Supplementary Information

Boreal forest cover was reduced in the mid-Holocene with warming and recurring wildfires

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Table S1. ^{210}Pb dates (KB) and ^{14}C dates of bulk sediments from lakes M14, M15, O6, O14, O15, and O16.

Lake M14 ***120 cm depth 246 cm of sediment***	**Real depth (cm)**	**Core**	**^{14}C date BP** (AD Year)	**Cal. Yr. BP (rbacon)**	**Laboratory number**
121	1-2	KB	-59 +/-4 (2009)	-59	
122	2-3	KB	-58 +/-3 (2008)	-57	
123	3-4	KB	-54 +/-3 (2004)	-54	
124	4-5	KB	-50 +/-3 (2000)	-51	
125	5-6	KB	-45 +/-3 (1995)	-48	
126	6-7	KB	-38 +/-3 (1988)	-39	
127	7-8	KB	-30 +/-3 (1980)	-30	
128	8-9	KB	-22 +/-3 (1972)	-21	
129	9-10	KB	-11 +/-3 (1961)	-13	
130	10-11	KB	-1 +/-3 (1951)	-4	
131	11-12	KB	9 +/-4 (1941)	7	
132	12-13	KB	18 +/-4 (1932)	17	
133	13-14	KB	29 +/-4 (1921)	27	
134	14-15	KB	39 +/-4 (1911)	37	
135	15-16	KB	49 +/-4 (1901)	47	
136	16-17	KB	63 +/-4 (1887)	59	
137	17-18	KB	74 +/-4 (1876)	70	
138	18-19	KB	82 +/-4 (1868)	82	
139	19-20	KB	101 +/-5 (1849)	93	
185	65	A	2320 +/-15	2332 (2165-2416)	UCIAMS-281103 – ULA-11274
205	85	A	3470 +/-15	3695 (3589-3800)	UCIAMS-265545 - ULA-10594
228	108	A	3610 +/-15	3958 (3875-4120)	UCIAMS-265544 - ULA-10593
240	120	A	4010 +/-15	4463 (4370-4539)	UCIAMS-281102 – ULA-11273
265	145	B	4925 +/-15	5629 (5565-5715)	UCIAMS-265550 – ULA-10595
290	170	B	5735 +/-15	6516 (6416-6616)	UCIAMS-283652 – ULA-11382
339	219	B	7195 +/-20	7990 (7923-8141)	UCIAMS-265552 - ULA-10597
359	239	C	7925 +/-20	8742 (8603-8965)	UCIAMS-265551 - ULA-10596

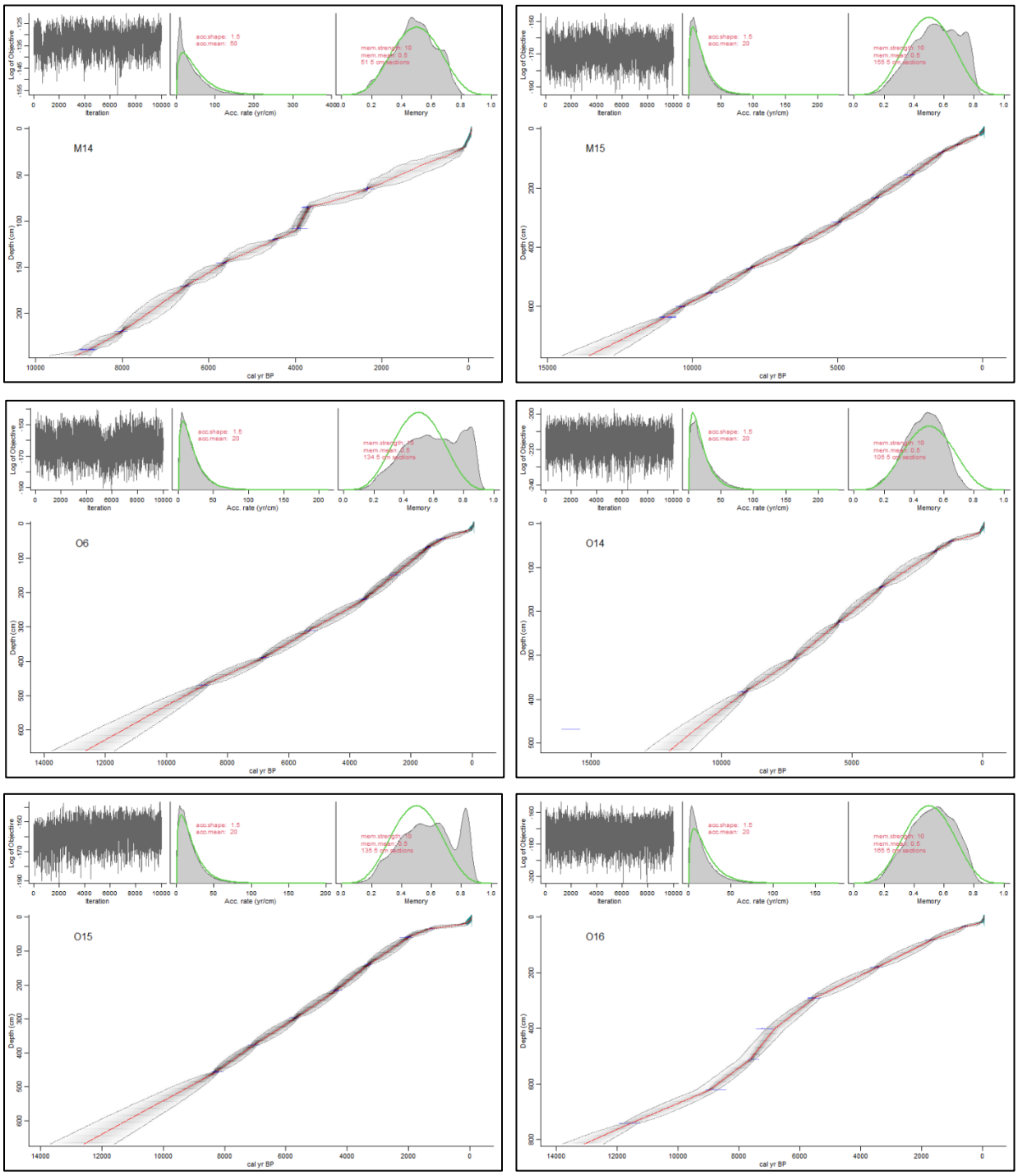
Lake M15 *570 cm depth 769 cm of sediment*	**Real depth (cm)**	**Core**	**^{14}C date BP** (AD Year)	**Cal. Yr. BP (rbacon)**	**Laboratory number**
571	1-2	KB	-59 +/-3 (2009)	-60	
572	2-3	KB	-57 +/-3 (2007)	-57	
573	3-4	KB	-54 +/-3 (2004)	-54	
574	4-5	KB	-51 +/-3 (2001)	-51	
575	5-6	KB	-46 +/-3 (1996)	-48	
576	6-7	KB	-38 +/-2 (1988)	-40	
577	7-8	KB	-29 +/-3 (1979)	-32	
578	8-9	KB	-20 +/-3 (1970)	-24	
579	9-10	KB	-12 +/-3 (1962)	-16	
580	10-11	KB	-5 +/-3 (1955)	-7	
581	11-12	KB	6 +/-3 (1944)	4	
582	12-13	KB	17 +/-3 (1933)	15	
583	13-14	KB	30 +/-4 (1920)	26	
584	14-15	KB	42 +/-3 (1908)	38	
585	15-16	KB	55 +/-4 (1895)	49	
586	16-17	KB	72 +/-4 (1878)	68	
587	17-18	KB	93 +/-4 (1857)	86	
624	54-55	A	960 +/-20	840 (763-917)	UCIAMS-226734 - ULA-8827
649	79-80	A	1505 +/-20	1364 (1304-1424)	UCIAMS-226735 - ULA-8828
726	156-157	B	2430 +/-20	2453 (2356-2676)	UCIAMS-226736 - ULA-8829
803	233-234	C	3415 +/-20	3654 (3567-3807)	UCIAMS-226737 - ULA-8830
885	315-316	D	4350 +/-20	4917 (4841-5033)	UCIAMS-226738 - ULA-8831
963	393-394	E	5570 +/-20	6344 (6281-6430)	UCIAMS-226739 - ULA-8832
1042	472-473	F	7190 +/-20	7984 (7894-8093)	UCIAMS-228751 - ULA-8833
1125	555-556	G	8380 +/-20	9421 (9285-9485)	UCIAMS-228752 - ULA-8834
1171	601-602	G	9215 +/-25	10336 (10241-10480)	UCIAMS-252787 - ULA-10037
1207	637-638	H	9500 +/-25	10970 (10688-11067)	UCIAMS-228753 - ULA-8835

Lake O6 ***330 cm depth 662 cm of sediment***	**Real depth (cm)**	**Core**	**^{14}C date BP** (AD Year)	**Cal. Yr. BP (rbacon)**	**Laboratory number**
331	1-2	KB	-58 +/-4 (2008)	-57	
332	2-3	KB	-54 +/-4 (2004)	-52	
333	3-4	KB	-48 +/-4 (1998)	-47	
334	4-5	KB	-42 +/-4 (1992)	-42	
335	5-6	KB	-36 +/-4 (1986)	-37	
336	6-7	KB	-30 +/-4 (1980)	-32	
337	7-8	KB	-22 +/-5 (1972)	-26	
338	8-9	KB	-16 +/-5 (1966)	-20	
339	9-10	KB	-9 +/-5 (1959)	-15	
340	10-11	KB	-3 +/-5 (1953)	-9	
341	11-12	KB	4 +/-5 (1946)	1	
342	12-13	KB	14 +/-4 (1936)	12	
343	13-14	KB	25 +/-4 (1925)	23	
344	14-15	KB	41 +/-5 (1909)	33	
345	15-16	KB	55 +/-4 (1895)	43	
346	16-17	KB	75 +/-4 (1875)	66	
347	17-18	KB	98 +/-5 (1852)	87	
374	44	A	1065 +/-20	939 (794-1041)	UCIAMS-252335 - ULA-10014
399	69	A	1570 +/-20	1432 (1346-1512)	UCIAMS-252336 - ULA-10015
479	149	B	2460 +/-20	2544 (2372-2691)	UCIAMS-252766 - ULA-10016
549	219	C	3285 +/-20	3501 (3398-3621)	UCIAMS-252767 - ULA-10017
640	310	D	4595 +/-20	5311 (5066-5438)	UCIAMS-252768 - ULA-10018
719	389	E	5980 +/-20	6805 (6671-6923)	UCIAMS-252782 - ULA-10032
799	469	F	7945 +/-25	8743 (8586-8962)	UCIAMS-252783 - ULA-10033

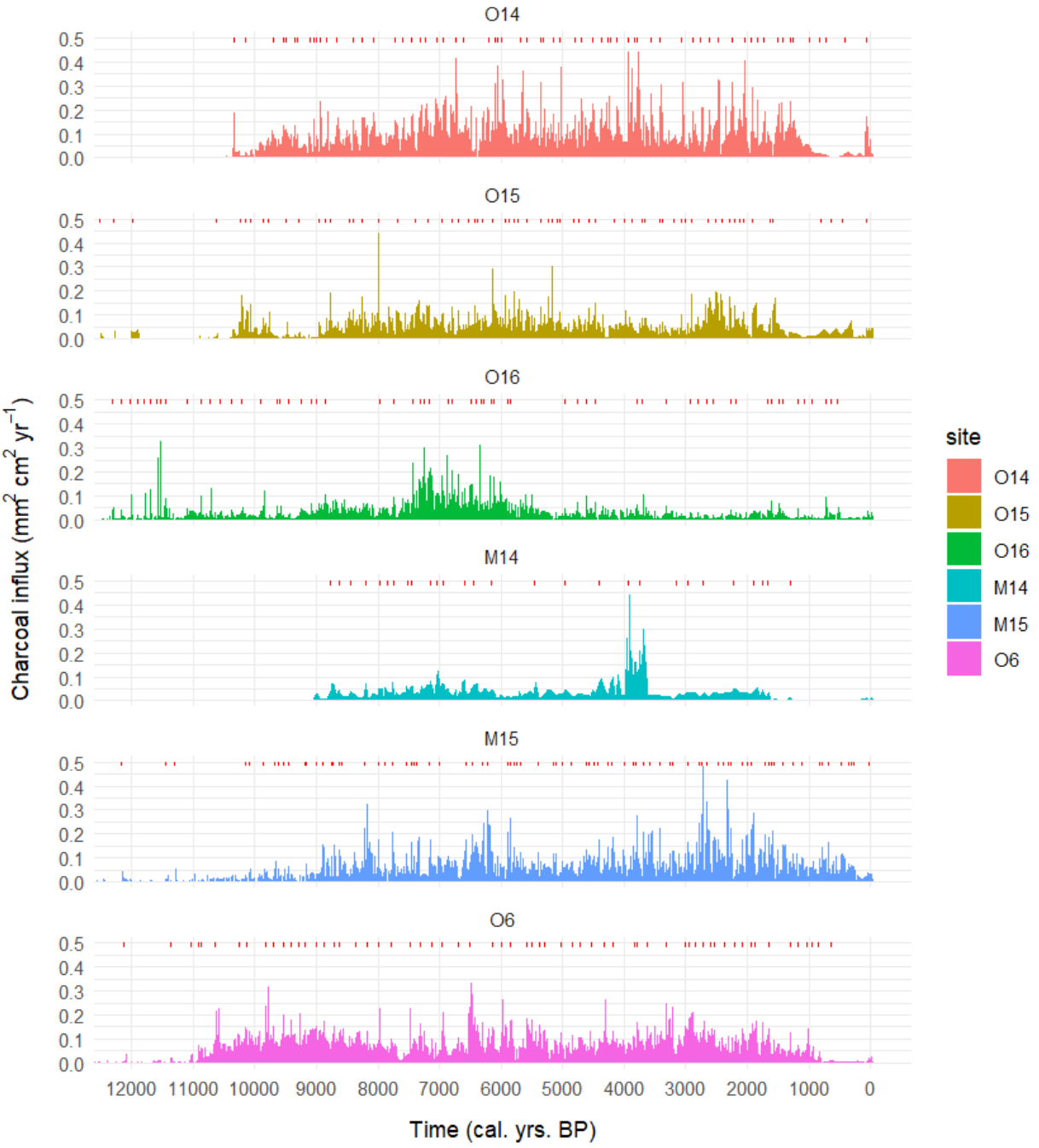
Lake O14 ***830 cm depth 519 cm of sediment***	**Real depth (cm)**	**Core**	**14C date BP** (AD Year)	**Cal. Yr. BP (rbacon)**	**Laboratory number**
831	1-2	KB	-59 +/-3 (2009)	-59	
832	2-3	KB	-57 +/-3 (2007)	-56	
833	3-4	KB	-52 +/-4 (2002)	-53	
834	4-5	KB	-47 +/-3 (1997)	-50	
835	5-6	KB	-41 +/-4 (1991)	-47	
836	6-7	KB	-34 +/-3 (1984)	-35	
837	7-8	KB	-24 +/-3 (1974)	-22	
838	8-9	KB	-11 +/-3 (1961)	-9	
839	9-10	KB	4 +/-3 (1946)	3	
840	10-11	KB	17 +/-4 (1933)	16	
841	11-12	KB	30 +/-4 (1920)	27	
842	12-13	KB	45 +/-4 (1905)	37	
843	13-14	KB	57 +/-5 (1893)	48	
844	14-15	KB	62 +/-5 (1888)	58	
845	15-16	KB	67 +/-5 (1883)	69	
846	16-17	KB	71 +/-5 (1879)	74	
847	17-18	KB	77 +/-4 (1873)	81	
848	18-19	KB	89 +/-4 (1861)	87	
849	19-20	KB	105 +/-5 (1845)	92	
870	40	A	1290 +/-15	1205 (1122-1276)	UCIAMS-265537 - ULA-10585
892	62	A	1890 +/-15	1784 (1725-1865)	UCIAMS-265538 - ULA-10586
974	144	B	3565 +/-15	3855 (3729-3952)	UCIAMS-265539 - ULA-10587
1055	225	C	4790 +/-15	5514 (5462-5582)	UCIAMS-265540 - ULA-10588
1137	307	D	6240 +/-15	7204 (7025-7247)	UCIAMS-265541 - ULA-10589
1213	383	E	8145 +/-20	9068 (8998-9249)	UCIAMS-265542 - ULA-10590
1299	469	F	13165 +/-35	10952 (10358-11776)	UCIAMS-265555 - ULA-10591

Lake O15 ***390 cm depth 670 cm of sediment***	**Real depth (cm)**	**Core**	**^{14}C date BP** (AD Year)	**Cal. Yr. BP (rbacon)**	**Laboratory number**
391	1-2	KB	-59 +/-3 (2009)	-59	
392	2-3	KB	-55 +/-3 (2005)	-54	
393	3-4	KB	-50 +/-3 (2000)	-50	
394	4-5	KB	-45 +/-3 (1995)	-46	
395	5-6	KB	-39 +/-3 (1989)	-42	
396	6-7	KB	-30 +/-3 (1980)	-32	
397	7-8	KB	-17 +/-3 (1967)	-22	
398	8-9	KB	-8 +/-3 (1958)	-12	
399	9-10	KB	2 +/-3 (1948)	-2	
400	10-11	KB	12 +/-4 (1938)	8	
401	11-12	KB	25 +/-3 (1925)	20	
402	12-13	KB	35 +/-3 (1915)	32	
403	13-14	KB	49 +/-3 (1901)	44	
404	14-15	KB	64 +/-3 (1886)	56	
405	15-16	KB	82 +/-3 (1868)	68	
406	16-17	KB	109 +/-4 (1841)	95	
424	34	A	1365 +/-20	1268 (1038-1327)	UCIAMS-246451 - ULA-9742
449	59	A	2060 +/-20	1983 (1860-2088)	UCIAMS-246452 - ULA-9743
529	139	B	3095 +/-15	3284 (3193-3365)	UCIAMS-247303 - ULA-9744
606	216	C	3930 +/-20	4365 (4244-4498)	UCIAMS-247304 - ULA-9745
686	296	D	4955 +/-20	5660 (5571-5830)	UCIAMS-247305 - ULA-9746
766	376	E	6145 +/-20	7020 (6907-7150)	UCIAMS-247316 - ULA-9757
846	456	F	7485 +/-25	8299 (8175-8374)	UCIAMS-247317 - ULA-9758

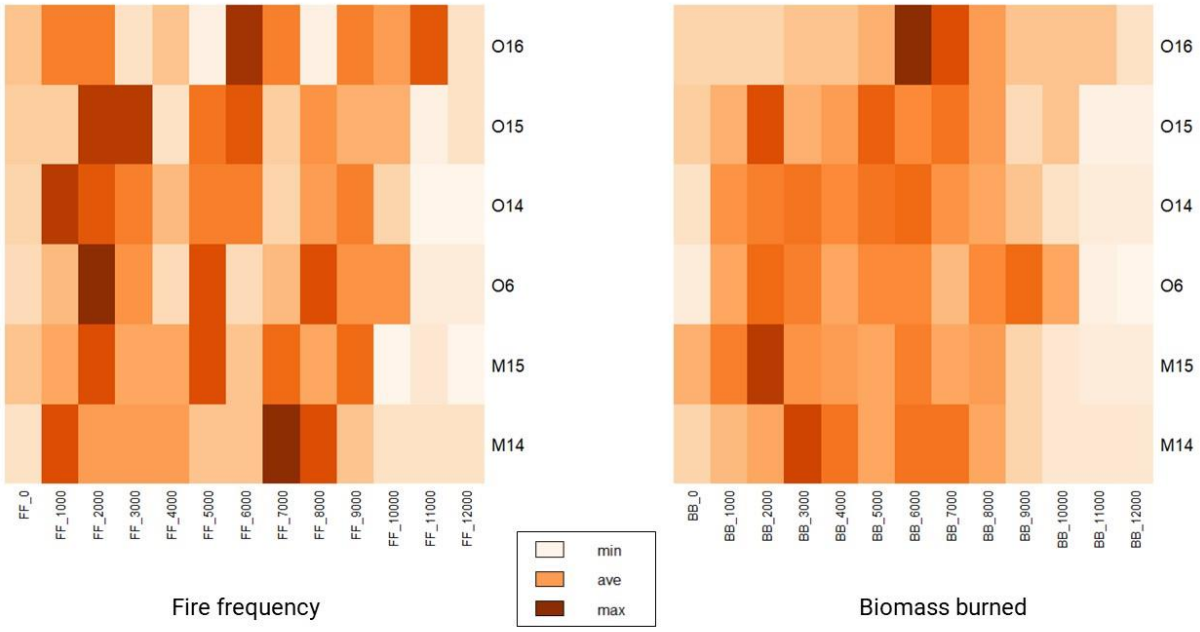
Lake O16 ***320 cm depth 818 cm of sediment***	**Real depth (cm)**	**Core**	**^{14}C date BP** (AD Year)	**Cal. Yr. BP (rbacon)**	**Laboratory number**
320	0	KB	-62 +/-3 (2012)	-62	
321	1	KB	-61 +/-4 (2011)	-60	
322	2	KB	-59 +/-3 (2009)	-57	
323	3	KB	-56 +/-3 (2006)	-55	
324	4	KB	-53 +/-3 (2003)	-52	
325	5	KB	-46 +/-4 (1996)	-50	
326	6	KB	-43 +/-4 (1993)	-45	
327	7	KB	-40 +/-4 (1990)	-41	
328	8	KB	-36 +/-5 (1986)	-37	
329	9	KB	-32 +/-4 (1982)	-32	
330	10	KB	-27 +/-5 (1977)	-28	
331	11	KB	-21 +/-6 (1971)	-23	
332	12	KB	-16 +/-6 (1966)	-17	
333	13	KB	-10 +/-6 (1960)	-12	
334	14	KB	-3 +/-6 (1953)	-7	
335	15	KB	4 +/-7 (1946)	-2	
336	16	KB	12 +/-7 (1938)	11	
337	17	KB	26 +/-8 (1924)	24	
338	18	KB	44 +/-12 (1906)	37	
339	19	KB	61 +/-15 (1889)	50	
340	20	KB	87 +/-31 (1863)	62	
350-360	30-40	A	620 +/-30	586 (513-650)	O16-1A_350-360 - BETA 373083
400-403	80-83	A	1780 +/-30	1643 (1546-1756)	O16-1A_400-403 - BETA 373084
500-502	180-182	C	3250 +/-30	3456 (3369-3564)	O16-1C_500-502 - BETA 375599
610-612	290-292	D	4850 +/-30	5503 (5329-5643)	O16-1D_610-612 - BETA 375595
720-722	400-402	F	6230 +/-40	6811 (6479-7083)	O16-1F_720-722 - BETA 375596
830-832	510-512	G	6650 +/-40	7576 (7472-7978)	O16-1G_830-832 - BETA 375597
940-942	620-622	H	7890 +/-50	8941 (8698-9394)	O16-1H_940-942 - BETA 375598
1060-1063	740-743	J	10070 +/-40	11568 (11328-11807)	O16-1J_1060-1063 - BETA 398036



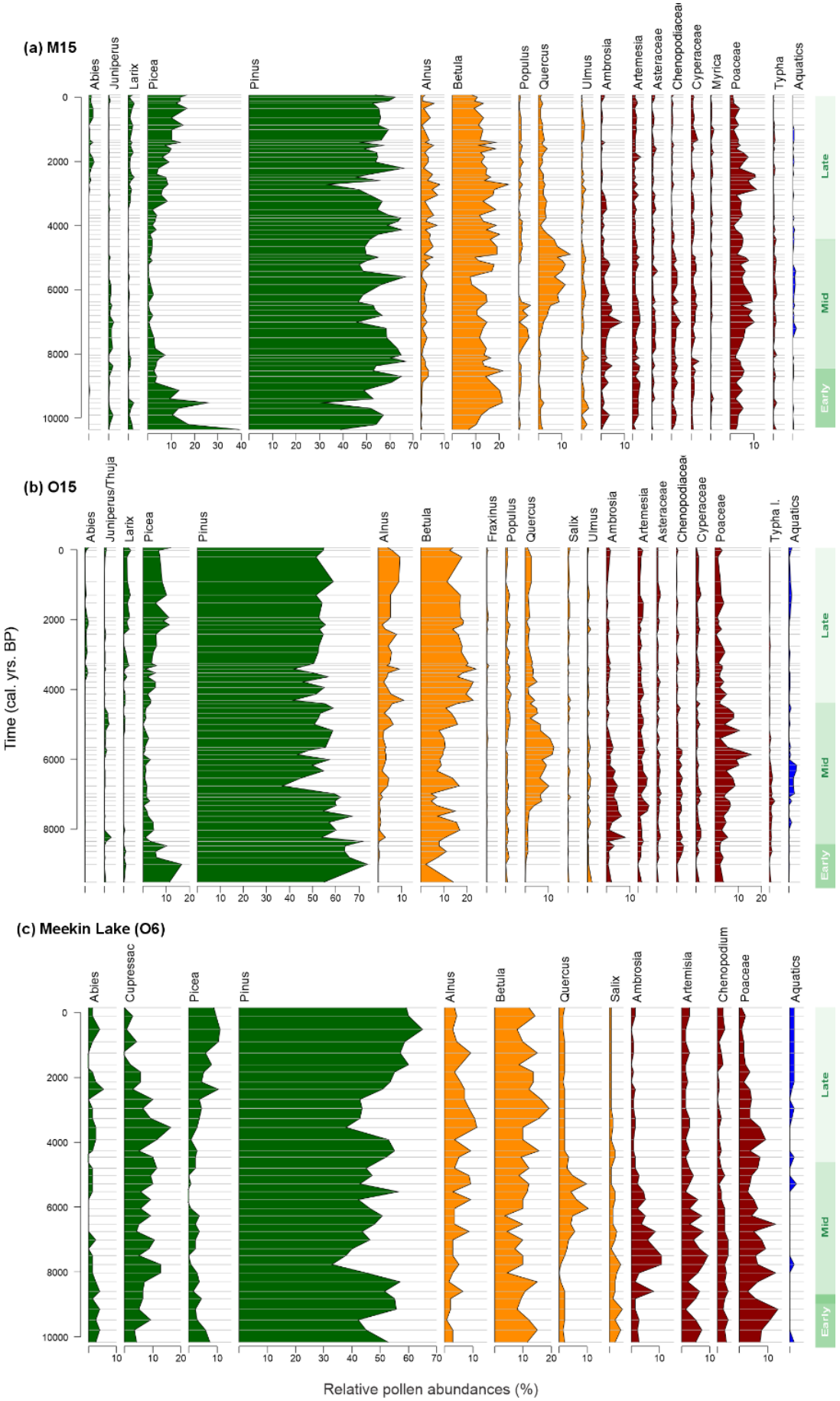
Supplementary Figure 1: Age-depth models based on ^{14}C and ^{210}Pb results. Models were produced using *'rbacon'* R package[1]. Top panels show the MCMC (Markov chain Monte Carlo) run (left), prior (empty curve) and posterior (grey-filled curve) distributions for accumulation rate (middle) and its variability (right). Main panel shows the calibrated ^{14}C (blue) and ^{210}Pb (green) dates, and the age-depth model where grey-scales indicate all possible age-depth models, and dotted lines indicate the mean and 95% confidence ranges.



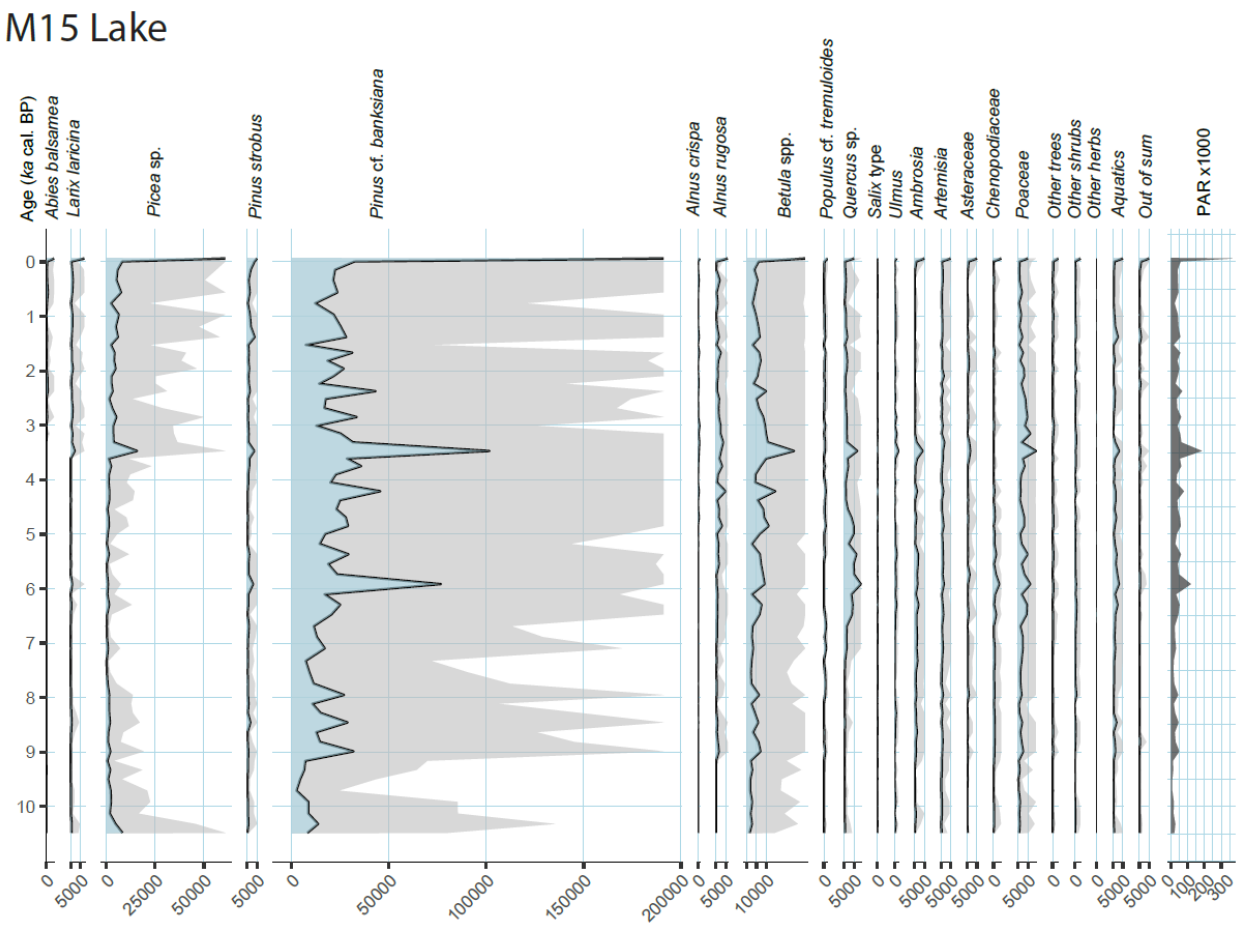
Supplementary Figure 2: **Charcoal accumulation rate, interpreted as biomass burned during the last 12,000 years, interpolated from charcoal influx for the six lakes.** Boreal sites: O6, O15, O16, and M14; Hemiboreal sites: M15 and O6 (see Fig. 1).



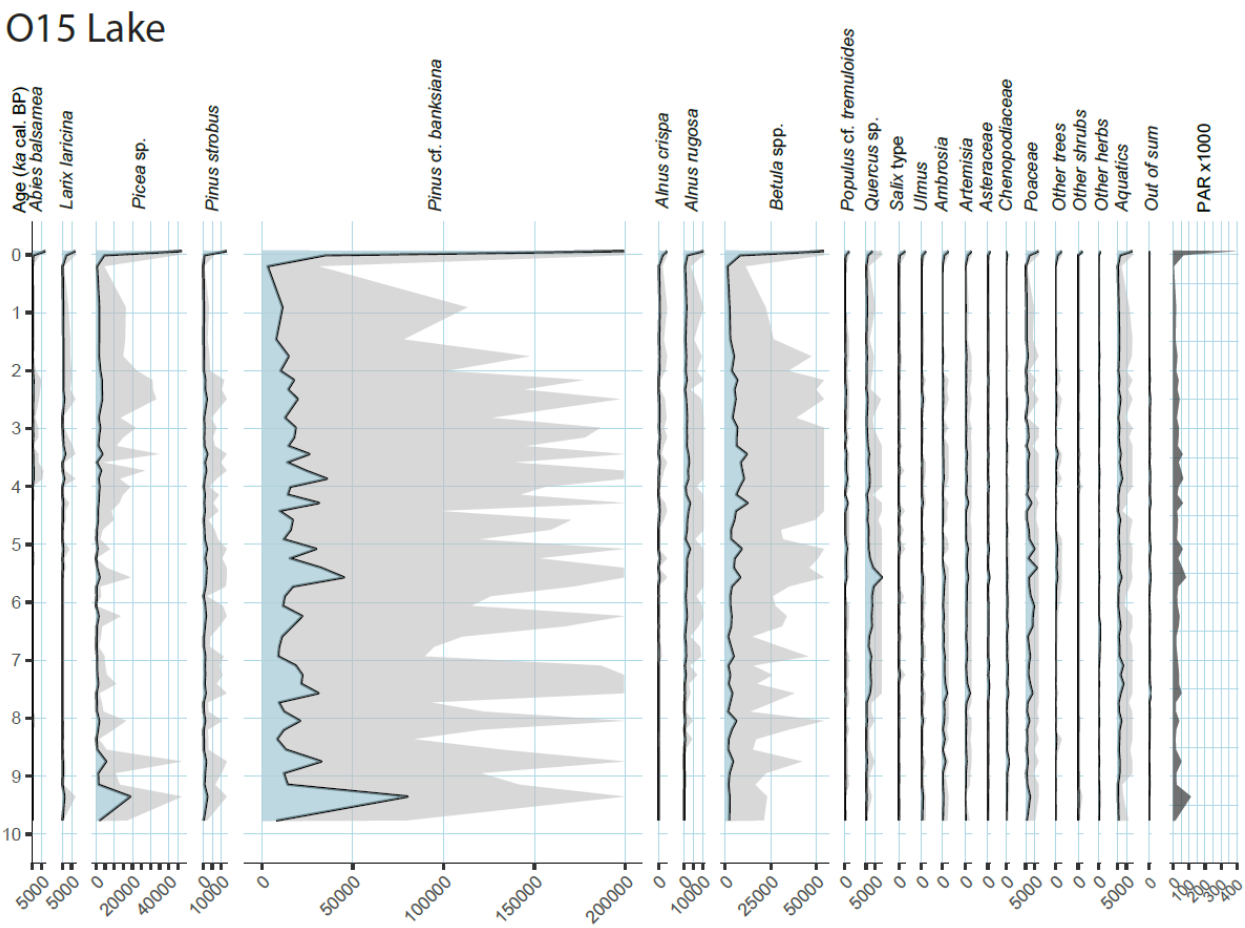
Supplementary Figure 3: **Heatmap showing the site-level means of fire frequency and biomass burned per thousand years, from 0 to 12,000 BP.**


(a) M15
Abies
Juniperus
Larix
Picea
Pinus
Alnus
Betula
Populus
Quercus
Ulmus
Ambrosia
Artemesia
Asteraceae
Chenopodiacea
Cyperaceae
Myrica
Poaceae
Typha
Aquatics
0
2000
4000
6000
8000
10000
Late
Mid
Early
(b) O15
Abies
Juniperus/Thuja
Larix
Picea
Pinus
Alnus
Betula
Fraxinus
Populus
Quercus
Salix
Ulmus
Ambrosia
Artemesia
Asteraceae
Chenopodiacea
Cyperaceae
Poaceae
Typha l.
Aquatics
Time (cal. yrs. BP)
0
2000
4000
6000
8000
Late
Mid
Early
(c) Meekin Lake (O6)
Abies
Cupressac
Picea
Pinus
Alnus
Betula
Quercus
Salix
Ambrosia
Artemisia
Chenopodium
Poaceae
Aquatics
0
2000
4000
6000
8000
10000
Late
Mid
Early
Relative pollen abundances (%)

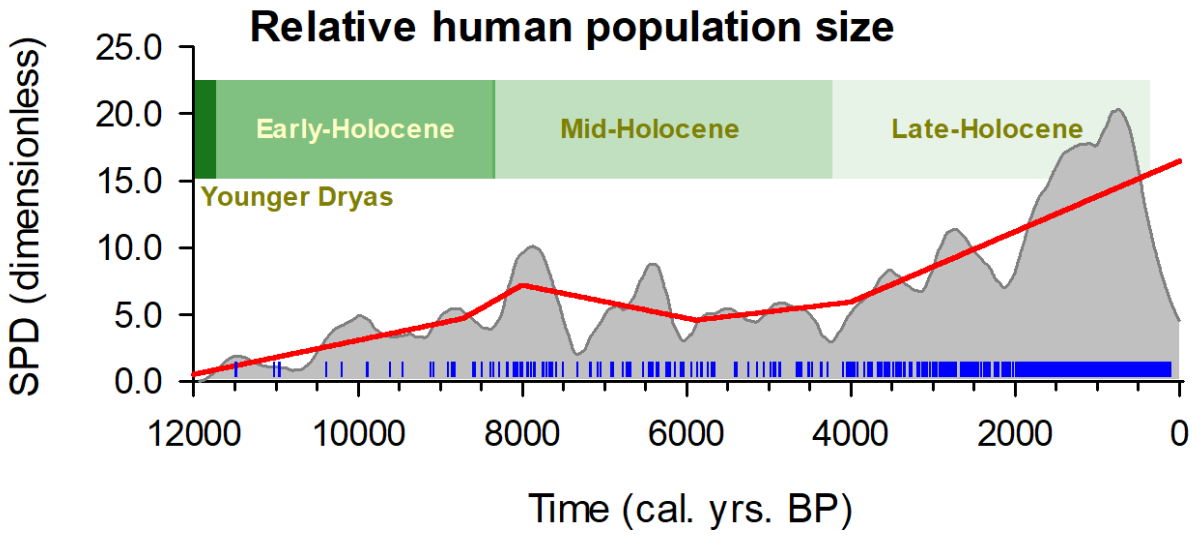
Supplementary Figure 4: Relative pollen abundances (%) for the main taxa of lakes M15, O15 and O6 (Meekin Lake). Represented are conifer trees (in green), deciduous trees (orange), shrubs and herbaceous plants (red) and aquatic plants (blue), all having an average percentage greater than 1% for lakes O15 and M15, and 5% for the lake closer to O6 (Meeking Lake, as per Danesh et al., 2022) over the study period. Note that the scale differs for each pollen taxon.



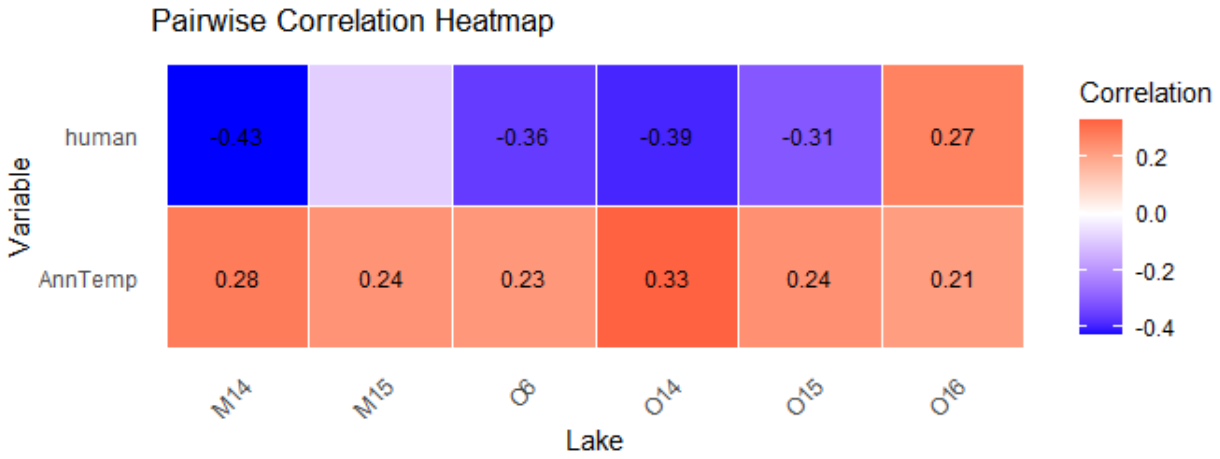
Supplementary Figure 5: Simplified pollen accumulation rate diagrams for O15 and M15 lakes. Units: *n* grains cm^{-2} yr^{-1}. Gray areas are exaggerated x10.



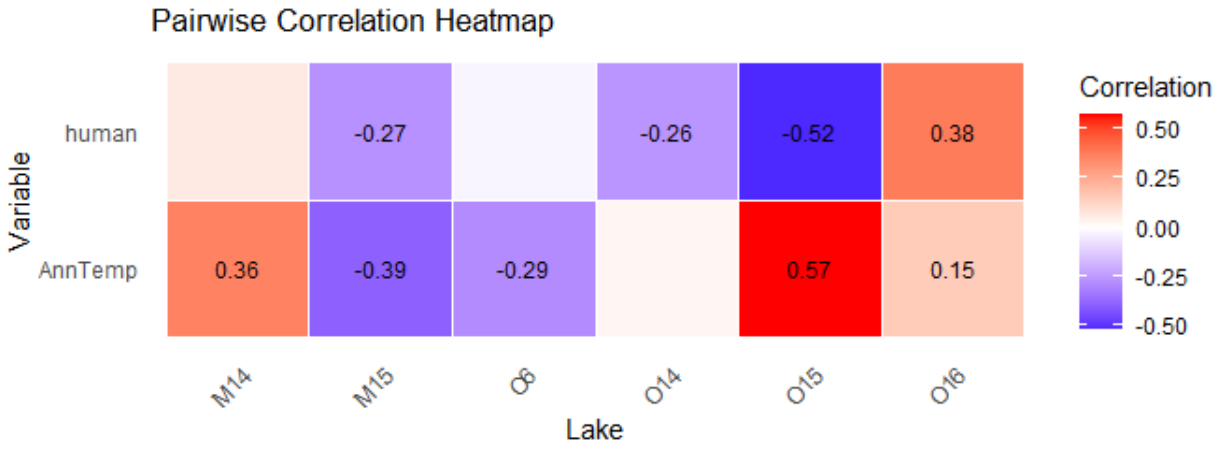
Supplementary Figure 5: *Continues.*



Supplementary Figure 6: Pointbreaks in summed probability distribution for relative human population size inferred from archaeological data. For this study, we obtained archaeological radiocarbon dates for the domain 100W-90W and 45N-55N from CARD 2.0 (Gajewski et al., 2011; database downloaded in July 2022), and P3K14C (Bird et al., 2022; downloaded in June 2022). Our analysis is truncated during the European Period due to challenges in estimating post-European population trends using this method. Pointbreaks were estimated using Multivariate Adaptive Regression Splines, with penalty per knots set to 4, and nfolds and cross parameters both set to 10 (R package 'earth'). Sub-epochs of the Holocene epoch are delineated. The rug plot (blue thick marks) indicates the median calibrated age of the individual dates, whereas the density plot is based on the entire distribution of the calibrated ages.



Supplementary Figure 7: Pairwise correlation heatmap for the relationships between mean regional human population size, temperature (AnnTemp), and site-level biomass burning. Significant correlation coefficients are identified by their rho values. The period of analysis was set to 10,000 yrs BP to present.



Supplementary Figure 8: Pairwise correlation heatmap for the relationships between mean regional human population size, temperature (AnnTemp), and site-level fire frequency. Significant correlation coefficients are identified by their rho values. The period of analysis was set to 10,000 yrs BP to present.

Supplementary References

1. Blaauw, M. & Christen, J. A. Flexible paleoclimate age-depth models using an autoregressive gamma process. *Bayesian Anal.* **6**, 457–474 (2011).
2. Danesh, D. C., Gushulak, C. A. C., Moos, M. T., Karmakar, M. & Cumming, B. F. Changes in the prairie–forest ecotone in northwest Ontario (Canada) across the Holocene. *Quat. Res.* **106**, 44–55 (2022).
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