



New Phytologist Supporting Information

Article title: **Seed dormancy responses to temperature relate to *Nothofagus* species distribution and determine temporal patterns of germination across altitude in Patagonia**

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Fig. S1 (a–c) Altitudinal relationships between air daily mean temperatures. Data were taken over 4 yr (2010–2014). Each point corresponds to the daily mean temperature value at both altitudinal levels for the same day. Solid lines indicate the 1:1 relationship between both levels.

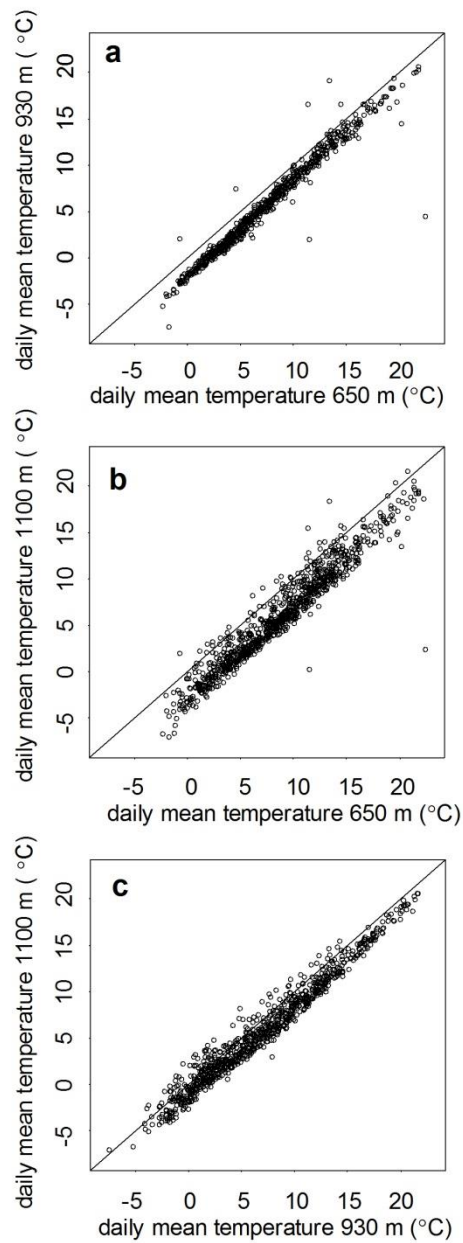


Fig. S2 Cumulative germination curves of *N. obliqua* (a–d), *N. nervosa* (e–h) and *N. pumilio* (i–l) at 12 (open blue circles), 17 (closed black circles) and 22°C (open red squares) after stratification at 0.5°C for the periods indicated above each panel. Solid lines show the predicted germination calculated by the population threshold models. Coefficients of determination (R^2) are indicated inside each panel. Dashed lines indicate that estimation of R^2 was not possible due to zero germination in the test. Vertical bars indicate SEM.

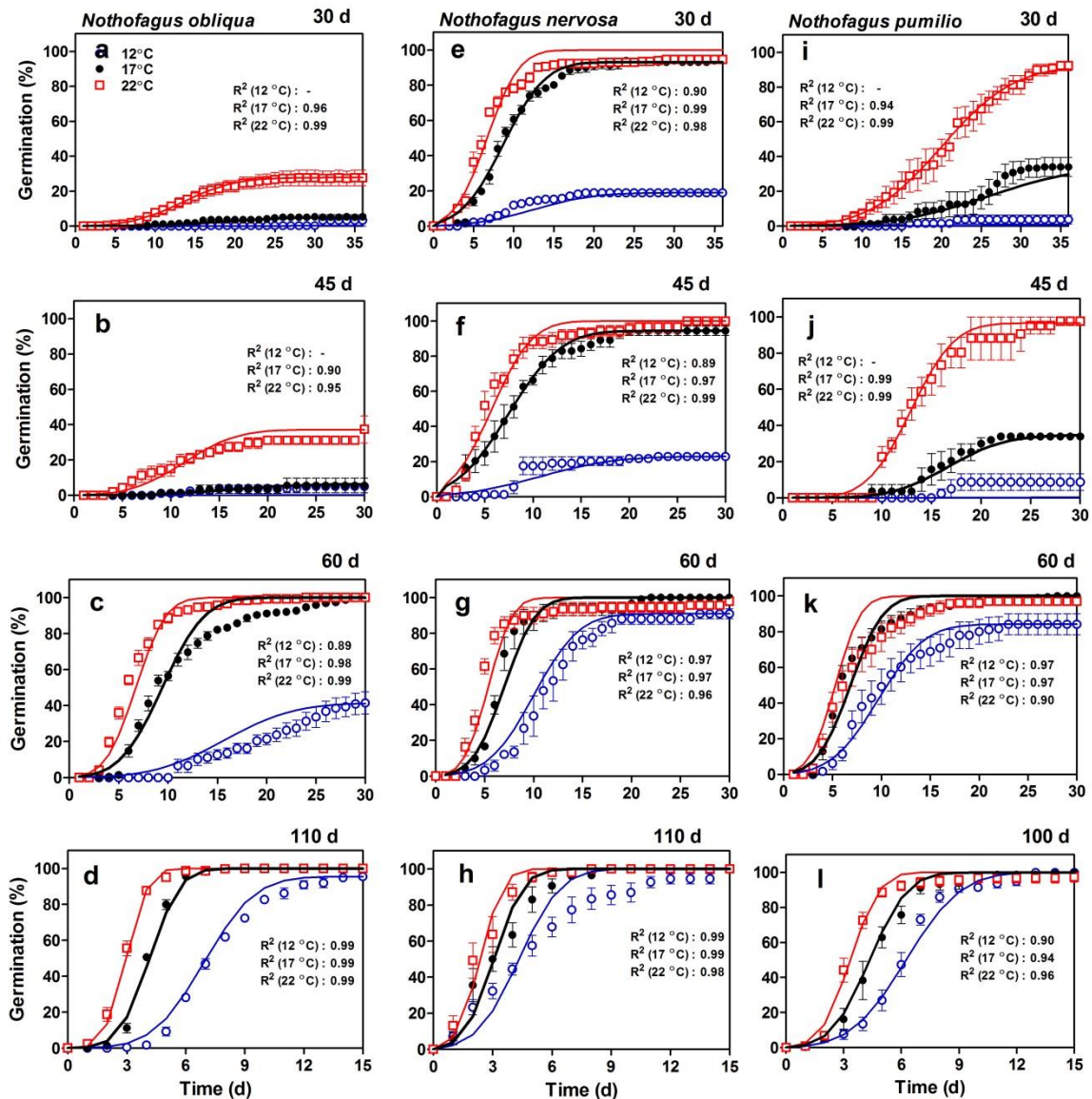


Fig. S3 Validation of thermal time models in the laboratory. Predicted (solid line) and observed (open blue circles) cumulative germination curves of *N. obliqua*, *N. nervosa* and *N. pumilio* seeds stratified for 95 d at 0.5°C and then germinated at 12°C. Predicted thermal time parameters for theoretical data calculation was performed using the equations of Fig. 2 and are listed in Table S6. Vertical bars indicate SEM. R^2 for the observed and predicted values fitting are shown inside each panel.

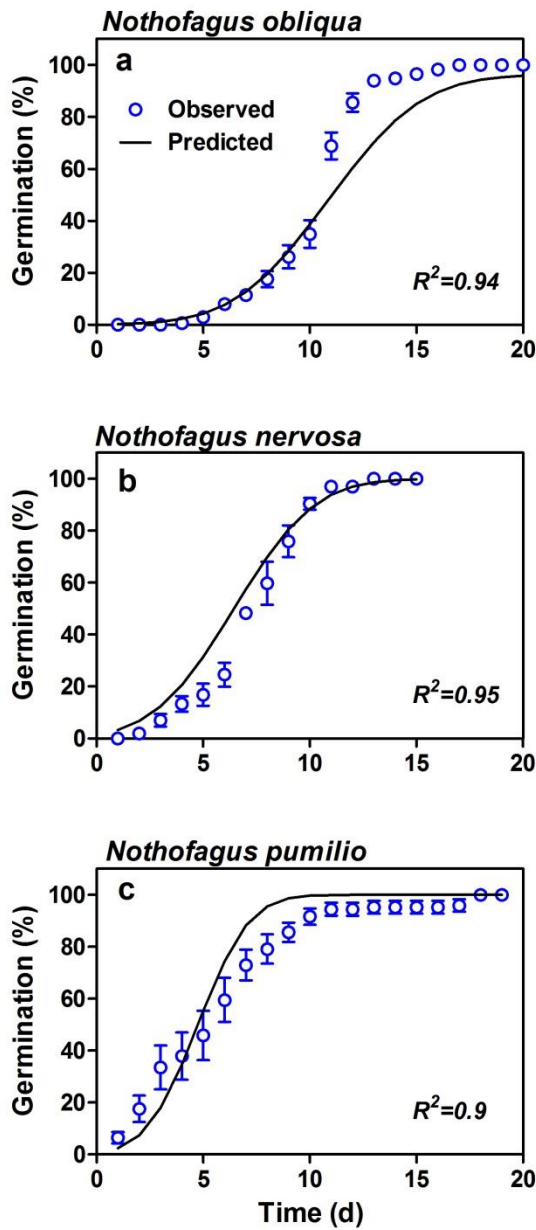


Fig. S4 Daily mean soil hydric content across elevation during the period of seed overwintering and germination in the forest (autumn-spring) for the experiments shown in Fig. 4. Data correspond to the daily average values for 2012 and 2013 seasons.

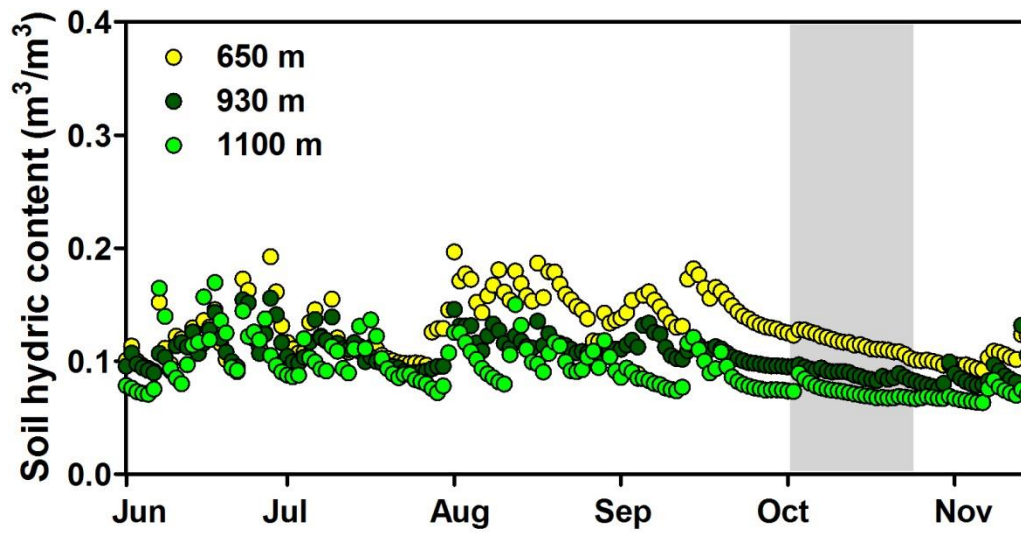


Table S1 Populations sampled in the study. The name of the populations, the year of harvesting, their location, altitude, and annual precipitation (as mm/m²) according to Bianchi & Carvero (2010), are indicated.

Species	Population	Year	Latitude (S)	Longitude (W)	Altitude (m asl)	Annual precipitation (mm/m ²)
<i>N. obliqua</i>	Yuco	2010	40°09'07"	71°30'39"	680	1500
	Quila Quina	2010	40°09'07"	71°26'37"	670	1300
	Yuco	2011	40°09'07"	71°30'39"	680	1500
	Nonthué	2011	40°08'46"	71°37'03"	680	1900
	Yuco	2012	40°09'07"	71°30'39"	680	1500
	Quila Quina	2012	40°09'07"	71°26'37"	670	1300
<i>N. nervosa</i>	Yuco Alto	2010	40°07'48"	71°34'48"	930	1500
	Quilanolahue	2010	40°07'48"	71°28'48"	920	1500
	Yuco Alto	2011	40°07'48"	71°34'48"	930	1500
	Yuco Alto	2012	40°07'48"	71°34'48"	930	1500
	Trómen	2012	39°34'12"	71°25'48"	910	1900
<i>N. pumilio</i>	Van Titter	2010	41°19'82"	71°48'61"	1350	1000
	Van Titter	2011	41°19'82"	71°48'61"	1350	1000
	Chall-huaco	2011	41°15'29"	71°17'07"	1175	850
	Cerro Colorado	2011	40°08'59"	71°23'15"	1130	1200
	Chall-huaco	2012	41°15'29"	71°17'07"	1175	850
	Chapelco	2012	40°11'59"	71°20'08"	1204	1200
	Cerro Colorado	2012	40°08'59"	71°23'15"	1130	1200

Table S2 Final germination percentages of *N. obliqua*, *N. nervosa* and *N. pumilio* seeds freshly harvested or stored at 2°C. *N. obliqua* and *N. pumilio* seeds were stratified for 30 d at 0.5°C and germinated at 17°C; whereas *N. nervosa* seeds were germinated at 12°C without stratification. Time of seed storage: *N. obliqua*: 20 months, *N. nervosa* and *N. pumilio*: 17 months. The table shows the final percent of germination and the SEM. *P* values of Student' test after angular transformation of the data are indicated in the last column.

	Freshly harvested	Stored at 2°C	<i>P</i> value
<i>N. obliqua</i>	7.9 ± 3.34	7.4 ± 0.85	0.88
<i>N. nervosa</i>	6.5 ± 7.65	7.7 ± 2.57	0.85
<i>N. pumilio</i>	30.3 ± 10.92	22.3 ± 4.91	0.61

Table S3 Linear regressions between GR and temperature. The table shows the standard deviation of the residuals ($s_{y.x}$) for each population fraction for different segmental linear regression calculations, in which T_b was varied in increments of 0.5°C.

Species	T_b (°C) ⁽¹⁾	Population fraction									$\Sigma s_{y.x}$
		10	20	30	40	50	60	70	80	90	
<i>N. obliqua</i>	4	0.014	0.010	0.009	0.009	0.010	0.010	0.011	0.012	0.014	0.098
	4.5	0.008	0.004	0.005	0.006	0.008	0.009	0.010	0.012	0.014	0.076
	5	0.009	0.007	0.008	0.009	0.010	0.010	0.012	0.013	0.015	0.093
<i>N. nervosa</i>	0	0.012	0.007	0.007	0.008	0.009	0.009	0.009	0.009	0.007	0.077
	0.55	0.009	0.002	0.004	0.006	0.008	0.008	0.009	0.009	0.007	0.062
	1	0.011	0.006	0.007	0.008	0.009	0.010	0.010	0.009	0.008	0.078
<i>N. pumilio</i>	1.5	0.016	0.012	0.012	0.012	0.012	0.012	0.012	0.011	0.001	0.100
	-0.5	0.143	0.021	0.011	0.013	0.013	0.014	0.013	0.013	0.011	0.252
	0	0.149	0.021	0.006	0.009	0.012	0.013	0.013	0.011	0.010	0.244
	0.5	0.157	0.023	0.010	0.009	0.014	0.014	0.014	0.010	0.009	0.261
	1	0.168	0.038	0.019	0.015	0.019	0.018	0.017	0.011	0.001	0.306

⁽¹⁾ Temperature above which seeds are able to germinate, and accumulate thermal time units when are incubated in the range between T_i and T_o .

Table S4 Linear regressions between GR and temperature. The table shows the standard deviation of the residuals ($s_{y.x}$) for each population fraction for different segmental linear regression calculations, in which T_0 was varied in increments of 0.5°C. *N. nervosa* and *N. pumilio* population fractions between 60 and 90 did not germinate at 30°C. This prevented the calculation of segmental linear regressions in these population fractions.

Species	T_0 (°C) ⁽¹⁾	Population fraction								$\Sigma s_{y.x}$
		20	30	40	50	60	70	80	90	
<i>N. obliqua</i>	21.5	0.051	0.043	0.038	0.035	0.032	0.030	0.029	0.029	0.287
	22	0.048	0.040	0.035	0.032	0.029	0.028	0.028	0.028	0.269
	22.5	0.019	0.012	0.008	0.008	0.010	0.013	0.016	0.021	0.107
	23	0.019	0.014	0.011	0.011	0.013	0.013	0.018	0.022	0.121
<i>N. nervosa</i>	22	0.026	0.032	0.039	0.021	-	-	-	-	0.118
	22.5	0.017	0.024	0.032	0.018	-	-	-	-	0.091
	23	0.010	0.017	0.025	0.018	-	-	-	-	0.070
	23.5	0.005	0.011	0.018	0.021	-	-	-	-	0.055
	24	0.010	0.009	0.014	0.025	-	-	-	-	0.058
	24.5	0.014	0.007	0.008	0.030	-	-	-	-	0.059
	25	0.020	0.013	0.008	0.035	-	-	-	-	0.076
25.5	0.028	0.020	0.014	0.041	-	-	-	-	0.103	
<i>N. pumilio</i>	20.5	0.062	0.044	0.034	0.068	-	-	-	-	0.208
	21	0.053	0.033	0.023	0.057	-	-	-	-	0.167
	21.5	0.056	0.031	0.017	0.057	-	-	-	-	0.161
	22	0.065	0.033	0.018	0.058	-	-	-	-	0.174
	22.5	0.082	0.046	0.029	0.058	-	-	-	-	0.215

⁽¹⁾Optimum temperature for germination.

Table S5 Effect of stratification temperature on the germination of *Nothofagus* seeds

	<i>N. obliqua</i>			<i>N. nervosa</i>				<i>N. pumilio</i>		
	12°C	17°C	22°C	12°C	17°C	22°C		12°C	17°C	22°C
30 d of stratification							30 d of stratification			
-4°C	0	0	0	0	0	0	-4°C	0	0	0
0.5°C	0.3±0.3	5.7±2.0	27.8±4.5	19.0±1.4	93.1±1.8	96.6±1.1	0.5°C	3.8±2.6	34.1±5.5	92.2±2.7
1.5°C	0	8.7±0.2	33.7±5.3	15.0±3.4	90.6±3.7	100	1.5°C	2.5±1.7	35.4±4.6	91.7±2.3
4°C	0	3.0±1.6	17.0±2.2	24.3±1.5	96.7±1.7	100	4°C	2.5±1.6	35.8±7.5	70.2±4.2
8°C	0	0	0	5.5±1.1	85.9±4.1	89.8±6.5	8°C	0	0	0
12°C	0	0	0	4.7±0.4	75.7±4.3	77.4±5.2	12°C	0	0	0
110 d of stratification							110 d of stratification			
-4°C	0	0	0	0	0	0	-4°C	0	0	0
0.5°C	100	100	100	100	100	100	0.5°C	100	100	100
1.5°C	100	100	100	100	100	100	1.5°C	100	100	100
4°C	100	100	100	100	100	100	4°C	100	100	100
8°C	nd	nd	nd	nd	nd	nd	8°C	nd	nd	nd
12°C	nd	nd	nd	nd	nd	Nd	12°C	nd	nd	nd

Table S6 Predicted dormancy and germination related parameters for *N. obliqua*, *N. nervosa* and *N. pumilio* seeds after 60, 85, 90, 120 and 160 d of stratification

Days of stratification	<i>N. obliqua</i>						<i>N. nervosa</i>						<i>N. pumilio</i>					
	$T_{l(50)}$ ⁽¹⁾	σ_{Tl} ⁽²⁾	$\Theta_{(50)}$ ⁽³⁾	σ_{θ} ⁽⁴⁾	$T_{h(50)}$ ⁽⁵⁾	σ_{Th} ⁽⁶⁾	$T_{l(50)}$	σ_{Tl}	$\Theta_{(50)}$	σ_{θ}	$T_{h(50)}$	σ_{Th}	$T_{l(50)}$	σ_{Tl}	$\Theta_{(50)}$	σ_{θ}	$T_{h(50)}$	σ_{Th}
60	12.5	2.7	144.8	51.8	45	0.5	10.4	1.6	124.9	63.6	36.4	1.2	10.7	1.8	160.2	48.0	35.9	2.4
85	9.0	1.9	99.6	33.4	45	0.5	4.8	1.2	91.6	42.6	36.4	1.2	2.8	1.0	75.2	20.0	35.9	2.3
90	8.9	1.8	90.9	29.7	45	0.5	4.2	1.1	82.9	38.5	36.4	1.2	2.1	0.9	65.3	16.8	35.9	2.3
95	8.8	1.8	81.5	26.0	45	0.5	3.7	1.0	74.2	31.0	36.4	1.2	1.5	0.8	57.0	14.1	35.9	2.3
120	8.7	1.6	36.3	7.5	45	0.5	2.0	0.6	30.7	13.2	36.4	1.2	0.1	0.1	31.3	5.8	35.9	2.3
160	8.7	1.5	0.3 ^{*140d}	0.1 ^{*130d}	45	0.5	1.3	0.1 ^{*150d}	4.6 ^{*135d}	0.6 ^{*135d}	36.4	1.2	0.0 ^{*125d}	0.0	19.0	1.4	35.9	2.3

⁽¹⁾ Mean lower limit temperature for germination of the seed population. The term indicates the lower temperature that yields 50% of germination of the seed population.

⁽²⁾ Standard deviation of the values of lower limit temperature for germination (T_l) in the seed population.

⁽³⁾ Mean higher limit temperature for germination of the seed population. The term indicates the higher temperature that yields 50% of germination of the seed population.

⁽⁴⁾ Standard deviation of the values of higher limit temperature for germination (T_h) in the seed population.

⁽⁵⁾ Required amounts of thermal time units ($^{\circ}\text{C d}$) for completion of germination of the 50% of the seed population.

⁽⁶⁾ Standard deviation of the required thermal time units (θ) for the completion of germination of the different fractions of the seed population.

References

Bianchi A, Cravero C. 2010. *Atlas climático Digital de la República Argentina – Instituto Nacional de Tecnología Agropecuaria*. Buenos Aires, Argentina: INTA editions.