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Supplementary material for

Comparison of vapour-exchange methods for predicting hourly twig fuel moisture contents of Larch and Birch stands in Daxinganling Region, China

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Supplementary Appendix SA: Materials and methods

Field experiment

The study area was located at the Pangu Forest Farm, Tahe Forestry Bureau, Daxinganling Region, China (Fig. S1), with an elevation range between 300 to 900 mm. Annual mean rainfall is 430 mm, and annual mean temperature is 2.88℃ with highest temperature is 35.2℃ (in July of the year). The zonal soil is Umbri-Gelic Cambosols (Cooperative Research Group on Chinese Soil Taxonomy, Chinese Soil Taxonomy). The dominate vegetation in the study area consists largely of *Larix gmelinii* and *Betula platyphylla*.

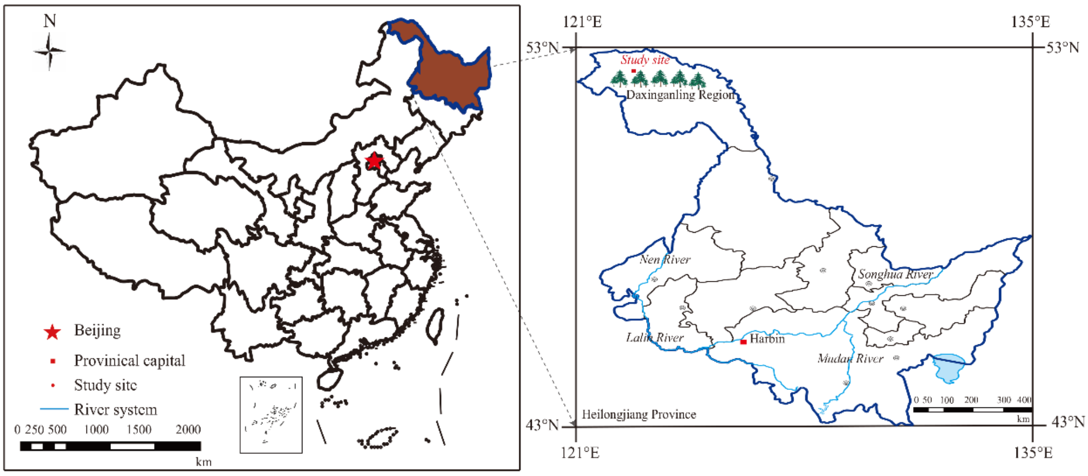

Fig. S1. Geographical research site in this study.

Model evaluation and description

In this research, two τ models were used: The Nelson Eq. (1) and Simard Eq. (2) functions were described in literatures (Simard 1968; Catchpole *et al*. 2001).

The Nelson equation is given by:

$$E = \alpha + \beta \ln(-RT_a / m \ln RH) \tag{1}$$

where E is equilibrium moisture content (%), R is the gas constant (8.314 $J.mol^{-1}.K^{-1}$), m is the molecular mass of water (18.015 g.mol^{-1}), and α and β are the empirically determined parameters.

The Simard equation is given by:

$$E = \begin{cases} 0.03 + 0.2626RH - 0.00104RHT_a & (\text{if } RH < 10) \\ 1.76 + 0.1601RH - 0.0266T_a & (\text{if } 10 \le RH < 50) \\ 21.06 - 0.4944RH + 0.005565RH^2 - 0.00063RHT_a & (\text{if } RH > 50) \end{cases} \quad (2)$$

The direct regression model is a multiple linear model in the following form see Eq. (3). The direct regression model is given by:

$$M(T_i) = b_0 + b_1T_i + b_2T_i + b_3T_i + b_4T_i \quad (3)$$

where T_i is the weather variable for the current temperature (°C). b_0-b_4 are the estimated parameters.

Data processing

To improve the accuracy of modelling, a 1-h interval was used for modelling. Moisture contents above 35%, i.e., the fibre saturation point, were also included in the analysis to simulate the FMC of twigs under the field conditions. In previous experiments, modelling avoided the problems caused by condensation and precipitation effects for fire behaviour based on a 24 h sampling period (Nelson 2000). Thus, the variation of meteorological factors reached a stable state in a broader time range of 24 h. In this study, these effects were considered for practical uses, and models were developed with an adequate accuracy of 1% (Trevitt 1991) based on 1-hour intervals; this was done to realize close to real-time and real-situation fuel moisture predictions as required by hazard reduction burning. Two rainfall events were observed during the experimental period. A rainfall intensity of 0.20 mm h^{-1} occurred in plots 1, 2, 5, and 6 and lasted during the sampling sequence of 32–47, and a rainfall intensity of 0.10 mm h^{-1} occurred in plots 3, 4, 7, and 8 and lasted during the sampling sequence of 24–39; the average diameter of each rain drop was less than 0.75 mm.

For each of the 48 datasets (multiply eight plots by three diameter classes and two degree of decay), parameters were estimated using the τ methods and the direct regression method, yielding 48 different models. Nonlinear regression was conducted using MATLAB 6.1 (MathWorks, Natick, MA, USA). The parameters for the direct regression model were estimated by the forward stepwise regression method. Plotting was completed with the OriginLab's OriginPro 9.0 software (OriginLab Inc., Northampton, MA, USA). For each of the datasets with a sample size of n, n-fold cross validations were used to compute model accuracy. The mean absolute error (MAE) and mean relative error (MRE) were then computed for each model:

$$MRE = \frac{1}{n}\sum_{i=1}^{n}\left[\frac{M_i - M'_i}{M_i}\right] \tag{4}$$

$$MAE = \frac{1}{n}\sum_{i=1}^{n}\left[M_i - M'_i\right] \tag{5}$$

where M_i and M'_i are the observed and predicted fuel moisture content values for i validation, respectively, n is the number of observations (n=80).

Each model was estimated using the two vapour-exchange methods, and one regression method applied to the other plots of larch and birch stands for extrapolation analysis, the variation coefficient (VC) of the model parameters obtained from the n-fold cross validations of the model were calculated (n=132). For each of the methods, the minimum, maximum and VC of the MAEs and MREs were computed.

To test whether EMC model parameters varied with fuel types and categories, we reclassified these plots into two general treatment groups based on the larch/birch ratio (plots 1–4 (larch) and plots 5–8 (birch)), then the models were obtained for each treatment (two levels of larch/birch ratio (72 models for each level), two levels of decay classes (36 models for each level), and three levels of fuel diameter classes (24 models for each level)). Finally, the model parameters values were averaged and then the standard errors were also obtained and compared, thus, model performance for each of these treatments can be reported, so we can understand if the models work better or worse for each of the treatment levels.

Supporting references

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Supplementary Appendix SB: Results of variations of temperature, relative humidity and fuel moisture change in sampling sites

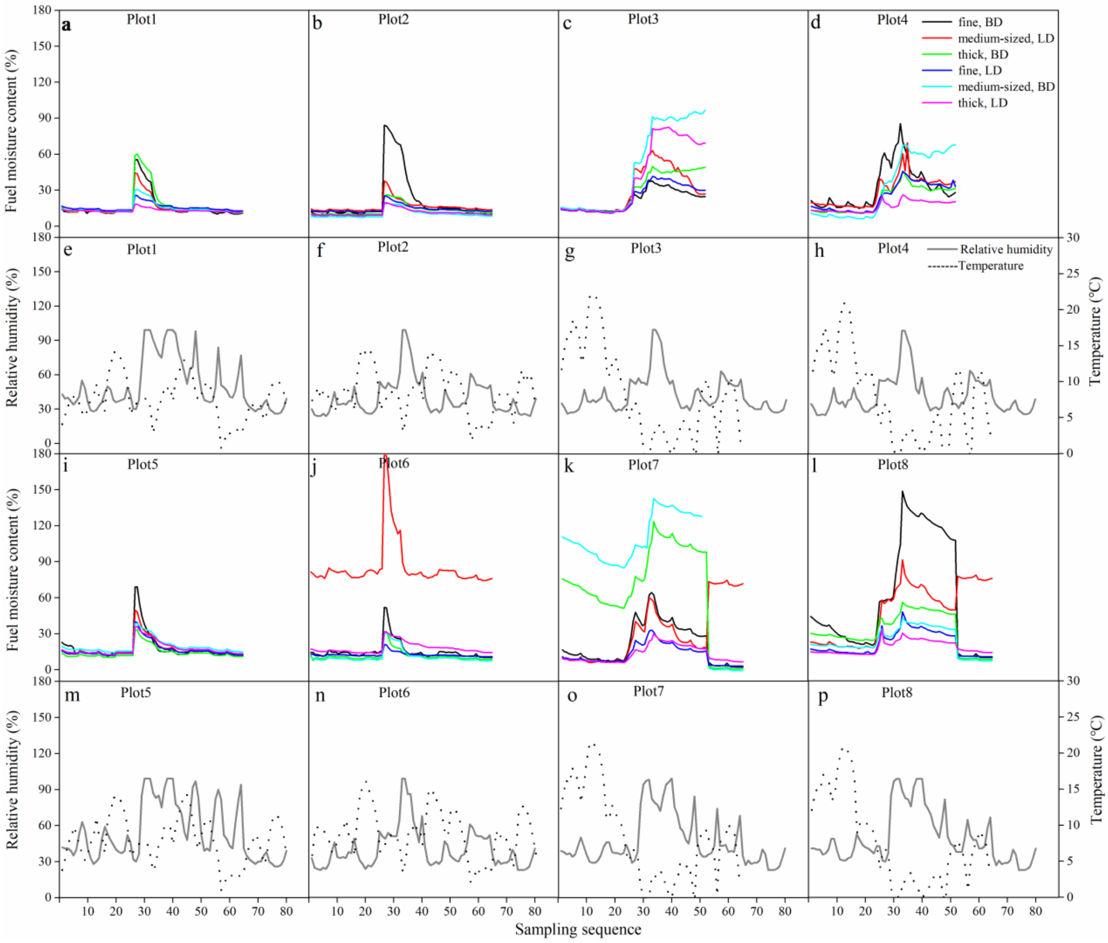

Fig. S2. Dynamics of measured fuel moisture contents and variation changes of measured air temperature and relative humidity in sampling plots. The number of observations is 80. BD is badly decomposed twigs; LD is lightly decomposed twigs. Diameter classes were divided into 0.0–0.6 cm (fine), 0.7–2.5 cm (medium-sized), and 2.6–7.6 cm (thick),

The sampling sequences and moisture contents were remaining consistent; the time was from 10:00–17:00 in the daytime (10 consecutive days). The temperature averaged 7.7°C, 8.6°C, 8.5°C, 7.8°C, 8.1°C, 8.9°C, 8.6°C and 7.7°C, and the relative humidity averaged 0.43, 0.40, 0.56, 0.60, 0.42, 0.41, 0.51 and 0.55 in plots 1 to 8.

Plot1: upper position of south-facing slope; Plot2: middle position of south-facing slope; Plot3: lower position of south-facing position; Plot4: lower position of north-facing slope; Plot5: upper position of south-facing slope; Plot6: middle position of south-facing slope; Plot7: lower position of south-facing position; Plot8: lower position of north-facing slope. Parameters for models established using the Nelson method is defined in Eq. (1). MAE is mean absolute error, MRE is mean relative error. τ is time lag. α and β are empirically parameters. R^2 is the coefficient of determination.

Supplementary Appendix SC: Accuracy of all the models for the three methods

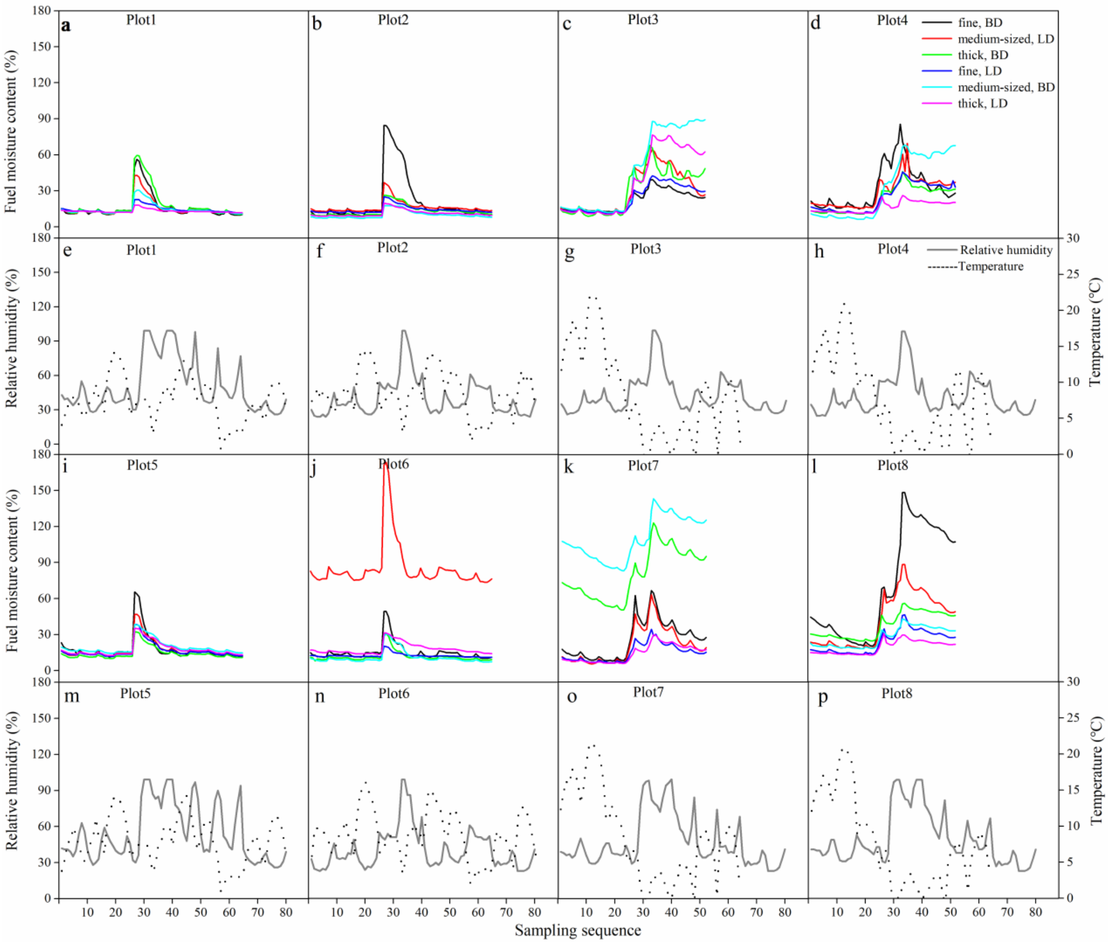

Fig. S3. Dynamics of predicted fuel moisture contents with Nelson models in sampling plots.

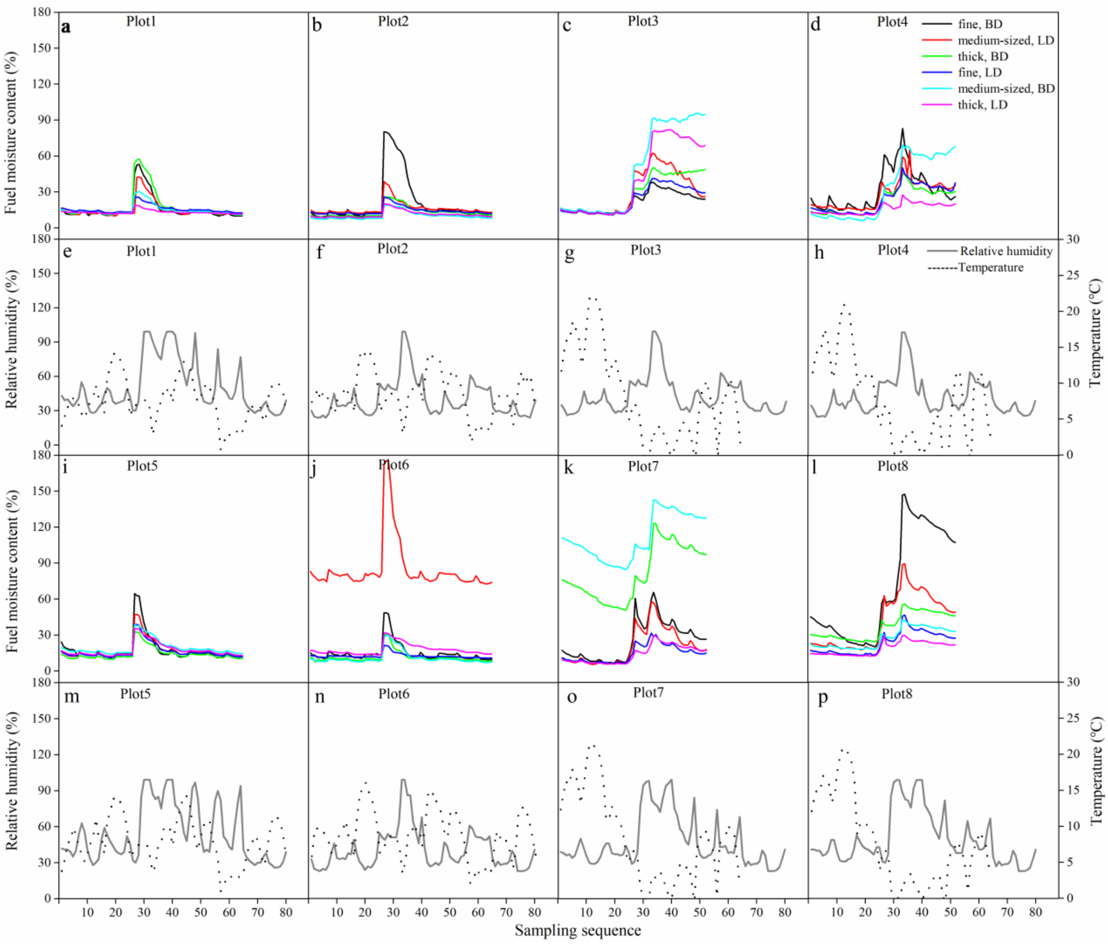

Fig. S4. Dynamics of predicted fuel moisture contents with Simard models in sampling plots.

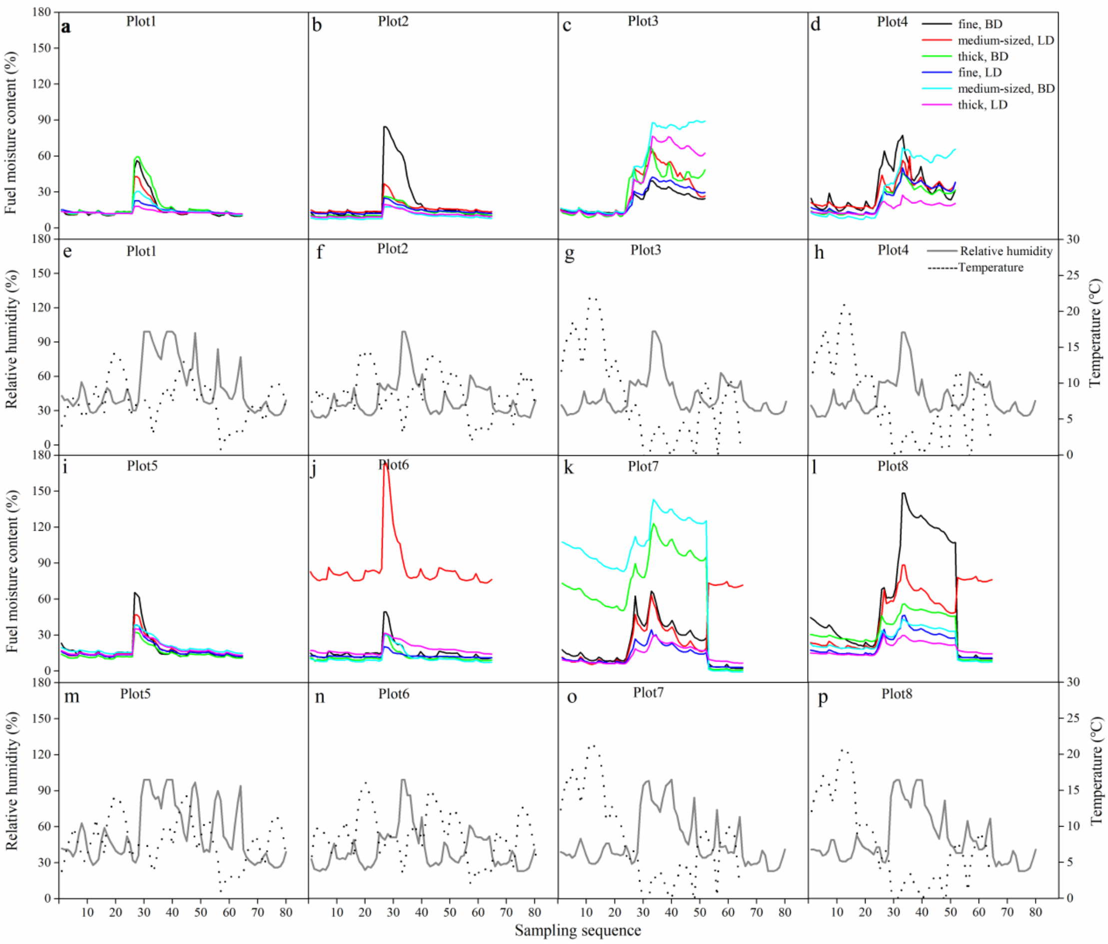

Fig. S5. Dynamics of predicted fuel moisture contents with direct regression models in sampling plots.

Supplementary Appendix SD: Parameterization of Nelson, Simard, and direct regression models

Table S1. Estimated parameters and errors of models established using the Nelson method

n	Fuel category	MAE	MRE	α	β	τ	R^2
Plot1	fine BD	0.00930	0.0543	0.638	–0.110	4.809	0.986
	medium–sized BD	0.00710	0.0361	0.658	–0.116	7.996	0.994
	thick BD	0.00310	0.0190	0.357	–0.0565	7.255	0.992
	fine LD	0.00550	0.0338	0.369	–0.0535	5.273	0.988
	medium–sized LD	0.00180	0.0116	0.0867	–0.00370	5.219	0.989
	thick LD	0.00120	0.00850	0.155	–0.00770	8.122	0.987
Plot2	fine BD	0.00920	0.0431	0.880	–0.164	9.186	0.995
	medium–sized BD	0.00200	0.0139	0.307	–0.043	11.989	0.995
	thick BD	0.00170	0.0139	0.0438	–0.000100	14.218	0.994
	fine LD	0.00370	0.0202	0.266	–0.0253	5.124	0.990
	medium–sized LD	0.00140	0.00890	0.209	–0.0176	8.986	0.996
	thick LD	0.00130	0.0100	0.177	–0.0176	12.263	0.997
Plot3	fine BD	0.00740	0.0296	0.623	–0.0995	13.704	0.980
	medium–sized BD	0.00710	0.0230	2.390	–0.497	7.502	0.825
	thick BD	0.00960	0.0236	0.622	–0.0988	13.178	0.998
	fine LD	0.0117	0.0379	0.996	–0.190	15.573	0.991
	medium–sized LD	0.00560	0.0219	0.871	–0.163	28.763	0.994
	thick LD	0.00930	0.0291	0.712	–0.137	7.169	0.995
Plot4	fine BD	0.0236	0.0643	0.929	–0.164	3.993	0.964
	medium–sized BD	0.00810	0.0331	0.679	–0.118	10.566	0.987
	thick BD	0.0110	0.0378	0.681	–0.0966	13.695	0.997
	fine LD	0.0277	0.0827	0.630	–0.0886	3.955	0.844
	medium–sized LD	0.00920	0.0354	0.678	–0.115	12.234	0.983
	thick LD	0.00660	0.0349	0.371	–0.0522	6.938	0.953
Plot5	fine BD	0.0113	0.0556	0.517	–0.0808	3.308	0.980
	medium–sized BD	0.00310	0.0212	0.264	–0.0328	6.867	0.989
	thick BD	0.00260	0.0125	0.332	–0.0409	11.451	0.995
	fine LD	0.00610	0.0303	0.357	–0.0474	5.408	0.986
	medium–sized LD	0.00400	0.0210	0.302	–0.0369	6.629	0.989
	thick LD	0.00290	0.0152	0.293	–0.0362	11.552	0.995
Plot6	fine BD	0.00940	0.0516	0.471	–0.0701	1.983	0.972
	medium–sized BD	0.00570	0.0439	0.299	–0.0403	2.462	0.965
	thick BD	0.00380	0.0303	0.356	–0.0565	7.255	0.990
	fine LD	0.0208	0.0213	1.663	–0.180	2.743	0.980
	medium–sized LD	0.00230	0.0162	0.175	–0.0113	3.752	0.968
	thick LD	0.00260	0.0142	0.230	–0.0203	16.784	0.995
	fine BD	0.0205	0.0586	1.056	–0.175	5.174	0.965
	medium–sized BD	0.0142	0.0167	2.456	–0.396	7.075	0.960

Plot7	thick BD	0.0113	0.00990	2.992	–0.486	12.788	0.967
	fine LD	0.0148	0.0451	1.017	–0.177	6.046	0.969
	medium–sized LD	0.00730	0.0287	0.688	–0.111	8.694	0.978
	thick LD	0.00430	0.0179	0.712	–0.118	15.236	0.990
Plot8	fine BD	0.0187	0.0310	4.713	–0.971	33.880	0.995
	medium–sized BD	0.00740	0.0187	1.268	–0.212	20.727	0.983
	thick BD	0.00590	0.0201	0.906	–0.152	18.231	0.987
	fine LD	0.0181	0.0405	1.443	–0.253	11.181	0.984
	medium–sized LD	0.0102	0.0369	0.733	–0.121	9.619	0.967
	thick LD	0.00900	0.0397	0.482	–0.0687	7.240	0.916
Mean		0.00834	0.0297				0.977

Table S2. Estimated parameters and errors of models established using Simard method

Parameters for models established using the Simard method is defined in Eq. (2).

n	Fuel category	MAE	MRE	τ	R^2
Plot1	fine BD	0.00870	0.0504	11.080	0.979
	medium–sized BD	0.00630	0.0327	13.654	0.991
	thick BD	0.00320	0.0204	16.670	0.991
	fine LD	0.00630	0.0406	8.976	0.987
	medium–sized LD	0.00230	0.0142	26.029	0.990
	thick LD	0.00130	0.00920	64.126	0.986
Plot2	fine BD	0.00980	0.0417	13.132	0.993
	medium–sized BD	0.00230	0.0160	16.168	0.995
	thick BD	0.00140	0.0125	15.411	0.997
	fine LD	0.00480	0.0267	15.701	0.989
	medium–sized LD	0.00200	0.0129	25.401	0.996
	thick LD	0.00140	0.0110	21.506	0.997
Plot3	fine BD	0.00680	0.0273	35.152	0.973
	medium–sized BD	0.00690	0.0255	–11443.208	0.994
	thick BD	0.0108	0.0294	–167.499	0.997
	fine LD	0.0134	0.0433	29.768	0.987
	medium–sized LD	0.00590	0.0240	46.038	0.991
	thick LD	0.00960	0.0283	320.812	0.997
Plot4	fine BD	0.0292	0.0757	15.208	0.926
	medium–sized BD	0.00920	0.0360	19.588	0.978
	thick BD	0.0133	0.0525	–384.377	0.994
	fine LD	0.0256	0.0683	13.175	0.817
	medium–sized LD	0.00990	0.0362	23.646	0.977
	thick LD	0.00700	0.0380	10.473	0.940
Plot5	fine BD	0.0121	0.0621	6.471	0.976
	medium–sized BD	0.00400	0.0275	10.668	0.988
	thick BD	0.00330	0.0165	20.740	0.995
	fine LD	0.00670	0.0367	10.200	0.985
	medium–sized LD	0.00470	0.0277	12.532	0.988
	thick LD	0.00320	0.0180	18.126	0.995
Plot6	fine BD	0.0108	0.0628	6.846	0.962
	medium–sized BD	0.00600	0.0489	7.066	0.957
	thick BD	0.00390	0.0304	8.720	0.989
	fine LD	0.0238	0.0251	44.116	0.971
	medium–sized LD	0.00210	0.0154	74.517	0.965
	thick LD	0.00280	0.0150	32.059	0.995
	fine BD	0.0217	0.0556	18.171	0.942
	medium–sized BD	0.0145	0.0165	172.741	0.982
	thick BD	0.0118	0.0104	480.892	0.974

Plot7	fine LD	0.0163	0.0509	18.102	0.951
	medium–sized LD	0.00810	0.0323	25.974	0.965
	thick LD	0.00490	0.0210	30.779	0.984
Plot8	fine BD	0.0218	0.0377	99.042	0.989
	medium–sized BD	0.00690	0.0174	133.045	0.972
	thick BD	0.00600	0.0207	53.797	0.976
	fine LD	0.0180	0.0379	37.239	0.973
	medium–sized LD	0.0105	0.0378	20.616	0.951
	thick LD	0.00840	0.0366	18.389	0.897
Mean		0.00895	0.0320		0.974

Table S3. Estimated parameters and errors of models established using direct regression method

Parameters for models established using the direct regression method is defined in Eq. (3). b_0-b_4 are constant.

n	Fuel category	MAE	MRE	b_0	b_1	b_2	b_3	R^2
Plot1	fine BD	0.0422	0.278	–2.628	–0.00460	–0.0126	0.0136	0.770
	medium–sized BD	0.0546	0.338	–3.659	–0.00630	–0.141	0.0189	0.732
	thick BD	0.0216	0.145	–1.188	–0.00270	–0.0798	0.00710	0.713
	fine LD	0.0304	0.205	–1.649	–0.00130	0.0286	0.00710	0.754
	medium–sized LD	0.0159	0.102	–0.536	–0.000900	–0.0456	0.00310	0.608
	thick LD	0.00760	0.0578	–0.158	–0.000100	–0.00660	0.00110	0.602
Plot2	fine BD	0.0889	0.525	–8.418	0.00360	0.0521	0.0253	0.722
	medium–sized BD	0.0234	0.177	–1.490	–0.00110	–0.0515	0.00650	0.624
	thick BD	0.0169	0.162	–1.123	–0.00110	–0.0480	0.00520	0.598
	fine LD	0.0221	0.134	–1.362	0.00210	0.101	0.00290	0.727
	medium–sized LD	0.0154	0.106	–0.957	0.000300	0.00620	0.00330	0.675
	thick LD	0.0148	0.129	–0.832	–0.000300	–0.0166	0.00340	0.608
Plot3	fine BD	0.0559	0.280	2.052	–0.0115	–0.137	0.00480	0.505
	medium–sized BD	0.116	0.561	5.089	–0.0254	–0.379	0.00850	0.364
	thick BD	0.269	1.100	12.074	–0.0582	–0.937	0.0176	0.339
	fine LD	0.107	0.485	3.867	–0.0250	–0.349	0.0118	0.548
	medium–sized LD	0.0784	0.410	3.257	–0.0170	–0.260	0.00620	0.436
	thick LD	0.222	0.970	10.160	–0.0461	–0.784	0.0120	0.346
Plot4	fine BD	0.0883	0.280	1.609	–0.00480	0.134	–0.000900	0.659
	medium–sized BD	0.0691	0.368	2.205	–0.00370	0.0605	–0.00370	0.480
	thick BD	0.197	1.189	5.691	–0.00430	0.242	–0.0150	0.304
	fine LD	0.0749	0.285	2.224	–0.000200	0.151	–0.00710	0.475
	medium–sized LD	0.0802	0.388	2.415	–0.000800	0.118	–0.00720	0.408
	thick LD	0.0314	0.192	0.925	–0.000600	0.0375	–0.00220	0.423
Plot5	fine BD	0.0494	0.266	–2.601	0.00980	0.369	–0.000800	0.655
	medium–sized BD	0.0232	0.165	–1.328	0.000300	0.0104	0.00450	0.673
	thick BD	0.0317	0.165	–1.862	–0.000500	–0.0600	0.00730	0.592
	fine LD	0.0340	0.200	–2.225	0.00300	0.118	0.00490	0.696
	medium–sized LD	0.0282	0.174	–1.690	0.00170	0.0488	0.00440	0.664
	thick LD	0.0298	0.174	–1.799	0.000100	–0.0446	0.00650	0.586
Plot6	fine BD	0.0274	0.166	–1.895	0.00640	0.320	0.000200	0.786
	medium–sized BD	0.0170	0.139	–1.174	0.00220	0.146	0.00200	0.760
	thick BD	0.0239	0.217	–1.977	0.00150	0.0944	0.00550	0.727
	fine LD	0.0775	0.0859	–5.053	0.0108	0.794	0.00840	0.778
	medium–sized LD	0.00800	0.0602	–0.480	0.00160	0.0662	0.000400	0.715
	thick LD	0.0254	0.144	–1.294	0.000100	0.0131	0.00480	0.546

Plot7	fine BD	0.0862	0.340	3.074	–0.0268	–0.482	0.0165	0.622
	medium–sized BD	0.172	0.220	6.380	–0.0310	–0.746	0.0117	0.220
	thick BD	0.152	0.139	5.523	–0.0237	–0.626	0.00850	0.155
	fine LD	0.0720	0.301	2.608	–0.0245	–0.454	0.0157	0.669
	medium–sized LD	0.0388	0.188	1.427	–0.0115	–0.213	0.00690	0.620
	thick LD	0.0483	0.244	2.292	–0.0133	–0.283	0.00600	0.421
Plot8	fine BD	0.325	0.806	16.706	–0.0908	–1.813	0.0350	0.359
	medium–sized BD	0.0753	0.222	3.930	–0.0224	–0.420	0.00990	0.410
	thick BD	0.0548	0.217	3.137	–0.0172	–0.319	0.00710	0.462
	fine LD	0.132	0.433	6.9011	–0.0483	–0.8472	0.0250	0.558
	medium–sized LD	0.0600	0.291	3.1093	–0.0182	–0.3495	0.00800	0.495
	thick LD	0.0358	0.200	1.726	–0.0121	–0.2068	0.00660	0.524
Mean		0.0702	0.300					0.565

Supplementary Appendix SE: Assessment of model robustness

Table S4. Mean, maximum, minimum, and variation coefficient of mean absolute error (MAE) and mean relative error (MRE) estimated by extrapolation analysis of all models using the Nelson, Simard, and direct regression methods

Method	Error	Mean value	Maximum value	Minimum value	Variation coefficient
Nelson	MAE	0.0268	0.385	0.00108	1.197
	MRE	0.0909	1.687	0.00790	1.148
Simard	MAE	0.0129	0.148	0.00138	0.975
	MRE	0.0380	0.129	0.00910	0.468
direct regression	MAE	0.192	1.054	0.00709	0.900
	MRE	0.838	10.700	0.0540	1.184

Supplementary Appendix SF: Nelson, Simard, and direct regression model parameters vary as a function of different treatments

Table S5. The Nelson model parameters vary as a function of larch/birch ratio

Treatment	MAE	MRE	α	β	τ	R^2
Larch	0.00768	0.0303	0.597	–0.101	9.904	0.976
	(0.00649)	(0.0180)	(0.472)	(0.101)	(5.363)	(0.0448)
Birch	0.00901	0.0290	0.988	–0.162	9.837	0.978
	(0.00600)	(0.0144)	(1.067)	(0.208)	(7.235)	(0.0173)

Values in the parentheses indicates standard error (n=24).

Table S6. The Simard model parameters vary as a function of larch/birch ratio

Treatment	MAE	MRE	τ	R^2
Larch	0.00822	0.0322	36.272	0.978
	(0.00696)	0.0180	(5.363)	(0.0448)
Birch	0.000968	0.0317	56.702	0.972
	(0.00655)	(0.0154)	(99.704)	(0.0218)

Values in the parentheses indicates standard error (n=24).

Table S7. The direct regression model parameters vary as a function of larch/birch ratio

Treatment	MAE	MRE	b_0	b_1	b_2	b_3	R^2
Larch	0.0726	0.369	4.297	0.002	0.0931	0.00880	0.559
	(0.0691)	(0.310)	(3.497)	(0.00165)	(0.0710)	(0.00654)	(0.147)
Birch	0.0678	0.232	4.734	0.00341	0.198	0.00895	0.570
	(0.0693)	(0.146)	(4.161)	(0.00384)	(0.242)	(0.00787)	(0.166)

Values in the parentheses indicates standard error (n=24).

Table S8. The Nelson model parameters vary as a function of decay classes

Treatment		MAE	MRE	α	β	τ	R^2
	BD	0.00827	0.0326	0.734	–0.130	9.841	0.976
Larch		(0.00571)	(0.0180)	(0.472)	(0.101)	(5.363)	(0.0448)
	LD	0.00708	0.0279	0.460	–0.0726	9.968	0.976
		(0.00739)	(0.0180)	(0.472)	(0.101)	(5.363)	(0.0448)
	BD	0.00949	0.0308	1.302	–0.226	10.933	0.979
Birch		(0.00593)	(0.0174)	(1.390)	(0.276)	(9.379)	(0.0126)
	LD	0.00853	0.0272	0.674	–0.0984	8.740	0.976
		(0.00630)	(0.0111)	(0.482)	(0.0754)	(4.343)	(0.0214)

Values in the parentheses indicates standard error (n=12).

Table S9. The Simard model parameters vary as a function of decay classes

Treatment		MAE	MRE	τ	R^2
	BD	0.00899	0.0350	17.340	0.984
Larch		(0.00728)	(0.0180)	(5.363)	(0.0448)
	LD	0.00746	0.0294	50.471	0.971
		(0.00686)	(0.0180)	(5.363)	(0.0448)
	BD	0.0102	0.0339	84.850	0.979
Birch		(0.00649)	(0.0191)	(136.913)	(0.0154)
	LD	0.009125	0.0295	28.554	0.968
		(0.00686)	(0.0110)	(17.664)	(0.0271)

Values in the parentheses indicates standard error (*n*=12).

Table S10. The direct regression model parameters vary as a function of decay classes

Treatment		MAE	MRE	b_0	b_1	b_2	b_3	R^2
	BD	0.0869	0.450	4.787	0.00360	0.122	0.0119	0.568
Larch		(0.0761)	(0.349)	(3.956)	(0.00100)	(0.0880)	(0.00727)	(0.165)
	LD	0.0583	0.289	3.808	0.00120	0.0737	0.00565	0.551
		(0.0612)	(0.255)	(3.268)	(0.00127)	(0.0576)	(0.00397)	(0.133)
	BD	0.0865	0.255	6.458	0.00404	0.188	0.00984	0.535
Birch		(0.0906)	(0.183)	(5.192)	(0.00396)	(0.152)	(0.00948)	(0.211)
	LD	0.0492	0.208	3.010	0.00288	0.208	0.00813	0.606
		(0.0329)	(0.100)	(2.000)	(0.00403)	(0.330)	(0.00638)	(0.103)

Values in the parentheses indicates standard error (*n*=12).

Table S11. The Nelson model parameters vary as a function of diameter classes

Treatment		MAE	MRE	α	β	τ	R^2
	fine	0.0123	0.0457	0.666	–0.111	7.702	0.967
		(0.00868)	(0.0180)	(0.472)	(0.101)	(5.363)	(0.0448)
Larch	medium-sized	0.00529	0.0230	0.735	–0.134	11.657	0.970
		(0.00312)	(0.0180)	(0.472)	(0.101)	(5.363)	(0.0448)
	thick	0.00548	0.0221	0.390	–0.0583	10.355	0.989
		(0.00412)	(0.0180)	(0.472)	(0.101)	(5.363)	(0.0448)
	fine	0.0150	0.0418	1.405	–0.244	8.715	0.979
		(0.00550)	(0.0134)	(1.416)	(0.302)	(10.557)	(0.00983)
Birch	medium-sized	0.00678	0.0254	0.773	–0.120	8.228	0.975
		(0.00396)	(0.0102)	(0.770)	(0.130)	(5.573)	(0.0114)
	thick	0.00645	0.0234	0.800	–0.127	11.528	0.978
		(0.00414)	(0.0120)	(0.815)	(0.136)	(4.251)	(0.0242)

Values in the parentheses indicates standard error (*n*=8).

Table S12. The Simard model parameters vary as a function of diameter classes

Treatment		MAE	MRE	τ	R^2
Larch	fine	0.0131	0.0168	17.774	0.956
		(0.00926)	(0.0180)	(5.363)	(0.0448)
	medium-sized	0.00560	0.0247	24.360	0.989
		(0.00313)	(0.0180)	(5.363)	(0.0448)
	thick	0.00600	0.0252	74.833	0.987
		(0.00482)	(0.0180)	(5.363)	(0.0448)
Birch	fine	0.0164	0.0461	30.023	0.969
		(0.00608)	(0.0137)	(31.126)	(0.0161)
	medium-sized	0.00710	0.0279	57.145	0.971
		(0.00394)	(0.0117)	(63.684)	(0.0140)
	thick	0.00554	0.0211	82.938	0.978
		(0.00313)	(0.00853)	(161.365)	(0.0329)

Values in the parentheses indicates standard error (*n*=8).

Table S13. The direct regression model parameters vary as a function of diameter classes

Treatment		MAE	MRE	b_0	b_1	b_2	b_3	R^2
Larch	fine	0.0637	0.309	2.438	0.00285	0.0933	0.0109	0.645
		(0.0307)	(0.132)	(0.987)	(0.00106)	(0.0523)	(0.00814)	(0.1118)
	medium-sized	0.0566	0.306	3.242	0.000300	0.0616	0.00775	0.541
		(0.0362)	(0.163)	(1.313)	(0.00100)	(0.0559)	(0.00584)	(0.136)
	thick	0.0975	0.493	7.212	–0.0161	0.140	0.00773	0.492
		(0.1111)	(0.496)	(4.972)	(0.0249)	(0.145)	(0.00608)	(0.156)
Birch	fine	0.100	0.325	7.322	0.00750	0.400	0.0151	0.640
		(0.0966)	(0.222)	(6.545)	(0.00354)	(0.284)	(0.0120)	(0.136)
	medium-sized	0.0528	0.182	3.712	0.00145	0.0678	0.00598	0.570
		(0.0531)	(0.0676)	(2.062)	(0.000810)	(0.0571)	(0.00387)	(0.182)
	thick	0.0512	0.199	2.786	0.000567	0.0538	0.00749	0.530
		(0.0384)	(0.0490)	(1.474)	(0.000808)	(0.0575)	(0.00306)	(0.160)

Values in the parentheses indicates standard error (*n*=8).