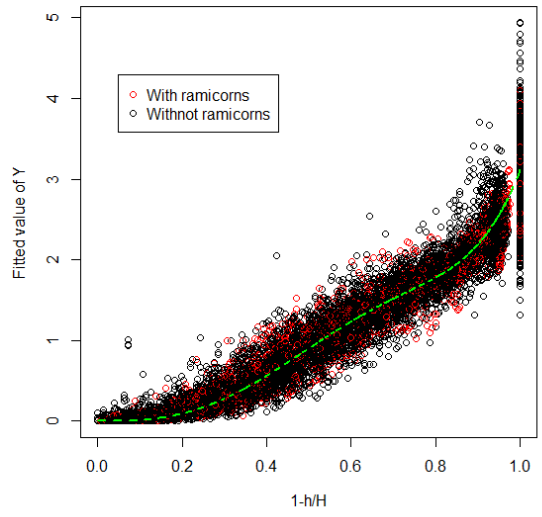
Model system 1



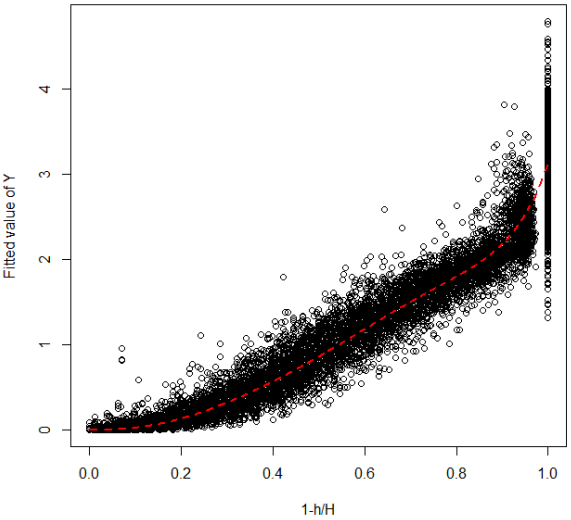
Model system 2



Model system 3



Model system 4



Tab. S7 – Frequencies, *Bias* and *MAD* of the *vib* model in system 4.

Item	DBH_{ob} class (cm)											
	2	4	6	8	10	12	14	16	18	20	22	Over all
Frequencies	25	92	154	175	176	127	87	56	27	13	5	937
Bias (10^{-3} m^3)	-0.05	-0.04	0.04	0.03	0.09	0.31	0.39	-0.59	1.66	2.28	-10.6	0.09
MAD (10^{-3} m^3)	0.13	0.30	0.55	0.92	1.57	2.43	3.26	4.05	4.32	8.32	10.79	1.76

Tab. S8 - Frequencies, *Bias* and *MAD* of *dib* model in system 4.

Rhg (%)	Fit data			Validation data			Entire data		
	Freq.	*Bias* (cm)	*MAD* (cm)	Freq.	*Bias* (cm)	*MAD* (cm)	Freq.	*Bias* (cm)	*MAD* (cm)
5	1473	-0.04	0.37	373	-0.23	0.57	1846	-0.04	0.37
15	1135	0.01	0.29	292	-0.11	0.25	1427	-0.01	0.29
25	743	0.05	0.37	196	-0.08	0.36	939	0.03	0.38
35	687	0.05	0.45	172	0.02	0.53	859	0.04	0.47
45	677	0.14	0.53	181	-0.03	0.56	858	0.09	0.53
55	632	0.12	0.59	162	-0.01	0.69	794	0.08	0.60
65	621	0.08	0.60	161	-0.07	0.60	782	0.03	0.60
75	620	0.07	0.52	164	-0.06	0.56	784	0.04	0.53
85	651	0.16	0.47	167	0.06	0.45	818	0.15	0.47
95	668	0.38	0.43	167	0.46	0.51	835	0.40	0.45
Over all	7907	0.08	0.44	2035	-0.03	0.50	9942	0.06	0.45