

Supplementary Information

Site	Depth (cm)	Dated material	Laboratory code	Measured radiocarbon result	Calibrated age range, 95 %
TNG	9-10	Plant	D-AMS 032232	109.93 ± 0.33 pMC	1958.6-1958.9; 1998.8-2001.5 cal CE
TNG	20-21	Plant matter	D-AMS 019108	117.35 ± 0.34 pMC	1959.8-1960.5; 1987.4-1989.8 cal CE
TNG	32-33	Plant matter	D-AMS 019109	112.02 ± 0.41 pMC	1958.9-1959.1; 1994.4-1998.0 cal CE
TNG	41-42	Plant	D-AMS 035220	1019 ± 26 ¹⁴ C yr BP	995-1000; 1020-1054; 1059-1071; 1079-1151 cal CE
TNG	43-44	Plant	D-AMS 032233	1049 ± 27 ¹⁴ C yr BP	992-1049; 1084-1143 cal CE
TNG	57-58	Plant	D-AMS 032234	1167 ± 24 ¹⁴ C yr BP	890-989 cal CE
TNG	70-71	Plant material	D-AMS 029300	1242 ± 27 ¹⁴ C yr BP	693-697; 773-894; 937-955 cal CE
OTT	5-6	Plant	D-AMS 032251	106.21 ± 0.36 pMC	1957.9-1958.3; 2006.3-2011.0 cal CE
OTT	9-10	Plant	D-AMS 032252	104.55 ± 0.28 pMC	1957.5-1957.8; 2011.2-2013.4 cal CE
OTT	25-26	Plant	D-AMS 032253	125.96 ± 0.35 pMC	1962.6-1963.0; 1981.4-1982.4 cal CE
OTT	41-42	Wood	D-AMS 035346	164 ± 24 ¹⁴ C yr BP	1676-1735; 1800-1896; 1903-1915; 1918-1950 cal CE
OTT	58-59	Charred plant	D-AMS 032254	419 ± 25 ¹⁴ C yr BP	1451-1510; 1549-1561; 1578-1623 cal CE
OTT	90-91	Plant	D-AMS 032255	975 ± 25 ¹⁴ C yr BP	1030-1159; 1171-1178 cal CE
OTT	123-124	Plant	D-AMS 032256	1367 ± 24 ¹⁴ C yr BP	655-691; 700-726; 735-772 cal CE
OTT	155-156	Plant	D-AMS 032257	1586 ± 27 ¹⁴ C yr BP	429-583 cal CE
OTT	188-189	Sphagnum/plant material	D-AMS 029309	1223 ± 25 ¹⁴ C yr BP	774-823; 829-897; 929-962 cal CE
OTT	196-196	Moss	D-AMS 035231	1986 ± 27 ¹⁴ C yr BP	44-9 cal BCE; 18-121 cal CE

Table S1. Radiocarbon (¹⁴C) dating results for the Tangonge (TNG) and Otautau (OTT). For each sample, depth, laboratory code, measured age are reported, together with the calibrated age range.

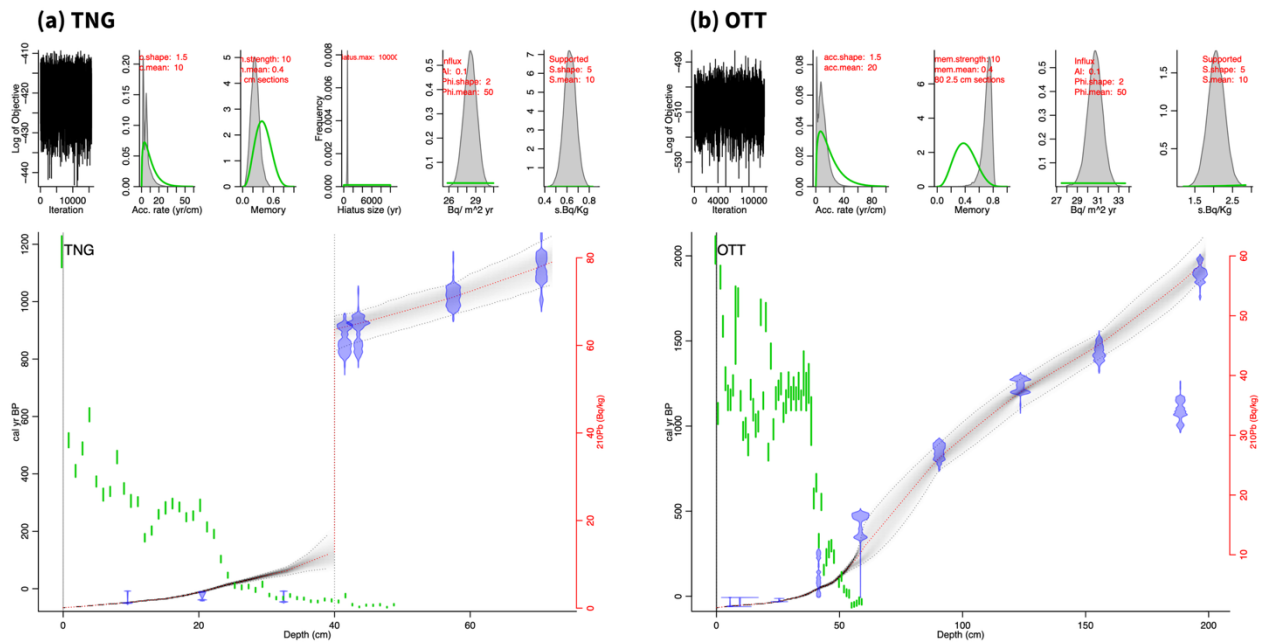


Figure S1. Bayesian age-depth models for the Tangonge (TNG, left) and Otautau (OTT, right) cores, constructed using rplum.

15 Shaded envelopes show the 95 % confidence interval with the modelled median age at the horizontal centre; calibrated ^{14}C , and ^{210}Pb age determinations are shown at their respective depths.

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Site	Site name	Latitude (° S)	Species	n	$\delta^{18}\text{O}$ (‰)	δD (‰)
TKA	Tahakopa	46.534	<i>E. minus</i>	3	2.42 (1.59)	-17.21 (9.16)
OTT	Otautau	46.134	<i>E. minus</i>	3	11.55 (3.42)	11.08 (7.90)
BOR	Borland	45.781	<i>E. minus</i>	3	-0.98 (1.11)	-29.11 (9.53)
KEP	Kepler	45.524	<i>E. minus</i>	3	5.40 (2.17)	0.07 (10.09)
DML	Dismal	44.033	<i>E. minus</i>	3	-2.74 (1.91)	-22.73 (18.62)
OKA	Okarito	43.247	<i>E. minus</i>	3	9.60 (1.56)	-3.16 (4.56)
CMC	Crooked Mary Creek	42.399	<i>E. minus</i>	3	11.78 (2.61)	-16.22 (9.55)
REP	Reporoa	39.585	<i>E. minus</i>	3	-1.89 (0.76)	-11.33 (2.33)
ERU	Erua	39.179	<i>E. minus</i>	3	3.86 (0.44)	-22.77 (3.26)
MOA	Moanatuatua	37.924	<i>E. robustum</i>	3	22.96 (6.22)	44.30 (11.97)
KOP	Kopuatai	37.386	<i>E. robustum</i>	3	18.28 (4.77)	37.49 (5.08)
OTK	Otakairangi	35.596	<i>E. robustum</i>	3	23.49 (2.05)	37.52 (8.78)
TNG	Tangonge	35.104	<i>E. robustum</i>	3	3.84 (13.40)	-0.01 (34.12)
All spatial samples				39	8.27 (9.53)	0.61 (26.59)

Table S2. Internal shoot water $\delta^{18}\text{O}$ and δD for the spatial dataset. Values are site means of three replicate samples collected during the 2016-2017 campaign, reported as mean (standard deviation) in ‰ relative to VSMOW. Sites are ordered from south to north. Internal shoot water is excluded from the combined peatland-water definition used in Figure 3 and in the meteoric water line regressions, because it is strongly modified by transpirational enrichment and does not represent a peatland-scale source-water pool.

Site	Species	Period	n	$\delta^{18}\text{O}$ (‰)	δD (‰)
MOA	<i>E. robustum</i>	Nov-Mar	6	11.25 (9.00)	14.90 (26.77)
MOA	<i>E. robustum</i>	Apr-Oct	7	-0.87 (2.67)	-7.65 (9.52)
MOA	<i>E. robustum</i>	All months	13	4.72 (8.76)	2.76 (21.93)
OTT	<i>E. minus</i>	Nov-Mar	6	3.04 (5.02)	-12.77 (13.31)
OTT	<i>E. minus</i>	Apr-Oct	6	-1.90 (6.46)	-42.91 (28.53)
OTT	<i>E. minus</i>	All months	12	0.57 (6.09)	-27.84 (26.43)
All samples			25	2.73 (7.74)	-11.93 (28.35)

Table S3. Internal shoot water $\delta^{18}\text{O}$ and δD for the temporal dataset. Values are means of monthly samples collected over a single year at Moanatuatua (MOA, *E. robustum*) and Otautau (OTT, *E. minus*), reported as mean (standard deviation) in ‰ relative to VSMOW. Seasonal subsets follow the growing-season definitions used in the mixing model (Sect. 2.5): November to March, and April to October.

Water pool	Dataset	Slope	Intercept	r ²	p	n
Internal shoot water	<i>Spatial</i>	3.11	-25.14	0.760	<0.001	39
Internal shoot water	<i>Temporal</i>	4.33	-23.74	0.686	<0.001	25
Combined peatland waters	<i>Spatial</i>	8.80	9.60	0.955	<0.001	76
Global meteoric water line		8.00	10.00			

Table S4. Regressions of $\delta^{18}\text{O}$ and δD for internal shoot water, compared with the combined peatland-water regression reported in the main text. The global meteoric water line has a slope of 8. The much shallower slopes for internal shoot water are characteristic of evaporative enrichment and confirm that this pool has been substantially modified from meteoric composition by transpirational water loss, justifying its exclusion from the combined peatland-water definition. Regressions are fitted by major axis (orthogonal) regression, as used for the meteoric water line fits reported in the main text, because both isotope ratios are subject to measurement error.

Candidate source water	Spatial dataset			Temporal dataset		
	<i>r</i>	<i>p</i>	<i>n</i>	<i>r</i>	<i>p</i>	<i>n</i>
Isoscape / measured precipitation	0.163	0.322	39	0.102	0.635	24
Root-associated water	0.004	0.980	37	0.120	0.560	26
Internal root water	0.046	0.782	39	0.130	0.528	26
Internal shoot water	0.248	0.128	39	0.044	0.836	25
Mean internal root + shoot water	0.255	0.117	39	0.101	0.623	26
Bog water	0.142	0.388	39	0.209	0.306	26

Table S5. Pearson correlations between root cellulose $\delta^{18}\text{O}$ and candidate source waters. Spatial correlations are sample-level values. Temporal correlations are for the combined MOA+OTT dataset. Values shown are Pearson's *r*, *p*, and *n*. Italicised *p* values are non-significant. Mean internal root + shoot water is bolded as the best-performing source in the mechanistic model comparison. Site-mean spatial correlations were also non-significant (all $p > 0.28$) and are not shown.

Group	<i>f_A</i> (zero-mean)	<i>f_B</i> (zero-mean)
Spatial global	0.537	0.463
<i>E. robustum</i>	0.725	0.275
<i>E. minus</i>	0.379	0.621
NovMar (combined)	0.514	0.486
AprOct (combined)	0.000	1.000

Table S6. Zero-mean fixed-ratio sensitivity model results. Values closely parallel the MAE optima in Table 5, confirming the species contrast and seasonal pattern are robust to optimisation criterion.