Supplementary Material for

Anthropogenic modification of phosphorus sequestration in lake sediments during the Holocene: a global perspective

Luyao Tu [a, b], Madeleine Moyle [c], John F. Boyle [c], Paul D. Zander [d], Tao Huang [e], Lize Meng [e], Changchun Huang [e, *], Xin Zhou [f, *], Martin Grosjean [b]

[a] Department of Marine Science and Engineering, Nanjing Normal University, Nanjing 210023, China

[b] Oeschger Centre for Climate Change Research & Institute of Geography, University of Bern, Bern 3012, Switzerland

[c] Department of Geography and Planning, University of Liverpool, Liverpool L69 3BX, United Kingdom

[d] Climate Geochemistry Department, Max Planck Institute for Chemistry, Mainz 55128, Germany

[e] Department of Geography Science, Nanjing Normal University, Nanjing 210023, China

[f] Department of Earth and Space Sciences, University of Science and Technology of China, Hefei 230026, China

Correspondence author: Xin Zhou (xinzhou@ustc.edu.cn) & Changchun Huang (huangchangchun@njnu.edu.cn)

Table S1 List of study lakes, their locations (region, latitude, and longitude), morphological attributes (lake surface area; km^2, mean water depth; m), time span of the record, parameters used to apply the model, biome, and the references. The abbreviations used are: water depth at coring site (Z_{core}), mean lake-water depth (Z_{mean}), sediment core P burial rates (L_{core}), sediment core total P concentrations (Pcon), core mass accumulation rates (MAR), sediment accumulation rates (SAR), dry bulk density (DBD), loss on ignition (LOI), total organic carbon (TOC), water contents (W), sediment-inferred mean lake-wide P burial rates (Lsed).

Region	No	Name	Lat (°N)	Long (°E)	Lake area (km^2)	Z_{mean} (m)	Time span (year)	Parameters	Biome	References
China	1	Chaohu	31.567	117.558	770	3	772	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Temperate Broadleaf & Mixed Forests	Zan et al. (2012)
China	2	Daihai	40.567	112.683	160	7.4	<200	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Temperate Grasslands, Savanna & Shrublands	Gao et al. (2006) and Sun et al. (2021)
China	3	Dali	43.300	116.592	228	6.8	1897	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Temperate Grasslands, Savanna & Shrublands	Zhen (2016)
China	4	Dongping	35.917	116.167	627	3	<200	Pcon, Z_{mean}, Z_{core}, MAR	Temperate Broadleaf & Mixed Forests	Chen (2012)
China	5	Dagze Co	31.900	87.533	245	18.5	<200	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Montane Grasslands & Shrubs	Liang et al. (2021)
China	6	Honghu	29.808	113.325	344	1.34	1143	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Temperate Broadleaf & Mixed Forests	Chen et al. (2004)

China	7	Hulun	48.925	117.342	2339	3.25	3935	Pcon, Z_{mean}, Z_{core}, DBD, SAR	Temperate Grasslands, Savanna & Shrublands	Lü et al. (2016)
China	8	Longgan	40.567	115.800	316	4	<200	Pcon, Z_{mean}, Z_{core}, MAR	Temperate Broadleaf & Mixed Forests	Wu and Wang (2006)
China	9	Poyang	43.300	116.300	2933	5	1897	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Temperate Grasslands, Savanna & Shrublands	Guo (2016)
China	10	Shijiu	35.917	118.850	210	4.1	<200	Pcon, Z_{mean}, Z_{core}, SAR, LOI	Temperate Broadleaf & Mixed Forests	Yao and Xue (2009)
China	11	Taibai	31.900	115.800	26	3	1462	Pcon, Z_{mean}, Z_{core}, MAR	Temperate Broadleaf & Mixed Forests	Yang et al. (2005)
China	12	Wang	29.875	115.375	42	3.7	<200	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Temperate Broadleaf & Mixed Forests	Dong (2012)
China	13	Dongting	28.925	111.917	2433	6.4	<200	Pcon, Z_{mean}, Z_{core}, MAR	Temperate Broadleaf & Mixed Forests	Ji et al. (2018)
China	14	Zhangdu	40.567	114.733	42	1.2	<200	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Temperate Grasslands, Savanna & Shrublands	Zhang et al. (2013)
China	15	Bosten	43.300	87.067	992	8	8585	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Montane Grasslands & Shrubs	Chen. (2006)

China	16	Wudalianchi	48.725	126.175	8.2	9.2	<200	Pcon, Z_{mean}, Z_{core}, MAR	Temperate Grasslands, Savanna & Shrublands	Gui et al. (2011)
China	17	Gahai	31.900	100.550	35	9	<200	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Montane Grasslands & Shrubs	Sha et al. (2017)
China	18	Nam Co	30.717	90.658	1920	42	6773	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Montane Grasslands & Shrubs	Mügler et al. (2010)
China	19	Qinghai	36.892	100.192	4346	21	<200	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Montane Grasslands & Shrubs	Sha et al. (2017)
China	20	Xingyun	24.333	102.775	34.7	7	8900	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Tropical & Subtropical Moist Broadleaf Forests	Ma (2021) and Liu (2021)
China	21	Chenghai	26.542	100.658	77	26	<200	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Tropical & Subtropical Moist Broadleaf Forests	Zan et al. (2012)
China	22	Dianchi	24.850	102.658	300	3	<200	L_{core}, Z_{mean}, Z_{core},	Tropical & Subtropical Moist Broadleaf Forests	Tang (2021)
China	23	Erhai	25.783	100.200	250	10.2	<200	Pcon, Z_{mean}, Z_{core}, MAR	Tropical & Subtropical Moist Broadleaf Forests	Liu et al. (2019)

China	24	Fuxian	24.492	102.883	211	87	<200	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Tropical & Subtropical Moist Broadleaf Forests	Wang et al. (2014)
China	25	Tiancai	26.633	99.708	0.02	6	11,510	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Temperate Conifer Forests	Chen et al. (2018)
China	26	Lugu	27.717	100.792	48	40	<200	L_{core}, Z_{mean}, Z_{core}	Temperate Conifer Forests	Chen et al. (2021)
China	27	Qionghai	27.808	102.358	27.9	10.3	<200	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Tropical & Subtropical Moist Broadleaf Forests	Zhang et al. (2018)
China	28	Jingpohu	43.908	128.608	91.5	13.3	<200	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Temperate Broadleaf & Mixed Forests	Zhang et al. (2018); Liao and Li (2018)
China	29	Qilu	24.175	102.767	37	4.5	<200	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Tropical & Subtropical Moist Broadleaf Forests	Yang (2020)
China	30	Yangzonghai	24.908	102.992	31	20	<200	Pcon, Z_{mean}, Z_{core}, MAR	Tropical & Subtropical Moist Broadleaf Forests	Wu et al. (2021)
China	31	Huguangyan	21.150	110.283	2.3	12	<200	L_{core}, Z_{mean}, Z_{core}	Tropical & Subtropical Moist Broadleaf Forests	He (2021)

China	32	East lake	30.550	114.383	28	2.2	<200	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Temperate Broadleaf & Mixed Forests	Yang et al. (2004)
China	33	Yam Co	28.825	90.942	638	30	<200	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Montane Grasslands & Shrubs	He (2021)
China	34	Taihu	31.250	120.250	2425	2.1	<200	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Temperate Broadleaf & Mixed Forests	Mi et al. (2014)
China	35	Nansi	34.892	116.958	1280	1.6	<200	Pcon, Z_{mean}, Z_{core}, MAR	Temperate Broadleaf & Mixed Forests	Ding (2017)
China	36	Shengjin	30.375	117.083	133	1.3	<200	Pcon, Z_{mean}, Z_{core}, SAR, W	Temperate Broadleaf & Mixed Forests	Cheng et al. (2020)
China	37	Xiannv	27.817	114.942	50	12	<200	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Temperate Broadleaf & Mixed Forests	Zhou (2019)
China	38	Changdang	31.608	119.558	89	1.1	<200	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Temperate Broadleaf & Mixed Forests	Zhang et al. (2018) and Liu et al. (2022)
China	39	Gucheng	31.267	118.917	25	1.6	<200	Pcon, Z_{mean}, Z_{core}, MAR	Temperate Broadleaf & Mixed Forests	Yao et al. (2008) and Xu et al. (2021)
China	40	Chiba	29.292	113.350	18	6	<200	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Temperate Broadleaf & Mixed Forests	Zhang (2015)

China	41	Gaoyou	32.883	119.258	675	1.4	<200	Pcon, Z_{mean}, Z_{core}, MAR	Temperate Broadleaf & Mixed Forests	Li et al. (2013)
Europe	42	Grane Lanso	56.020	9.451	0.1	8	<200	Pcon, Z_{mean}, Z_{core}, SAR, LOI	Temperate Broadleaf & Mixed Forests	Klamt et al. (2017)
Europe	43	Renstrandtrasket	60.430	25.898	0.3	1.2	<200	Pcon, Z_{mean}, Z_{core}, SAR, LOI	Boreal Forests/Taiga	Vaalgamaa and Korhola (2007)
Europe	44	Annsjon	63.267	12.550	65	15	<200	Pcon, Z_{mean}, Z_{core}, SAR, W	Boreal Forests/Taiga	Paraskova et al. (2014)
Europe	45	Erken	59.850	18.583	24	9	<200	Pcon, Z_{mean}, Z_{core}, SAR, W	Temperate Broadleaf & Mixed Forests	Paraskova et al. (2014)
Europe	46	Bret	46.513	6.772	0.4	13	<200	Pcon, Z_{mean}, Z_{core}, MAR	Temperate Broadleaf & Mixed Forests	Thevenon et al. (2013)
Europe	47	Lugano	45.970	8.858	1.1	33	<200	L_{core}, Z_{mean}, Z_{core}	Temperate Conifer Forests	Tu et al. (2019)
Europe	48	Burgäschi	47.170	7.669	0.21	16	<200	L_{core}, Z_{mean}, Z_{core}	Temperate Broadleaf & Mixed Forests	Tu et al. (2020)
Europe	49	Bala	52.897	-3.609	4.1	24	<200	Pcon, Z_{mean}, Z_{core}, MAR	Temperate Broadleaf & Mixed Forests	Rowan et al. (2012)
Europe	50	Ballybeg	52.812	-8.993	0.2	2.7	<200	L_{core}, Z_{mean}, Z_{core}	Temperate Broadleaf & Mixed Forests	Taylor et al. (2006)
Europe	51	Crans	54.455	-6.905	0.1	6.7	<200	L_{core}, Z_{mean}, Z_{core}	Temperate Broadleaf & Mixed Forests	Taylor et al. (2006)
Europe	52	Egish	54.063	-6.791	1.2	3.3	<200	L_{core}, Z_{mean}, Z_{core}	Temperate Broadleaf & Mixed Forests	Taylor et al. (2006)

Europe	53	Inchiquin	52.953	-9.088	1.2	10.2	<200	L_{core}, Z_{mean}, Z_{core}	Temperate Broadleaf & Mixed Forests	Taylor et al. (2006)
Europe	54	Mullagh	53.814	-6.973	0.4	2.3	<200	L_{core}, Z_{mean}, Z_{core}	Temperate Broadleaf & Mixed Forests	Taylor et al. (2006)
Europe	55	Sillan	54.007	-6.927	1.7	6	<200	L_{core}, Z_{mean}, Z_{core}	Temperate Broadleaf & Mixed Forests	Taylor et al. (2006)
Europe	56	White Lough	54.115	-6.965	0.1	6.2	<200	Pcon, Z_{mean}, Z_{core}, MAR	Temperate Broadleaf & Mixed Forests	Anderson et al. (2012)
Europe	57	Friary Loch	54.445	-6.847	0.1	4.5	<200	Lsed	Temperate Broadleaf & Mixed Forests	Jordan et al. (2002)
North America	58	Bear	42.000	-111.330	280	29	<200	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Deserts & Xeric Shrublands	Smoak and Swarzenski (2004)
North America	59	Champlain	44.586	-73.300	1331	19.5	<200	L_{core}, Z_{mean}, Z_{core}	Temperate Broadleaf & Mixed Forests	Levine et al. (2018)
North America	60	Geneserath	45.596	-85.532	2	10.4	<200	L_{core}, Z_{mean}, Z_{core}	Temperate Broadleaf & Mixed Forests	Sawyers et al. (2016)
North America	61	Highland	44.522	-69.785	5.4	5.5	<200	L_{core}, Z_{mean}, Z_{core}	Temperate Broadleaf & Mixed Forests	Norton et al. (2008)
North America	62	Salmon	44.522	-69.785	24.9	7	<200	L_{core}, Z_{mean}, Z_{core}	Temperate Broadleaf & Mixed Forests	Norton et al. (2008)
North America	63	Joes Pond	44.410	-72.222	1.6	7	<200	Pcon, Z_{mean}, Z_{core}, SAR, LOI	Temperate Broadleaf & Mixed Forests	Dixit et al. (2000)
North America	64	Kenoza	42.791	-71.054	1	17	<200	Pcon, Z_{mean}, Z_{core}, SAR, LOI	Temperate Broadleaf & Mixed Forests	Dixit et al. (2000)

North America	65	French Pond	43.192	-71.776	0.2	4.2	<200	Pcon, Z_{mean}, Z_{core}, SAR, LOI	Temperate Broadleaf & Mixed Forests	Dixit et al. (2000)
North America	66	Mattamuskeet	35.509	-76.149	162	1	<200	L_{core}, Z_{mean}, Z_{core}	Temperate Grasslands, Savanna & Shrublands	Waters et al. (2010)
North America	67	Okeechobee	27.150	-80.780	1730	2.7	<200	Pcon, Z_{mean}, Z_{core}, SAR, LOI	Flooded Grassland & Savannas	Engstrom et al. (2006)
North America	68	Panasoffkee	28.806	-82.124	18.1	1.3	<200	L_{core}, Z_{mean}, Z_{core}	Temperate Grasslands, Savanna & Shrublands	Brenner et al. (2006)
North America	69	Pepin	44.536	-92.312	1730	5.4	<200	Lsed	Temperate Broadleaf & Mixed Forests	Engstrom et al. (2009)
North America	70	Russell	44.009	-71.653	0.2	10	<200	Pcon, Z_{mean}, Z_{core}, SAR, W	Temperate Broadleaf & Mixed Forests	Dixit et al. (2001)
North America	71	Willard	43.023	-72.017	0.4	8	<200	Pcon, Z_{mean}, Z_{core}, SAR, W	Temperate Broadleaf & Mixed Forests	Dixit et al. (2001)
North America	72	St. Croix	44.948	-92.755	35.3	9.7	<200	Lsed	Temperate Grasslands, Savanna & Shrublands	Triplett et al. (2009)
North America	73	Lake of the Woods	40.063	-119.562	450	60	<200	Lsed	Deserts & Xeric Shrublands	Edlund et al. (2017)
North America	74	Harris	28.783	-81.800	75	3.5	11,427	Pcon, Z_{mean}, Z_{core}, SAR, W	Temperate Grasslands, Savanna & Shrublands	Kenney et al. (2016); Moyle et al. (2021)

Europe	75	Lac d’Annecy	45.860	6.170	27	41.5	11,500	Pcon, Z_{mean}, Z_{core}, SAR, W	Temperate Conifer Forests	Loizeau et al. (2001); Moyle et al. (2021)
Europe	76	Plesne	48.780	13.870	0.075	8.3	11,478	Pcon, Z_{mean}, Z_{core}, MAR	Temperate Broadleaf & Mixed Forests	Kopáˇcek et al. (2007); Norton et al. (2016); Moyle et al. (2021)
Europe	77	Hatchmere	53.250	-2.670	0.0345	1.5	11,497	Lsed	Temperate Broadleaf & Mixed Forests	Boyle et al. (2015); Moyle et al. (2021)
Europe	78	Peipsi	58.650	27.460	3555	7.1	10,265	Pcon, Z_{mean}, Z_{core}, SAR, LOI	Temperate Broadleaf & Mixed Forests	Kisand et al. (2017); Moyle et al. (2021)
North America	79	Sargent Mountain Pond	44.330	-68.270	0.0075	1	11,466	Lcore, Z_{mean}, Z_{core}	Temperate Broadleaf & Mixed Forests	Norton et al. (2011); Moyle et al. (2021)
Europe	80	Dudinghauser See	53.910	12.210	0.188	1.2	4533	Pcon, Z_{mean}, Z_{core}, SAR, LOI	Temperate Broadleaf & Mixed Forests	Selig et al. (2007); Moyle et al. (2021)
Europe	81	Tiefer See	53.790	12.290	0.159	5	11,456	Pcon, Z_{mean}, Z_{core}, SAR, LOI	Temperate Broadleaf & Mixed Forests	Selig et al. (2007); Moyle et al. (2021)
Europe	82	Schulzensee	53.290	12.800	0.485	2.6	11,666	Pcon, Z_{mean}, Z_{core}, SAR, LOI	Temperate Broadleaf & Mixed Forests	Selig et al. (2007); Moyle et al. (2021)
Europe	83	Lac d’Anterne	45.990	6.800	0.12	6.3	10,160	Lsed	Temperate Conifer Forests	Giguet-Covex et al. (2011); Moyle et al. (2021)

North America	84	Jackson Pond	37.430	-85.730	0.035	1.5	1762-10,933	L_{core}, Z_{mean}, Z_{core}	Temperate Broadleaf & Mixed Forests	Filippelli and Souch (1999); Moyle et al. (2021)
North America	85	Anderson Pond	36.030	-85.500	0.13	1.6	5230-14,910	L_{core}, Z_{mean}, Z_{core}	Temperate Broadleaf & Mixed Forests	Filippelli and Souch (1999); Moyle et al. (2021)
North America	86	Dry	34.120	-116.830	0.05	0.5	9172	L_{core}, Z_{mean}, Z_{core}	Mediterranean Forests, Woodland & Scrub	Filippelli and Souch (1999); Moyle et al. (2021)
North America	87	Kokwaskey	50.120	-121.830	0.46	/	11,265	L_{sed}	Temperate Conifer Forests	Filippelli and Souch (1999); Moyle et al. (2021)
Europe	88	Windermere	54.340	-2.940	14.76	21.3	11,391	P_{con}, Z_{mean}, Z_{core}, SAR, LOI	Temperate Broadleaf & Mixed Forests	Mackereth (1966); Moyle et al. (2021)
Europe	89	Ennerdale Water	54.520	-3.380	2.999	17.8	11,247	P_{con}, Z_{mean}, Z_{core}, SAR, LOI	Temperate Broadleaf & Mixed Forests	Mackereth (1966); Moyle et al. (2021)
Europe	90	Esthwaite	54.360	-2.990	1.004	6.9	11,248	P_{con}, Z_{mean}, Z_{core}, SAR, LOI	Temperate Broadleaf & Mixed Forests	Mackereth (1966); Moyle et al. (2021)
Europe	91	Kråkenes	62.033	5.000	0.055	/	11,493	L_{sed}	Temperate Conifer Forests	Boyle et al. (2013); Moyle et al. (2021)
North America	92	Laguna Zoncho	8.810	-82.960	0.75	3	3115	L_{sed}	Tropical & Subtropical Moist Broadleaf Forests	Filippelli et al. (2010); Moyle et al. (2021)

North America	93	Lower Joffre Lake	50.370	122.500	0.104	/	10,681	Lsed	Temperate Conifer Forests	Filippelli et al. (2006); Moyle et al. (2021)
Europe	94	Sämbosjön	57.160	12.420	0.23	/	9839	L_{core}, Z_{mean}, Z_{core}	Temperate Broadleaf & Mixed Forests	Digerfeldt and Håkansson (1993)
Europe	95	Trummen	56.860	14.830	1	1	11,119	L_{core}, Z_{mean}, Z_{core}	Temperate Broadleaf & Mixed Forests	Digerfeldt (1972); Moyle et al. (2021)
Europe	96	Immeln	56.270	14.330	24	7.2	11,033	Pcon, Z_{mean}, Z_{core}, SAR, DBD	Temperate Broadleaf & Mixed Forests	Digerfeldt (1974); Moyle et al. (2021)
Europe	97	Kuzi	57.030	25.330	0.063	/	11,407	Lsed	Temperate Broadleaf & Mixed Forests	Moyle et al. (2021)
South Africa	98	Malawi	-12.020	34.460	29600	292	<200	L_{core}, Z_{mean}, Z_{core}	Tropical & Subtropical Grasslands, Savannas & Shrublands	Otu et al. (2011)
South Africa	99	Sibaya	-27.348	32.684	65	12	<200	Pcon, Z_{mean}, Z_{core}, SAR, LOI	Tropical & Subtropical Moist Broadleaf Forests	Humphries and Benitez-Nelson (2013)
South Africa	100	Victoria	0.350	31.000	68000	40	<200	Pcon, Z_{mean}, Z_{core}, MAR	Tropical & Subtropical Grasslands, Savannas & Shrublands	Campbell et al. (2003)
Australia	101	Alexandrina	-35.440	139.080	649	2.8	7564	Pcon, Z_{mean}, Z_{core}, MAR	Mediterranean Forests, Woodland & Scrub	Barnett (1994)

Europe	102	Soppensee	47.092	8.083	0.227	13	11,500	L_{core}, Z_{mean}, Z_{core}	Temperate Broadleaf & Mixed Forests	Tu et al. (2021)
Europe	103	Fuglsø	56.191	10.535	0.014	1.5	11,117	L_{core}, Z_{mean}, Z_{core}	Temperate Broadleaf & Mixed Forests	Klamt et al. (2021)
South America	104	Blanca	-34.883	-54.833	0.6	2	7310	Pcon, Z_{mean}, Z_{core}, SAR, LOI	Tropical & Subtropical Grasslands, Savannas & Shrublands	Garcı´a-Rodrı´guez et al. (2010)
South America	105	Laja	-36.900	-71.083	87	54	2000	Pcon, Z_{mean}, Z_{core}, SAR, LOI	Temperate Broadleaf & Mixed Forests	Urrutia et al. (2010)
Western Asia	106	Kinneret	32.824	35.588	168	25.6	<200	L_{core}, Z_{mean}, Z_{core}	Mediterranean Forests, Woodland & Scrub	Hambright et al. (2004）
North America	107	Simcoe	44.463	-79.335	722	14	<200	Pcon, Z_{mean}, Z_{core}, MAR	Temperate Broadleaf & Mixed Forests	Hiriart-Baer et al. (2011)
South America	108	Lagoa Negra	-19.067	-57.517	0.49	1.56	9476	Pcon, Z_{mean}, Z_{core}, SAR, TOC	Tropical & Subtropical Dry Broadleaf Forests	Oliveira Bezerra et al. (2019)

Table S2 Estimated global lake P burial rates and total P sink from three intervals during 11,500-4000 cal BP, 4000-100 cal BP, and 100 cal BP to the present time. The global estimation is based on sediment-inferred mean lake-wide P burial rates (Lsed) of 108 lakes in this study and is weighted by global biomes following the methodology of Anderson et al. (2020).

	11,500-4000 (cal BP)	4000-100 (cal BP)	100 cal BP to the present
Global lake P burial rate (Tg yr^{-1})	0.156	0.321	1.544
Global lake P burial (Tg)	1171	1252	262
Global lake P sink during the Holocene (Tg)		2686	

S1 Generalized additive model (GAM) smoothing

The GAM-smoothed trends for the mean values of the 100-year bins are mostly similar to GAM-smoothed trends for all compiled data (Fig. S4, S5), confirming the reliability of using GAM-smoothing approaches to reflect changes of lake P burial rates at centennial to millennial timescales over the Holocene. Therefore, the GAM smoothing on 100-year-binned means was used to assess the major variations of P burial rates at both global and regional scales.

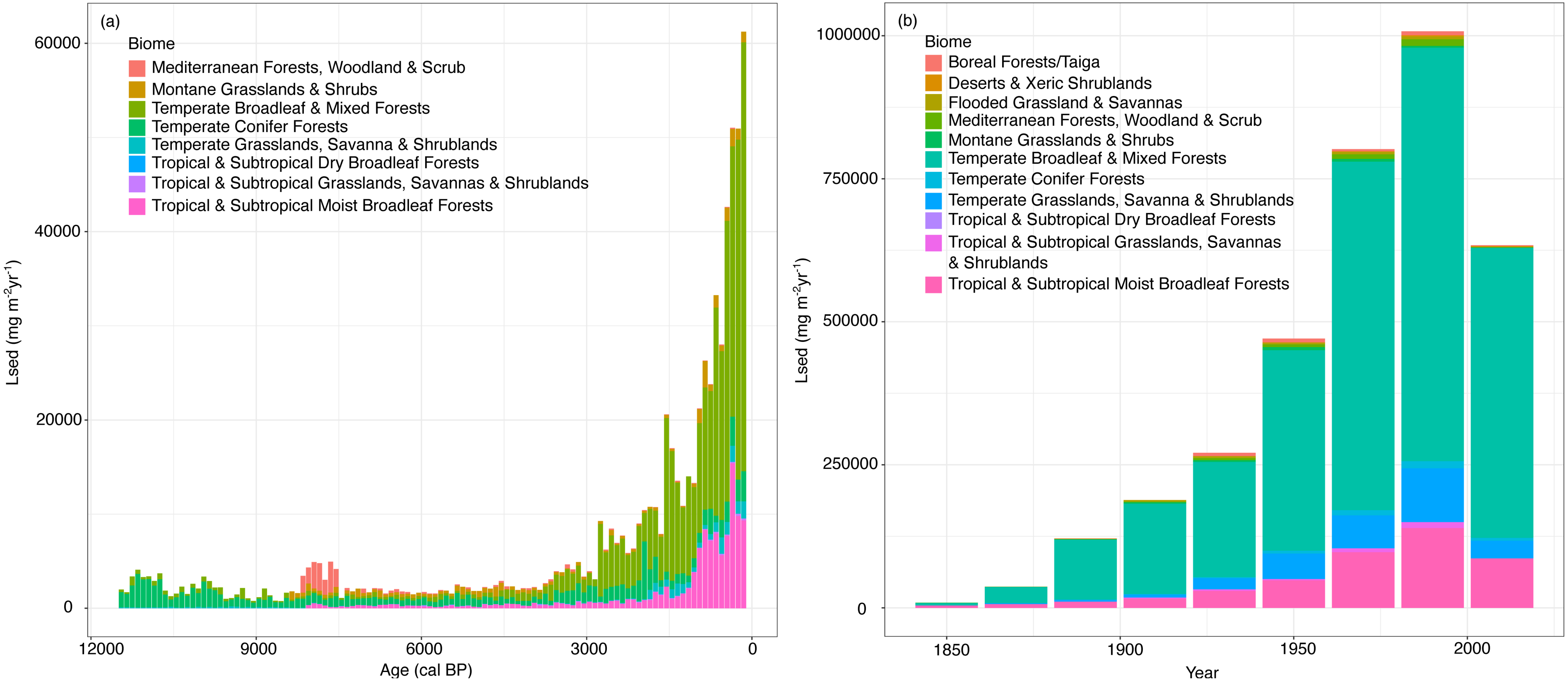

Fig. S1. Lsed for each of the global biomes (a) over the last 11,500 years (bin widths = 200 years) and (b) over the past 200 years (bin widths = 20 years).

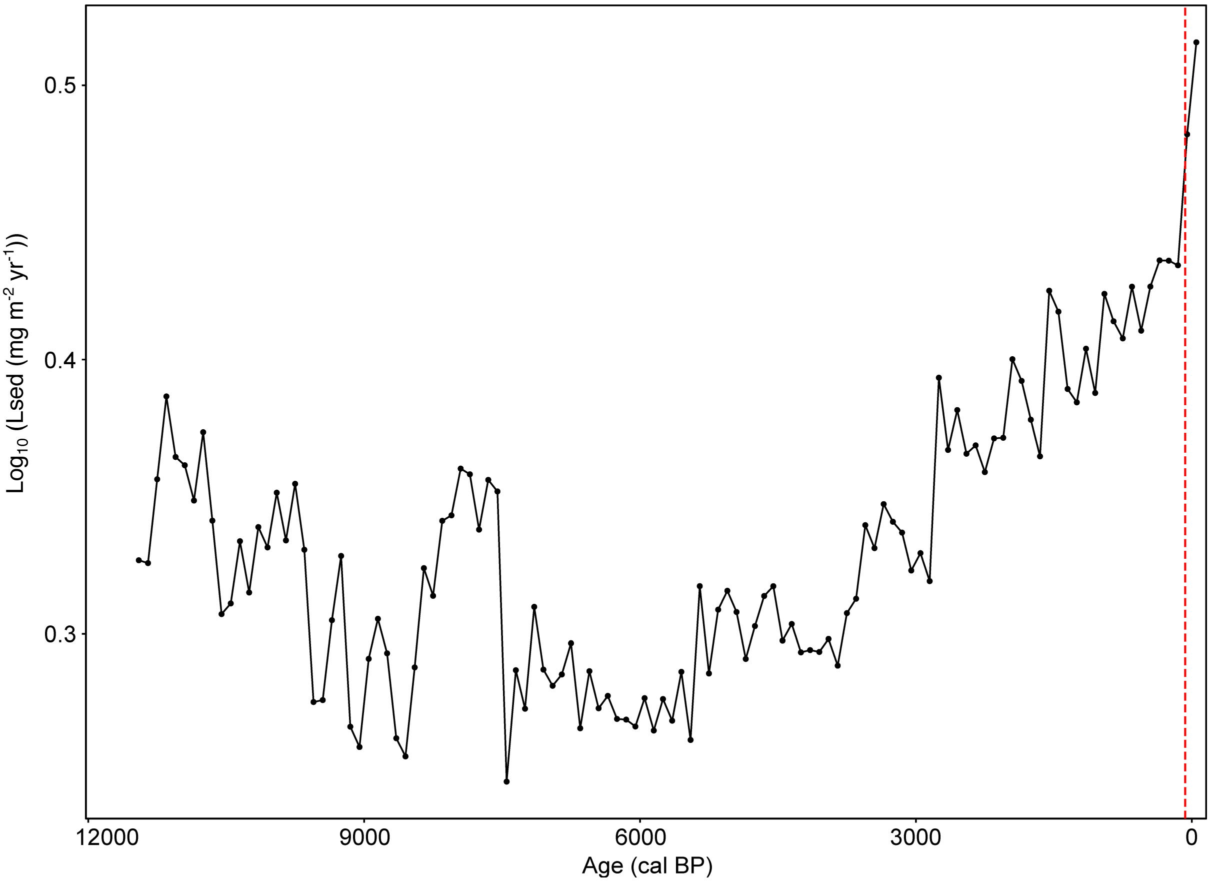

Fig. S2. The breakpoint (vertical dashed red line, at 50 cal BP, 1900 CE at range 0-100 cal BP, 1850-1950 CE) detected on the mean values of sediment-inferred mean lake-wide P burial rates (Lsed) globally, binned by 100-yr intervals during the Holocene; the data were $\log_{10}$ transformed.

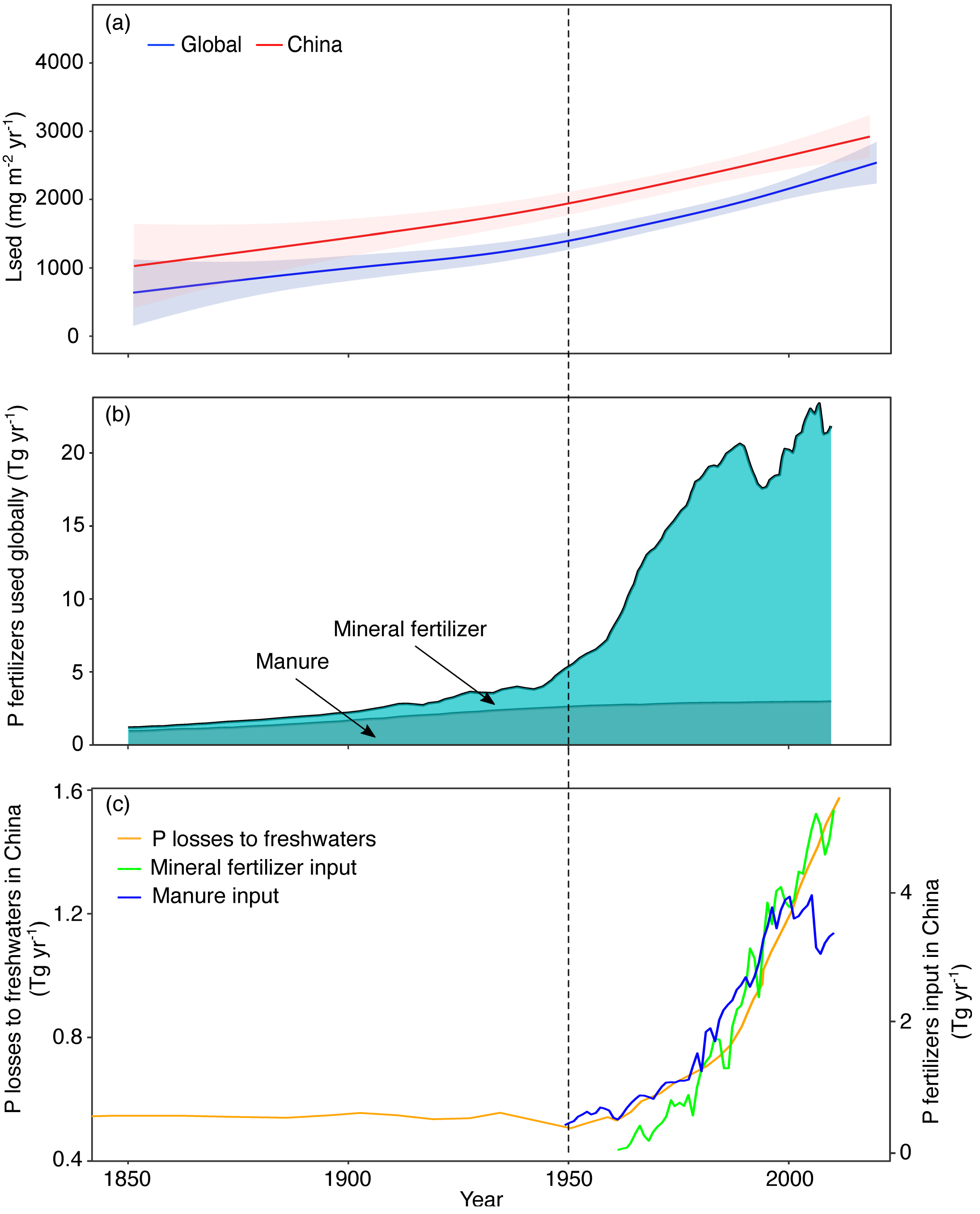

Fig. S3. (a) The comparison of GAM-smoothed trends of sediment-inferred mean lake-wide P burial rates (Lsed) of the global average and China from year 1850 CE to 2020 CE (solid curves, k=10, method = "REML") with 95% confidence intervals (shaded envelopes). (b) Historical sources of phosphorus (P) fertilizers (manure and mineral fertilizers) used in agriculture globally; data source is from Cordell et al. (2009). (c) P losses to inland waters in mainland China since 1850 (Liu et al., 2016) and P inputs with manure and mineral fertilizers to arable land in China since 1950 (Li et al., 2015).

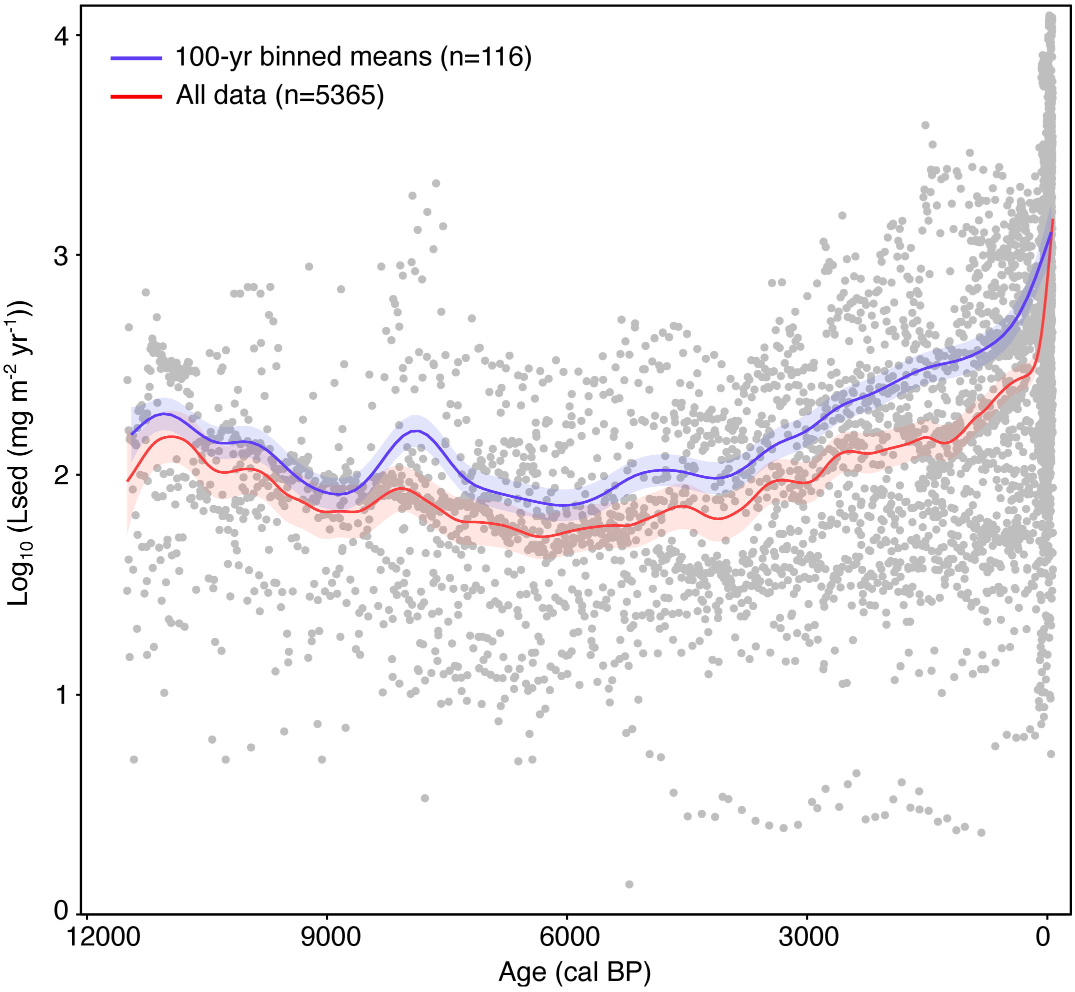

Fig. S4. The comparison of generalized additive model (GAM) based trends fitted to the means of P data in 100-yr bins (blue curve, basis dimension k=30) and the compiled raw P data (red curve, basis dimension k=400) in 108 lakes during the Holocene, with 95% confidence intervals on the predicted means (blue and red shaded envelopes, respectively); the blue and red fits are the results of a GAM with restricted maximum likelihood (REML) smoothness selection; the data of sediment-inferred mean lake-wide P burial rates (Lsed) (shown as grey points) were $\log_{10}$ transformed.

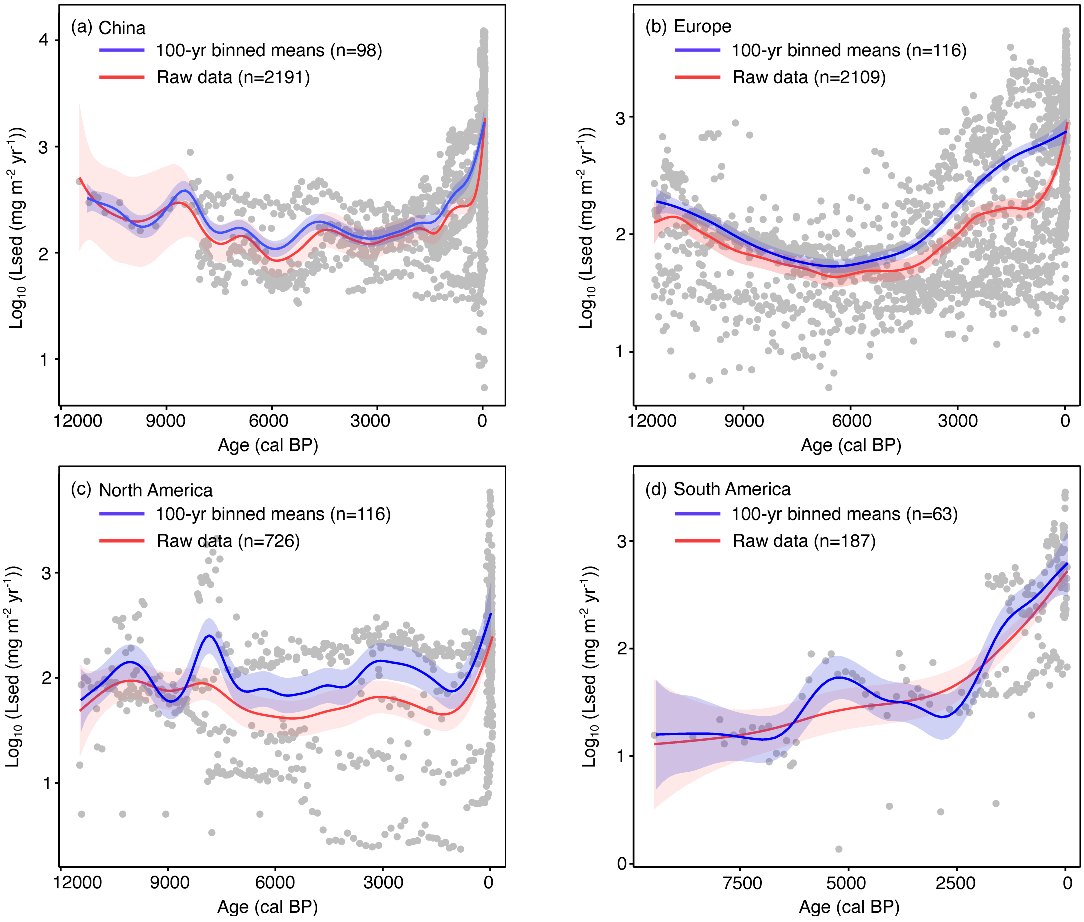

Fig. S5. The comparison of GAM-based trends fitted to the means of P data in 100-yr bins (blue curves, basis dimension k=30) and the compiled raw P data (red curves, basis dimension k=400 for China, Europe, and North America and k=100 for South America) from lakes in (a) China, (b) Europe, (c) North America, and (d) South America during the Holocene, with 95% confidence intervals on the predicted means (blue and red shaded envelopes, respectively); the blue and red fits are the results of a GAM with restricted maximum likelihood (REML) smoothness selection; the data of sediment-inferred mean lake-wide P burial rates (Lsed) (shown as gray points) were $\log_{10}$ transformed.

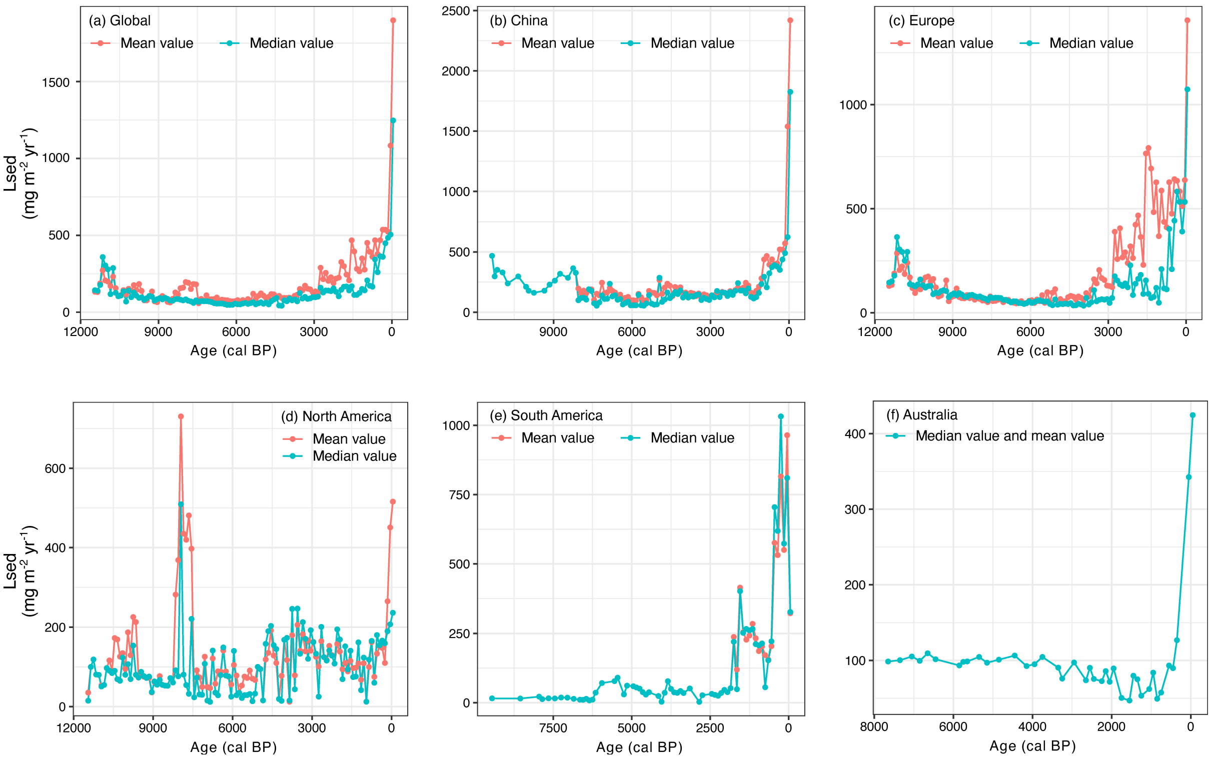

Fig. S6. The 100-yr-binned median and mean values for Lsed P burial rates during the Holocene from different regions.

S2 Lake P burial rates in recent times

The 20-yr binned means of sites in China, Europe, and Africa and of the global average all exhibited continuous and significant increases over the last 150 years (Fig. S7-S9; Fig. S12), whereas the curves of North America and South America showed no significant trends over time (Fig. S10; S11). Furthermore, Lsed P burial rates in North America declined slightly during the 21st century (Fig S9), probably because of the efforts of lake-watershed P management in the region.

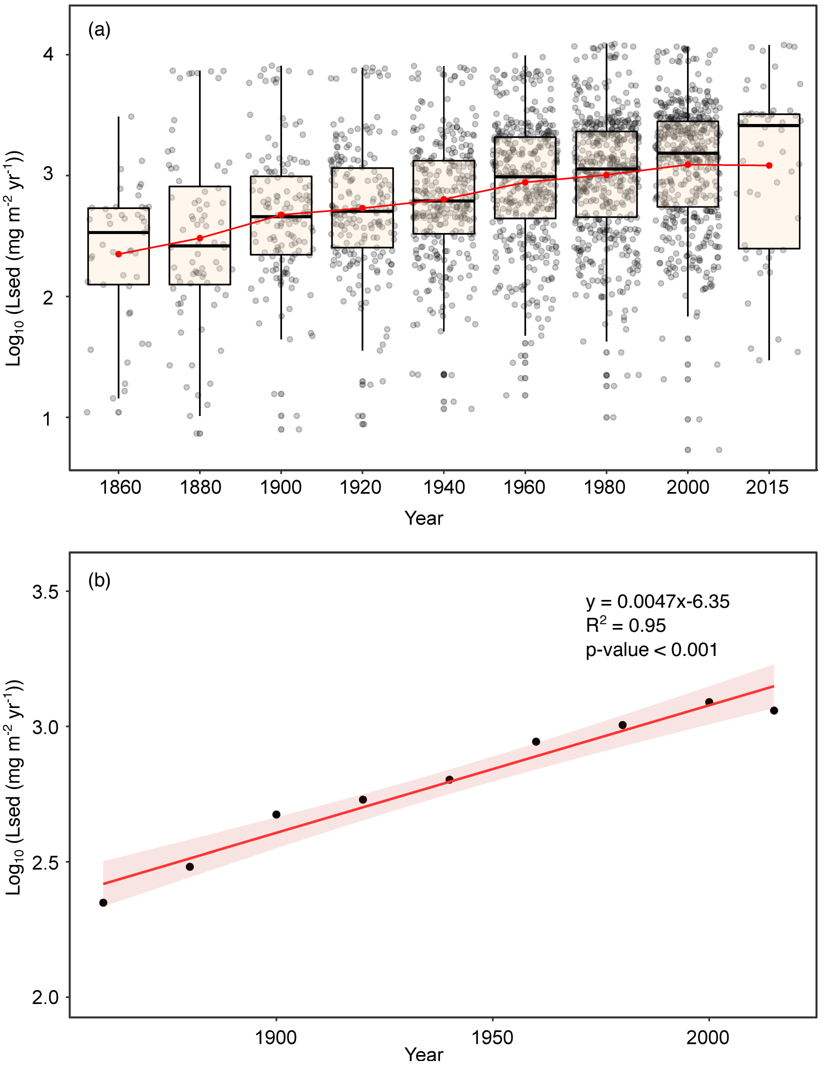

Fig. S7. (a) Sediment-inferred mean lake-wide P burial rates (Lsed) of the all-data average, binned by 20-yr intervals from 1850 CE to 2010 CE and by 10-yr intervals from 2010 CE to 2020 CE; the red dots and bold horizontal black lines in the boxplot indicate the mean values and median values of the intervals, respectively. (b) The binned mean values in (a) vs. time and the linear regression line (in red color) between time and the binned mean values; the red shaded envelope indicates 95% confidence intervals of the regression line.

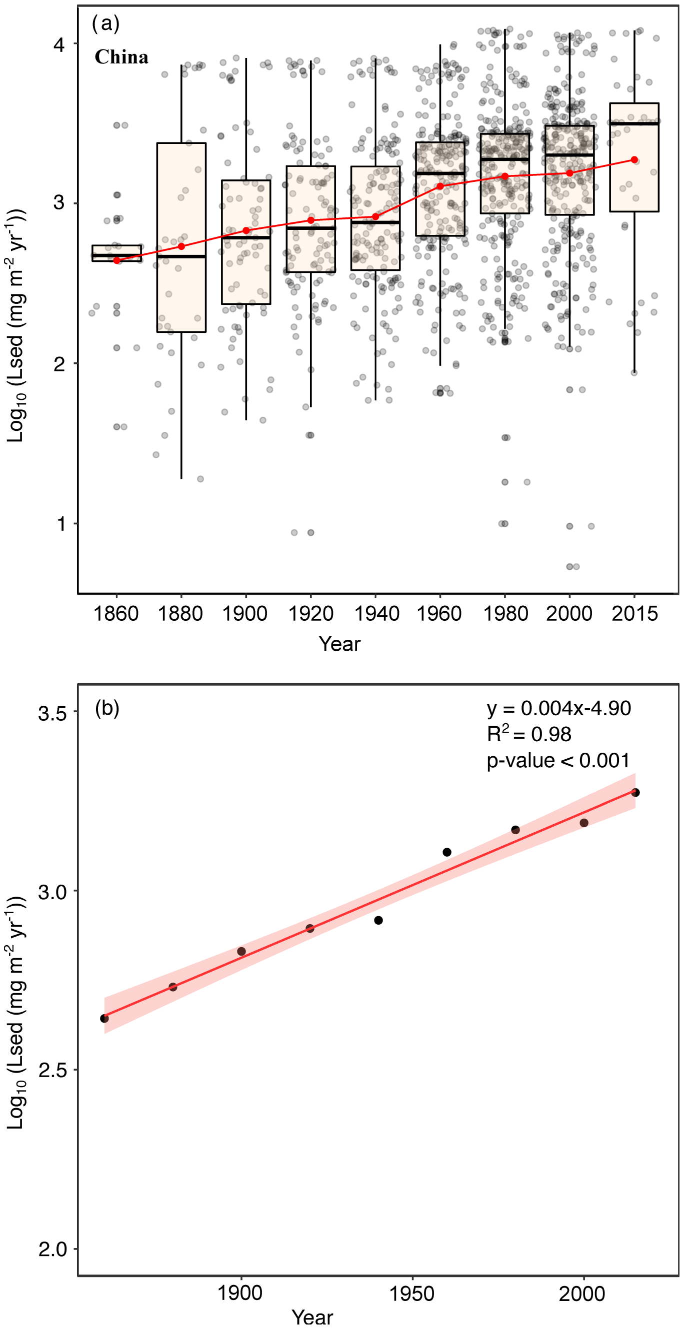

Fig. S8. (a) Sediment-inferred mean lake-wide P burial rates (Lsed) in China, binned by 20-yr intervals from 1850 CE to 2010 CE and by 10-yr intervals from 2010 CE to 2020 CE; the red dots and bold horizontal black lines in the boxplot indicate the mean values and median values of the intervals, respectively. (b) The binned mean values in (a) vs. time and the linear regression line (in red color) between time and the binned mean values; the red shaded envelope indicates 95% confidence intervals of the regression line.

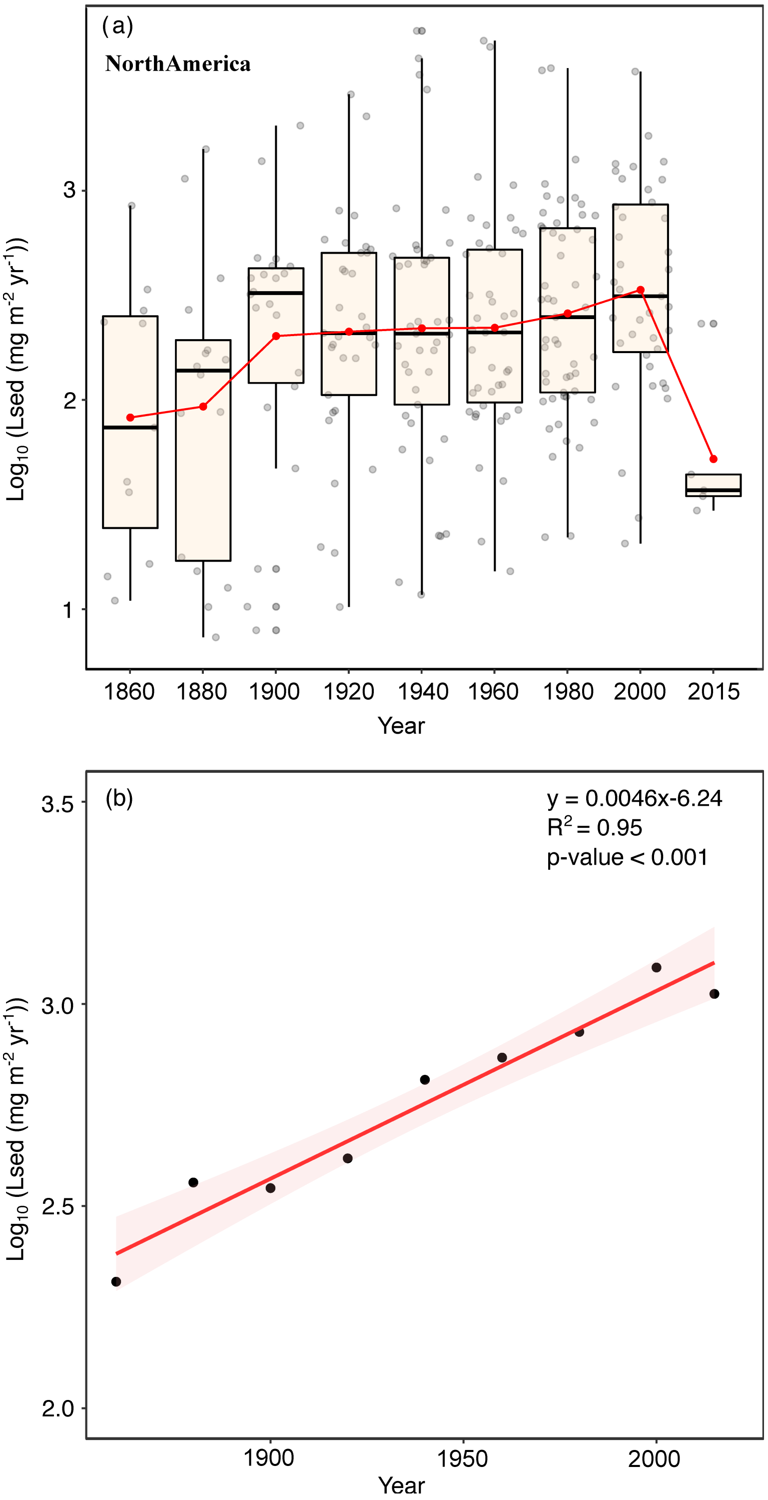

Fig. S9. (a) Sediment-inferred mean lake-wide P burial rates (Lsed) in Europe, binned by 20-yr intervals from 1850 CE to 2010 CE and by 10-yr intervals from 2010 CE to 2020 CE; the red dots and bold horizontal black lines in the boxplot indicate the mean values and median values of the intervals, respectively. (b) The binned mean values in (a) vs. time and the linear regression line (in red color) between time and the binned mean values; the red shaded envelope indicates 95% confidence intervals of the regression line.

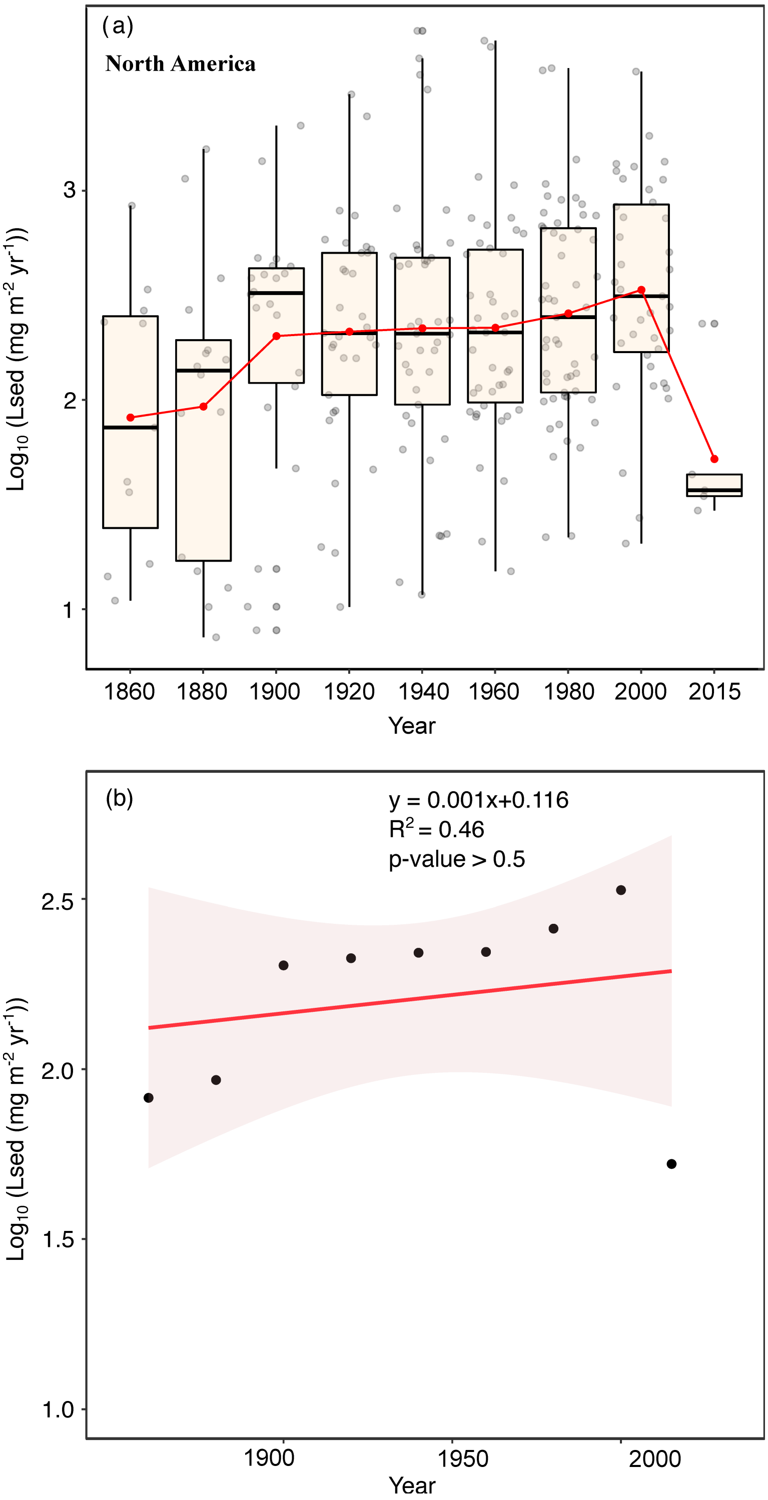

Fig. S10. (a) Sediment-inferred mean lake-wide P burial rates (Lsed) in North America, binned by 20-yr intervals from 1850 CE to 2010 CE and by 10-yr intervals from 2010 CE to 2020 CE; the red dots and bold horizontal black lines in the boxplot indicate the mean values and median values of the intervals, respectively. (b) The binned mean values in (a) vs. time and the linear regression line (in red color) between time and the binned mean values.

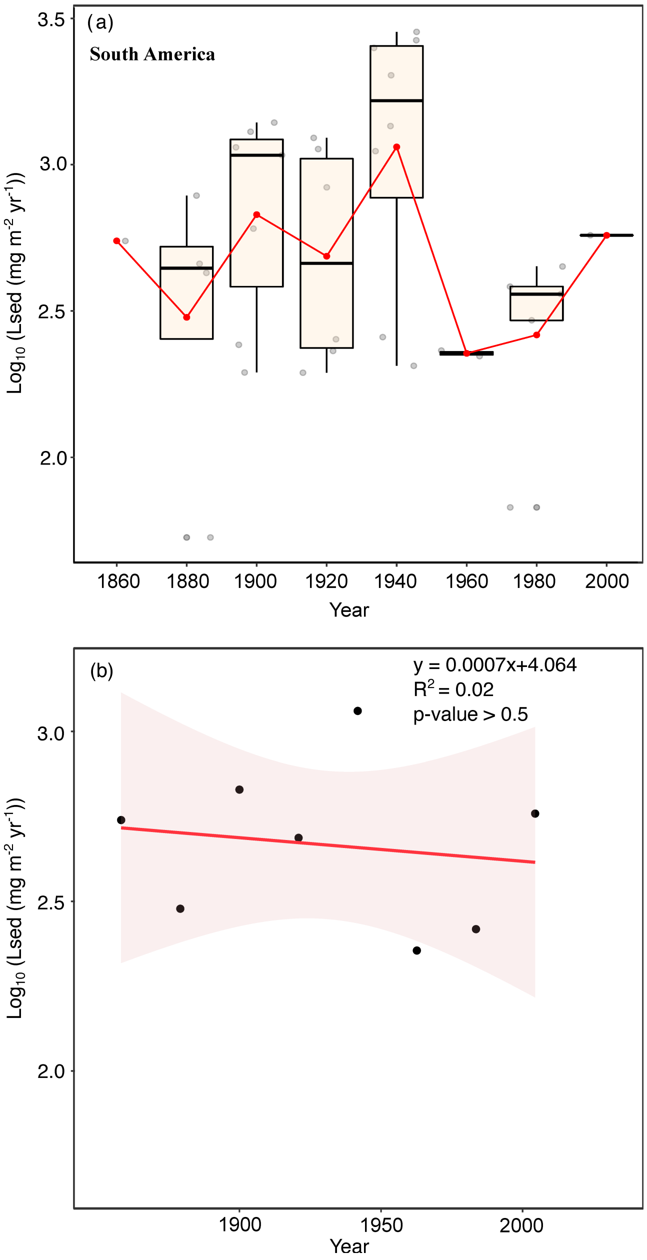

Fig. S11. (a) Sediment-inferred mean lake-wide P burial rates (Lsed) in South America, binned by 20-yr intervals from 1850 CE to 2010 CE and by 10-yr intervals from 2010 CE to 2020 CE; the red dots indicate the mean values of the intervals. (b) The binned mean values in (a) vs. time and the linear regression line (in red color) between time and the binned mean values; the red shaded envelope indicates 95% confidence intervals of the regression line.

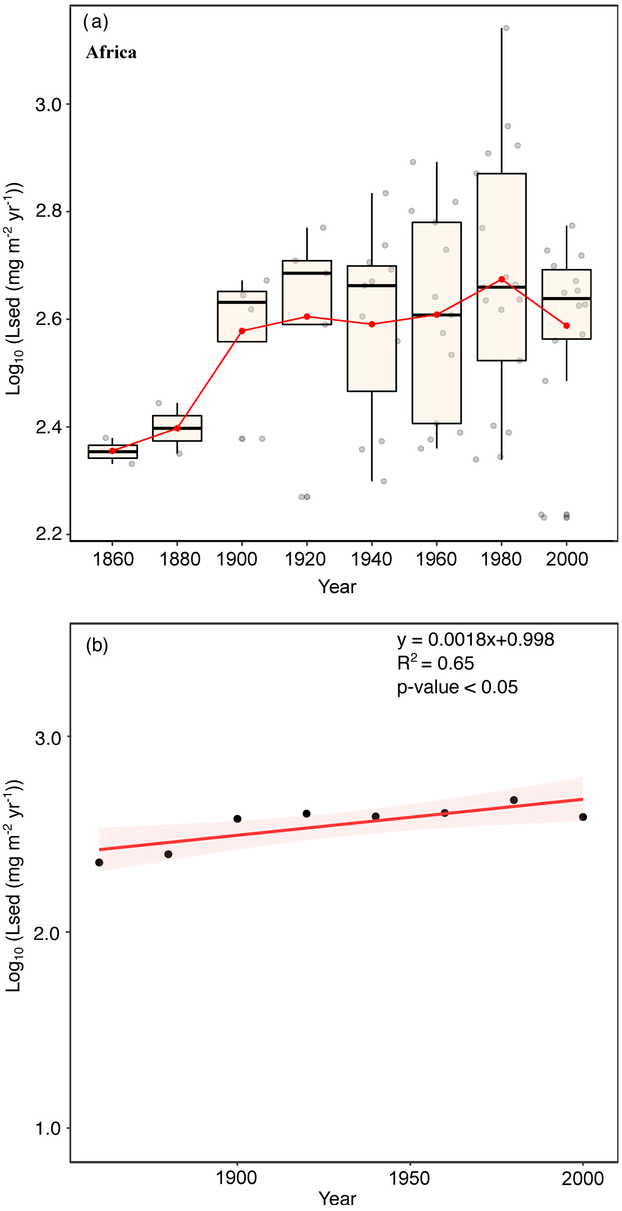

Fig. S12. (a) Sediment-inferred mean lake-wide P burial rates (Lsed) in Africa, binned by 20-yr intervals from 1850 CE to 2010 CE and by 10-yr intervals from 2010 CE to 2020 CE; the red dots and bold horizontal black lines in the boxplot indicate the mean values and median values of the intervals, respectively. (b) The binned mean values in (a) vs. time and the linear regression line (in red color) between time and the binned mean values; the red shaded envelope indicates 95% confidence intervals of the regression line.

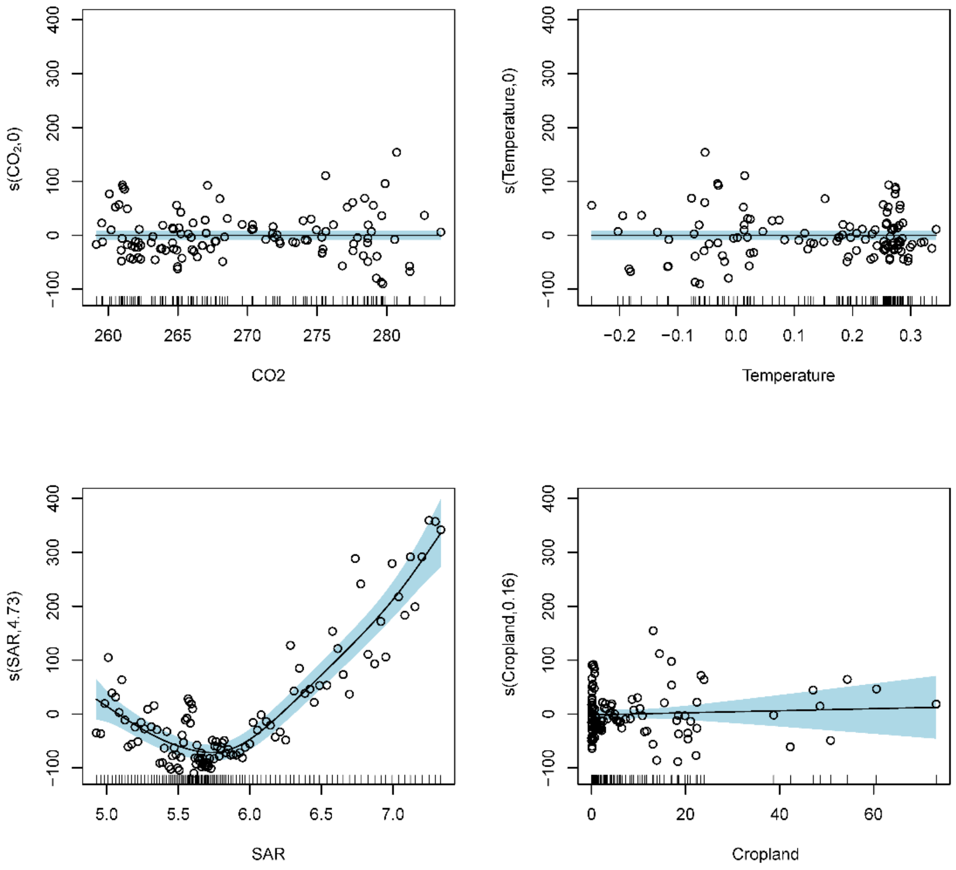

Fig. S13. Generalized additive model (GAM) plots showing the partial effects of selected explanatory variables on the global sediment-inferred mean lake-wide P burial rates (Lsed) during 11,500-100 cal BP.

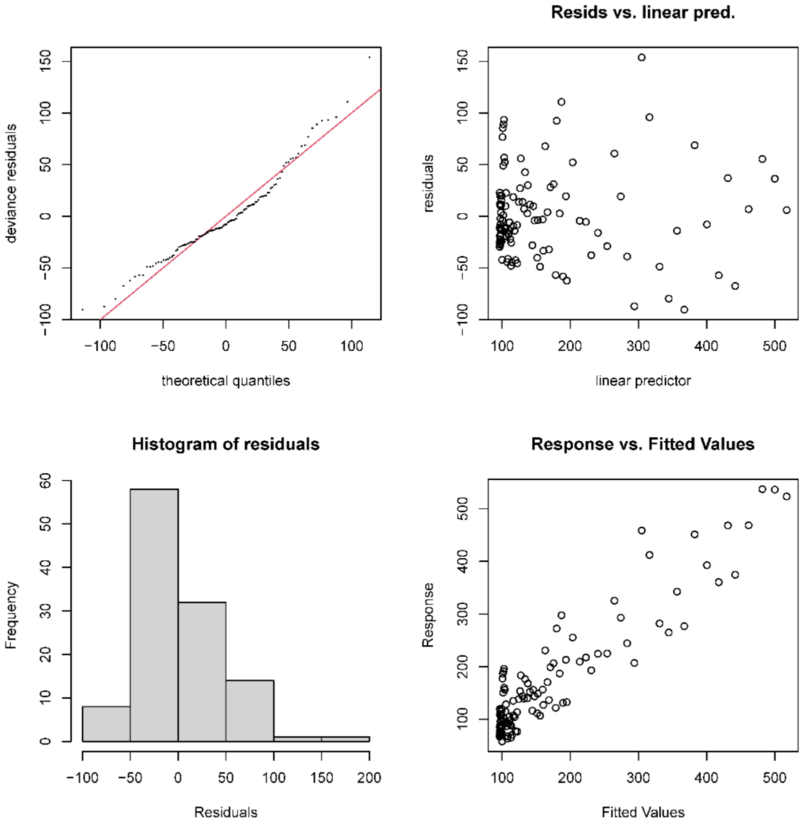

Fig. S14. GAM diagnostic plots showing the distribution of residuals and relationship between response and model fitted values.

References

Anderson, N. J., Foy, R. H., Engstrom, D. R., Rippey, B., and Alamgir, F., 2012. Climate forcing of diatom productivity in a lowland, eutrophic lake: White Lough revisited. *Freshw. Biol.* 57, 2030–2043.

Anderson, N.J., Heathcote, A.J., Engstrom, D.R., and Globocarb data contributors, 2020. Anthropogenic alteration of nutrient supply increases the global freshwater carbon sink. *Sci. Adv.* 6, eaaw2145.

Barnett, E.J., 1994. A Holocene paleoenvironmental history of Lake Alexandria, South Australia. *J. Paleolimnol.* 12, 259–268.

Bortleson, G. C. and Lee, G. F., 1972. Recent sedimentary history of Lake Mendota, Wis. *Environ. Sci. Technol.* 6, 799–808.

Bortleson, G. C. and Lee, G. F., 1974. Phosphorus, iron, and manganese distribution in sediment cores of six Wisconsin lakes. *Limnol. Oceanogr.* 19, 794–801.

Bortleson, G. C. and Lee, G. F., 1975. Recent sedimentary history of Lake Monona. Wisconsin. *Water Air Soil Pollut.* 4, 89–98.

Boyle, J. F., Chiverrell, R. C., Norton, S. A., and Plater, A. J., 2013. A leaky model of long-term soil phosphorus dynamics. *Global Biogeochem. Cy.* 27, 516–525.

Boyle, J. F., Chiverrell, R. C., Davies, H., and Alderson, D. M., 2017. An approach to modelling the impact of prehistoric farming on Holocene landscape phosphorus dynamics. *The Holocene* 25, 203–214.

Brenner, M., Hodell, D. A., Leyden, B. W., Curtis, J. H., Kenney, W. F., Gu, B., and Newman, J. M., 2006. Mechanisms for Organic Matter and Phosphorus Burial in Sediments of a Shallow, Subtropical, Macrophyte-Dominated Lake. *J. Paleolimnol.* 35, 129–148.

Brenner, M., Schelske, C. L., and Keenan, L. W., 2001. Historical rates of sediment and nutrient accumulation in marshes of the Upper St. Johns River Basin, Florida, USA. *J. Paleolimnol.* 26, 241–257.

Brenner, M., Whitmore, T. J., Curtis, J. H., Hodell, D. A., and Schelske, C. L., 1999a. Stable isotope ($\delta^{13}C$ and $\delta^{15}N$) signatures of sedimented organic matter as indicators of historic lake trophic state. *J. Paleolimnol.* 22 205–221.

Brenner, M., Whitmore, T. J., Lasi, M. A., Cable, J. E., and Cable, P. H., 1999b. A multi-proxy trophic state reconstruction for shallow Orange Lake, Florida, USA: possible influence of macrophytes on limnetic nutrient concentrations. *J. Paleolimnol.* 21, 215–233.

Brezonik, P. L. and Engstrom, D. R., 1998. Modern and historic accumulation rates of phosphorus in Lake Okeechobee, Florida. *J. Paleolimnol.* 20, 31–46.

Brooks, Y. M., Baustian, M. M., Baskaran, M., Ostrom, N. E., and Rose, J. B., 2016. Historical associations of molecular measurements of Escherichia coli and enterococci to anthropogenic activities and climate variables in freshwater sediment cores. *Environ. Sci. Technol.* 50. 6902–6911.

Campbell, L. M., Hecky, R. E., Muggide, R., Dixon, D. G., and Ramlal, P. S., 2003. Variation and distribution of total mercury in water, sediment and soil from northern Lake Victoria, East Africa. *Biogeochemistry* 65 195–211.

Cao, Y., Zhang, E., Langdon, P. G., Liu, E., and Shen, J., 2014. Chironomid-inferred environmental change over the past 1400 years in the shallow, eutrophic Taibai Lake (south-east China): Separating impacts of climate and human activity. *The Holocene* 24, 581–590.

Cardoso-Silva, S., Ferreira, P. A., Figueira, R. C. L., Silva, D., Moschini-Carlos, V., and Pompêo, M., 2018. Factors that control the spatial and temporal distributions of phosphorus, nitrogen, and carbon in the sediments of a tropical reservoir. *Environ. Sci. Pollut. Res. Int.* 25, 31776–31789.

Chen, P., He, B., Eudo, K., and Li, S., 2004. Records of human activities in sediments from Honghu Lake (in Chinese, with English abstract). *J. Lake Sci.* 3, 233-237.

Chen, X., Li, C., McGowan, S., and Yang, X., 2014a. Diatom response to heavy metal pollution and nutrient enrichment in an urban lake: evidence from paleolimnology. *Int. J. Limnol.* 50, 121–130.

Chen, Y., Chen, S., Yu, S., Zhang, Z., Yang, L., and Yao, M., 2014b Distribution and speciation of phosphorus in sediments of Dongping Lake, North China. Environ. *Earth Sci.* 72, 3173–3182.

Chen, X., McGowan, S., Xiao, X., Stevenson, M. A., Yang, X., Li, Y., and Zhang, E., 2018. Direct and indirect effects of Holocene climate variations on catchment and lake processes of a treeline lake, SW China. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* 502, 119129.

Chen, X., Yang, X., Dong, X., and Liu, E., 2013. Environmental changes in Chaohu Lake (southeast, China) since the mid 20th century: The interactive impacts of nutrients, hydrology and climate. *Limnologica* 43, 10–17.

Chen, Y., 2012. The evolutionary process and mechanism of DongPing Lake over the past 150 years (in Chinese, with English abstract). Master Thesis. Liaocheng Univeristy.

Chen, Y., Lin, Q., Liu, E., Zhang, E., Wang, X., and Shen, J., 2021. Spatio-temporal variations of sedimentary phosphorus in Lugu Lake and its environmental implications (in Chinese, with English abstract). *Quat. Sci.* 41, 1206–1215.

Cheng, L., Xue, B., Yao, S., and Liu, J., 2020. Response of Cladocera fauna to environmental change based on sediments from Shengjin Lake, a Yangtze River-connected lake in China. *Quat. Int.* 536, 52–59.

Chiaia-Hernandez, A. C., Krauss, M., and Hollender, J., 2013. Screening of lake sediments for emerging contaminants by liquid chromatography atmospheric pressure photoionization and electrospray ionization coupled to high resolution mass spectrometry. *Environ. Sci. Technol.* 47, 976–986.

Coard, A., Cousen, S. M., Cuttler, A. H., Dean, H. J., Dearing, J. A., Eglinton, I., Greaves, M., Lacey, P., O'Sullivan, E., Pickering, A., Rhead, M., Rodwell, K., and Simola, H., 1983. Paleolimnological studies of annually-laminated sediments in Loe Pool, Cornwall, U.K. *Hydrobiologia* 103, 185–191.

Danesh, C., McCarthy, M., Volik, O., and Drljepan, M., 2013. Non-pollen palynomorphs as indicators of water quality in Lake Simcoe, Ontario. *Canada Palynology* 37, 231–245.

Di, Z., Zhang, H., and Shan, B., 2015. Using sedimentary phosphorus/nitrogen as indicators of shallow lake eutrophication: concentrations or accumulation fluxes. *Environ. Earth Sci.* 74, 3935–3944.

Ding, Z., 2017. Study on the difference between the north and the south of the modern sediments of Nansi Lake under the influence of human activities (in Chinese, with English abstract). Doctoral Thesis. Nanjing Normal University.

Digerfeldt, G., 1972. Post-Glacial development of Lake Trummen. Regional vegetation history, water level changes and palaeolimnology. *Folia Limnol. Scand.* 16, 1–104.

Digerfeldt, G., 1974. The post-glacial development of the ranviken bay in lake Immeln I. The history of the regional vegetation, and II. the water-level changes. *GFF* 96, 3–32.

Dixit, S., Connor, J. N., and Landry, S., 2001. Paleolimnological Study of Willard and Russell Ponds in New Hampshire. *Lake Reserv. Manag.* 17, 197–216.

Dixit, S., Dixit, A., Smol. J., Hughes, M., and Paulsen, G., 2000. Water Quality Changes from Human Activities in Three Northeastern USA Lakes. *Lake Reserv. Manag.* 16, 305–321.

Earley, M., Waters, N., Thieme, D., and Smoak, M., 2017 Linking biogeochemical processes and historic primary producer communities in a SE USA sinkhole lake from the mid-Holocene to present. *J. Paleolimnol.* 57, 295–306.

Edlund, B., Schottler, P., Reavie, D., Engstrom, R., Baratono, G., Leavitt, R., Heathcote, J., Wilson, B., and Paterson, M., 2017. Historical phosphorus dynamics in Lake of the Woods (USA–Canada) — does legacy phosphorus still affect the southern basin? *Lake Reserv. Manag.* 33, 386–402.

Engstrom, R., Almendinger, E., and Wolin, A., 2009. Historical changes in sediment and phosphorus loading to the upper Mississippi River: mass-balance reconstructions from the sediments of Lake Pepin. *J. Paleolimnol.* 41, 563–588.

Engstrom, R., Schottler, P., Leavitt, R., and Havens, E., 2006. A reevaluation of the cultural eutrophication of Lake Okeechobee using multiproxy sediment records. *Ecol. Appl.* 16, 1194–1206.

Fan, B., Zhang, W., Zhang, R., Yang, X., Li, Y., Li, B., and Ding, G., 2019. Characteristics of dry-wet changes and human activities in the North China Plain since the Little Ice Age (in Chinese, with English abstract). *Quat. Sci.* 39, 483–496.

Filippelli, G. M., Souch, C., Menounos, B., Slater-Atwater, S., Timothy Jull, A. J., and Slaymaker, O., 2006. Alpine lake sediment records of the impact of glaciation and climate change on the biogeochemical cycling of soil nutrients. *Quat. Res.* 66, 158–166.

Filstrup, T., Thad, J., White, D., and Lind, T., 2010. Use of sediment elemental and isotopic compositions to record the eutrophication of a polymictic reservoir in central Texas, USA. *Lakes Reserv.* 15, 25–39.

Foster, L. and Lees, A., 1999. Changes in the physical and geochemical properties of suspended sediment delivered to the headwaters of LOIS river basins over the last 100 years: a preliminary analysis of lake and reservoir bottom sediments. *Hydrol. Process.* 13, 1067–1086

Fukushima, T., Kamiya, K., Onda, Y., Imai, A., Matsushige, K., and Others., 2010. Long-term changes in lake sediments and their influences on lake water quality in Japanese shallow lakes Fundam. *Appl. Limnol.* 177, 177–188.

Galicki, S., Davidson, R., and Threlkeld, T., 2008. Transport of agricultural Pb, as and P through a riparian wetland Am. *Midl. Nat.* 159, 457–467.

Gao, H., Li, C., and Sun, B., 2018. The impact of changed river discharge on water quality deterioration in a prairie lake revealed by the sedimentary evidence. *Water Sci. Technol. Water Supply* 18, 299–305.

Gao, X. 2006. Environmental geochemical characteristics of nutrients in Daihai lake (in Chinese, with English abstract). Master Thesis. Inner Mongolia University.

García-Rodríguez, F., Sprechmann, P., Metzeltin, D., Scafati, L., Melendi, D.L., Volkheimer, W., Mazzeo, N., Hiller, A., von Tümpling, and W. and Scasso, F., 2004. Holocene trophic state changes in relation to sea level variation in Lake Blanca, SE Uruguay. *J. Paleolimnol.* 31, 99–115.

Giguet-Covex, C., Arnaud, F., Poulenard, J., Disnar, J.R., Delhon, C., Francus, P., David, F., Enters, D., Rey, P.J., and Delannoy, J.J., 2011. Changes in erosion patterns during the Holocene in a currently treeless subalpine catchment inferred from lake sediment geochemistry (Lake Anterne, 2063 m asl, NW French Alps): the role of climate and human activities. *The Holocene* 21, 651-665.

Guan, Y., Zang, S., and Xiao, H., 2014. The vertical variation of nutrients in a sediment core of Delong Lake reveals the anthropogenic effect. *Ecotoxicology* 23. 480–500.

Gui. Z., Xue, B., Yao, S., Zhang, F., and Yi, S., 2012. Catchment erosion and trophic status changes over the past century as recorded in sediments from Wudalianchi Lake, the northernmost volcanic lake in China. *Quat. Int.* 282, 163–170.

Gui, Z., Xue, B., Yao, S., and Wei, W. 2011. Environmental Changes of Wudalianchi lake inferred from lake sediments in the past century (in Chinese, with English abstract). *Quat. Res.* 31, 544–553.

Guo, Y., 2016. Response of long-term changes in Poyang Lake ecosystem to climate-anthropogenic environment. Doctoral Thesis (in Chinese, with English abstract). Chinese Academy of Sciences University.

He, K., 2021. The relationship between environmental evolution and human activities in modern of Yamzhog Yumco Lake and Huguangyan Maar Lake. Master Thesis (in Chinese, with English abstract). Guizhou University.

Heathwaite, L. and O’Sullivan, E, 1991. Sequential inorganic chemical analysis of a core from Slapton Ley, Devon, UK. *Hydrobiologia* 214, 125–135.

Hecky. E., Mugidde, R., Ramlal, S., Talbot, R., and Kling, W., 2010. Multiple stressors cause rapid ecosystem change in Lake Victoria. *Freshw. Biol.* 55, 19–42.

Hiriart-Baer, P., Milne, E., and Marvin, H., 2011. Temporal trends in phosphorus and lacustrine productivity in Lake Simcoe inferred from lake sediment. *J. Great Lakes Res.* 37, 764–771.

Humphries, S. and Benitez-Nelson, R., 2013. Recent trends in sediment and nutrient accumulation rates in coastal, freshwater Lake Sibaya, South Africa Mar. *Freshwater Res.* 64, 1087–1099.

Ji, J., Zeng, L., Bian, H., and Chen, X., 2018. Variations in sedimentary nitrogen, phosphorus and silicon and regional environmental changes in East Dongting Lake in recent 50 years (in Chinese, with English abstract). *Quat. Res.* 38, 1017–1023.

Jia, B., Tang, Y., Tian, L., Franz, L., Alewell, C., and Huang, H., 2015. Impact of Fish Farming on Phosphorus in Reservoir Sediments. *Sci. Rep.* 5, 16617.

Jia, X., Luo, W., Wu, X., Wei, H., Wang, B., Phyoe, W., and Wang, F., 2017. Historical record of nutrients inputs into the Xin'an Reservoir and its potential environmental implication. *Environ. Sci. Pollut. Res. Int.* 24, 20330–20341.

Jin, G., Onodera, S., Amano, A., Saito, M., Shimizu, Y., and Satou, T., 2013. Effects of dam construction on sediment phosphorus variation in a semi-enclosed bay of the Seto Inland Sea, Japan Estuar. *Coast. Shelf Sci.* 135, 191–200.

Jin, G., Onodera, S., Saito, M., Maruyama, Y., Hayakawa, A., Sato, T., Ota, Y., and Aritomi, D., 2016 Vertical distribution of sediment phosphorus in Lake Hachirogata related to the effect of land reclamation on phosphorus accumulation. *Environ. Technol.* 37, 486–494.

Jinglu, W., Chengmin, H., Haiao, Z., Schleser, G., and Battarbee, R., 2007. Sedimentary evidence for recent eutrophication in the northern basin of Lake Taihu, China: human impacts on a large shallow lake. *J. Paleolimnol.* 38, 13–23.

Jordan, P., Rippey, B., and Anderson, N., 2002. The 20th century whole-basin trophic history of an inter-drumlin lake in an agricultural catchment. *Sci. Total Environ.* 297, 161–173.

Hambright, K.D., Eckert, W., Leavitt, P.R., and Schelske, C.L., 2004. Effects of historical lake level and land use on sediment and phosphorus accumulation rates in Lake Kinneret. *Environ. Sci. Technol.* 38, 6460–6467.

Hiriart-Baer, V.P., Milne, J.E., and Marvin, C.H., 2011. Temporal trends in phosphorus and lacustrine productivity in Lake Simcoe inferred from lake sediment. *J. Gt. Lakes Res.* 37, 764–771.

Kapanen, G., 2012. Pool of mobile and immobile phosphorus in sediments of the large, shallow Lake Peipsi over the last 100 years. *Environ. Monit. Assess.* 184, 6749–6763.

Kim, J. and Rejmánková, E., 2001. The paleoecological record of human disturbance in wetlands of the Lake Tahoe Basin. *J. Paleolimnol.* 25, 437–454.

Kisand, A., Kirsi, A.L., Ehapalu, K., Alliksaar, T., Heinsalu, A., Tõnno, I., Leeben, A., and Nõges, P., 2017. Development of large shallow Lake Peipsi (North-Eastern Europe) over the Holocene based on the stratigraphy of phosphorus fractions. *J. Paleolimnol.* 58, 43–56.

Klamt, A.M., Jensen, H.S., Mortensen, M.F., Schreiber, N., and Reitzel, K., 2017. The importance of catchment vegetation for alkalinity, phosphorus burial and macrophytes as revealed by a recent paleolimnological study in a soft water lake. *Sci. Total Environ.* 580, 1097–1107.

Klamt, A.M., Poulsen, S.P., Odgaard, B.V., Hübener, T., McGowan, S., Jensen, H.S., and Reitzel, K., 2021. Holocene lake phosphorus species and primary producers reflect catchment processes in a small, temperate lake. *Ecol. Monogr.* 91, p.e01455.

Kopáˇcek, J., Marešová, M., Hejzlar, J., and Norton, S. A., 2007. Natural inactivation of phosphorus by aluminum in preindustrial lake sediments. *Limnol. Oceanogr.* 52, 1147–1155,.

Kunz, M.J., Wüest, A., Wehrli, B., Landert, J., and Senn, D.B., 2011. Impact of a large tropical reservoir on riverine transport of sediment, carbon, and nutrients to downstream wetlands. *Water Resour. Res.* 47.

Lebo, M.E., Reuter, J.E., and Meyers, P.A., 1994. Historical changes in sediments of Pyramid Lake, Nevada, USA: consequences of changes in the water balance of a terminal desert lake. *J. Paleolimnol.* 12, 87–101.

Levine, S.N., Lini, A., Ostrofsky, M.L., Burgess-Grant, H., Lami, A., Collyer-Gilles, E., Reuter, D., Schwarting-Miller, L., and Kamman, N., 2018. The relative roles of point and nonpoint phosphorus sources in the eutrophication of Lake Champlain as recorded in sediment cores. *J. Great Lakes Res.* 44 1043–1056.

Li, S., Guo, W., and Yin, Y., 2013. Environmental changes recorded by geochemical records of Gaoyou Lake sediments and their responses to human activities (in Chinese with English abstract). *Mar. Geol. and Quat. Geol.* 33, 143–150.

Li, X., Liang, J., Hou, J., and Zhang, W., 2015. Centennial-scale climate variability during the past 2000 years on the central Tibetan Plateau. *The Holocene* 25, 892–899.

Liang, J., Lupien, R.L., Xie, H., Vachula, R.S., Stevenson, M.A., Han, B.P., Lin, Q., He, Y., Wang, M., Liang, P., and Huang, Y., 2021. Lake ecosystem on the Qinghai–Tibetan Plateau severely altered by climatic warming and human activity. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* 576, 110509.

Liao, M. and Li, Y., 2018. Diatom response to climate change and anthropogenic disturbances in Jingpo lake (NE China) (in Chinese, with English abstract). *Acta Ecologica Sinica* 38,1458–1469.

Liu, E., Shen, J., Birch, G.F., Yang, X., Wu, Y., and Xue, B., 2012. Human-induced change in sedimentary trace metals and phosphorus in Chaohu Lake, China, over the past half-millennium. *J. Paleolimnol.* 47, 677–691.

Liu, T., 2021. Lake sediment records on environmental changes and organic carbon burial rate in Xingyun Lake since the late Holocene (in Chinese, with English abstract). Master Thesis. Yunnan Normal University.

Liu, E., Shen, J., Liu, X., Zhu, Y., and Wang, S., 2006. Variation characteristics of heavy metals and nutrients in the core sediments of Taihu Lake and their pollution history. *Sci. China Ser. D Earth Sci.* 49, 82–91.

Liu, E., Shen, J., Zhang, E., Wu, Y., and Yang, L., 2010. A geochemical record of recent anthropogenic nutrient loading and enhanced productivity in Lake Nansihu, China. *J. Paleolimnol.* 44, 15–24.

Liu, J., Yang, X., and Wang, S., 2006. Study on the nutrient evolution and its controlling factors of Longgan Lake for the last 200 years. *Sci. China Ser. D Earth Sci.* 49 193–202

Liu, Q., Yang, X., Anderson, N.J., Liu, E., and Dong, X., 2012. Diatom ecological response to altered hydrological forcing of a shallow lake on the Yangtze floodplain, SE China. *Ecohydrol.* 5, 316–325.

Liu, W., Wu, J., Ma, L., and Zeng, H., 2014. A 200-year sediment record of environmental change from Lake Sayram, Tianshan Mountains in China. *GFF* 136, 548–555.

Liu, H., Liu, E., Yu, Z., Zhang, E., Lin, Q., Wang, R., and Shen, J., 2019. Spatio-temporal patterns of organic carbon burial in the sediment of Lake Erhai in China during the past 100 years (in Chinese, with English abstract). *J. Lake Sci.* 31, 282–292.

Liu, W., Lin, Q., Zhang, K., and Shen, J. 2022. The evolution of the ecological environment of Changdang Lake in the Taihu Lake Basin in the past 100 years (in Chinese, with English abstract). *Lake Science* 34, 675–683.

Loizeau, J.L., Span, D., Coppee, V., and Dominik, J., 2001. Evolution of the trophic state of Lake Annecy (eastern France) since the last glaciation as indicated by iron, manganese and phosphorus speciation. *J. Paleolimnol.* 25, 205–214.

Lu, Y., Meyers, P.A., Johengen, T.H., Eadie, B.J., Robbins, J.A., and Han, H., 2010. δ15N values in Lake Erie sediments as indicators of nitrogen biogeochemical dynamics during cultural eutrophication. *Chem. Geol.* 273, 1–7.

Lü, C., Wang, B., He, J., Vogt, R.D., Zhou, B., Guan, R., Zuo, L., Wang, W., Xie, Z., Wang, J., and Yan, D., 2016. Responses of organic phosphorus fractionation to environmental conditions and lake evolution. *Environ. Sci. Technol.* 50, 5007–5016.

Ma, H., Zhao, B., Li, L., Xie, F., Zhou, H., Zheng, Q., Wang, X., He, J., and Lü, C., 2019. Fractionation trends of phosphorus associating with iron fractions: An explanation by the simultaneous extraction procedure. *Soil Tillage Res.* 190, 41–49.

Ma, L., Wu, J., and Abuduwaili, J., 2013a. Climate and environmental changes over the past 150 years inferred from the sediments of Chaiwopu Lake, central Tianshan Mountains, northwest China. *Int. J. Earth Sci.* 102, 959–967.

Ma, L., Wu, J., and Abuduwaili, J., 2013b. Geochemical evidence of the anthropogenic alteration of element composition in lacustrine sediments from Wuliangsu Lake, north China. *Qua. Int.* 306, 107–113.

Ma, L., Wu, J., Abuduwaili, J., and Liu, W., 2016. Geochemical responses to anthropogenic and natural influences in Ebinur Lake sediments of arid Northwest China. *PLoS One* 11, e0155819.

Ma, S. 2021. Organic carbon burial and climate change in the Early-Middle Holocene of Xingyun Lake in Central Yunnan. Master Thesis (in Chinese, with English abstract). Yunnan Normal University.

Mackereth, J., 1966. Some chemical observations on post-glacial lake sediments. *Philos. T. R. Soc. B.* 250, 165–213.

Mayer, T., and Johnson, G., 1994. History of anthropogenic activities in Hamilton Harbour as determined from the sedimentary record. *Environ. Pollut.* 86, 341–347.

Mayer, T., Simpson, S.L., Thorleifson, L.H., Lockhart, W.L., and Wilkinson, P., 2006. Phosphorus geochemistry of recent sediments in the South Basin of Lake Winnipeg. *Aquat. Ecosyst. Health Manag.* 9, 307–318.

Mi, Y., Huang, C., Yang, H., Liu, H., Wang, Y., and Xie, B., 2014. Effects of human activities on lake sedimentary environment in Meiliang Bay area of Taihu Lake (in Chinese, with English abstract). *J. Subtrop. Res. Environ.* 9, 26–35.

Mizael, S., Cardoso-Silva, S., Frascareli, D., Pompêo, M.L.M., and Moschini-Carlos, V., 2020. Ecosystem history of a tropical reservoir revealed by metals, nutrients and photosynthetic pigments preserved in sediments. *Catena* 184, 104242.

Moss, B., 1980. Further studies on the palaeolimnology and changes in the phosphorus budget of Barton Broad, Norfolk. *Freshw. Biol.* 10, 261–279.

Moyle, M., Boyle, J.F., and Chiverrell, R.C., 2021. Holocene records of Sediment Inferred [lake water] Total Phosphorus concentration (SI-TP) and landscape phosphorus yield. [Data Collection] DOI: 10.17638/datacat.liverpool.ac.uk/1272

Mügler, I., Gleixner, G., Günther, F., Mäusbacher, R., Daut, G., Schütt, B., Berking, J., Schwalb, A., Schwark, L., Xu, B., and Yao, T., 2010. A multi-proxy approach to reconstruct hydrological changes and Holocene climate development of Nam Co, Central Tibet. *J. Paleolimnol.* 43, 625–648.

Müller, B., Finger, D., Sturm, M., Prasuhn, V., Haltmeier, T., Bossard, P., Hoyle, C., and Wüest, A., 2007. Present and past bio-available phosphorus budget in the ultra-oligotrophic *Lake Brienz. Aquat. Sci.* 69, 227–239.

Murphy, T., 1987. Sediment phosphorus release reduces the effect of the Chain Lake Water Diversion. *Lake Reserv. Manag.* 3, 48–57.

Ni, Z. and Wang, S., 2015. Economic development influences on sediment-bound nitrogen and phosphorus accumulation of lakes in China. Environ. *Sci. Pollut. Res. Int.* 22, 18561–18573.

Ni, Z., Wang, S., Wu, Y., and Pu, J., 2020. Response of phosphorus fractionation in lake sediments to anthropogenic activities in China. *Sci. Total Environ.* 699, 134242.

Norton, S.A., Coolidge, K., Amirbahman, A., Bouchard, R., Kopáček, J., and Reinhardt, R., 2008. Speciation of Al, Fe, and P in recent sediment from three lakes in Maine, USA. *Sci. Total Environ.* 404, 276–283.

Norton, S.A., Jacobson, G.L., Kopáček, J., and Navrátil, T., 2015. A comparative study of long-term Hg and Pb sediment archives. *Environ. Chem.* 13, 517–527.

Norton, S.A., Perry, R.H., Saros, J.E., Jacobson, G.L., Fernandez, I.J., Kopáček, J., Wilson, T.A., and SanClements, M.D., 2011. The controls on phosphorus availability in a Boreal lake ecosystem since deglaciation. *J. Paleolimnol.* 46, 107–122.

Oliveira Bezerra, M.A., Mozeto, A.A., de Oliveira, P.E., Volkmer-Ribeiro, C., Rodrigues, V.V., and Aravena, R., 2019. Late Pleistocene/Holocene environmental history of the southern Brazilian Pantanal wetlands. *Oecol. Aust.* 23.

Osborne, L. and Moss, B., 1977. Paleolimnology and trends in the phosphorus and iron budgets of an old man-made lake, Barton Broad, Norfolk. *Freshw. Biol.* 7, 213–233.

Otu, M.K., Ramlal, P., Wilkinson, P., Hall, R.I., and Hecky, R.E., 2011. Paleolimnological evidence of the effects of recent cultural eutrophication during the last 200 years in Lake Malawi, East Africa. *J. Great Lakes Res.* 37, 61–74.

Pan, Y. and Brugam, R., 1997. Human disturbance and trophic status changes in Crystal Lake, McHenry County, Illinois, USA. *J. Paleolimnol.* 17, 369–376.

Paraskova, J.V., Sjöberg, P.J., and Rydin, E., 2014. Turnover of DNA-P and phospholipid-P in lake sediments. Biogeochemistry 119, 361–370.

Punning, J.M. and Kapanen, G., 2009. Phosphorus flux in Lake Peipsi sensu stricto, Eastern Europe. *Estonian. J. Ecol.* 58.

Qin, L., Lei, P., Lei, Q., Liu, H., Li, X., Zhang, H., and Lindsey, S., 2020. Evaluating the effect of dam construction on the phosphorus fractions in sediments in a reservoir of drinking water source, China. Environ. *Monit. Assess.* 192, 99.

Rees, A.W.G., Hinton, G.C.F., Johnson, F.G., and O'Sullivan, P.E., 1991. The sediment column as a record of trophic status: examples from Bosherston Lakes, SW Wales. Environmental History and Palaeolimnology. pp. 171–180, Springer, Dordrecht.

Reynolds, R.L., Mordecai, J.S., Rosenbaum, J.G., Ketterer, M.E., Walsh, M.K., and Moser, K.A., 2010. Compositional changes in sediments of subalpine lakes, Uinta Mountains

(Utah): evidence for the effects of human activity on atmospheric dust inputs. *J. Paleolimnol.* 44, 161–175.

Rose, N.L., Boyle, J.F., Du, Y., Yi, C., Dai, X., Appleby, P.G., Bennion, H., Cai, S., and Yu, L., 2004. Sedimentary evidence for changes in the pollution status of Taihu in the Jiangsu region of eastern China. *J. Paleolimnol.* 32, 41–51.

Rowan, S., Black, S., and Franks, W., 2012. Sediment fingerprinting as an environmental forensics tool explaining cyanobacteria blooms in lakes. *Appl. Geogr.* 32, 832–843.

Rydberg, J. and Martinez-Cortizas, A., 2014. Geochemical assessment of an annually laminated lake sediment record from northern Sweden: a multi-core, multi-element approach. *J. Paleolimnol.* 51, 499–514.

Sawyers, J.E., McNaught, A.S., and King, D.K., 2016. Recent and historic eutrophication of an island lake in northern Lake Michigan, USA. *J. Paleolimnol.* 55, 97–112.

Schelske, C.L., Robbins, J.A., Gardner, W.S., Conley, D.J., and Bourbonniere, R.A., 1988. Sediment record of biogeochemical responses to anthropogenic perturbations of nutrient cycles in Lake Ontario. *Aquat. Sci.* 45 1291–1303.

Schneider, L., Haberle, S.G., Maher, W.A., Krikowa, F., Zawadzki, A., and Heijnis, H., 2016. History of human impact on Lake Kutubu, Papua New Guinea: The geochemical signatures of oil and gas mining activities in sediments. *Chemosphere* 148, 369–379.

Selig, U., Leipe, T., and Dörfler, W., 2007. Paleolimnological records of nutrient and metal profiles in prehistoric, historic and modern sediments of three lakes in north-eastern Germany. *Water Air Soil Pollut.* 184, 183–194.

Sha, Z., Wang, Q., Wang, J., Du, J., Hu, J., Ma, Y., Kong, F., and Wang, Z., 2017. Regional environmental change and human activity over the past hundred years recorded in the sedimentary record of Lake Qinghai, China. Environ. *Sci. Pollut. Res.* 24, 9662–9674.

Shen, B., Wu, J., and Jin, M., 2018. Sedimentary polycyclic aromatic hydrocarbons record recent anthropogenic activities near high-elevation Lake Sayram, northwest China. *Limnologica* 71, 62–67.

Smoak, J.M. and Swarzenski, P.W., 2004. Recent increases in sediment and nutrient accumulation in Bear Lake, Utah/Idaho, USA. *Hydrobiologia* 525, 175–184.

Sun, W., Ni, Z., Meng, X., Jiang, Q., and Zhang, E., 2021. Environmental change recorded by radionuclides and organic geochemical signatures in a sediment core from Lake Daihai, North China. *Catena* 206,105564.

Tammeorg, O., Horppila, J., Tammeorg, P., Haldna, M., and Niemistö, J., 2016. Internal phosphorus loading across a cascade of three eutrophic basins: a synthesis of short- and long-term studies. *Sci. Total Environ.* 572, 943–954.

Tang, F. 2021. Study on the chemical characteristics of carbon, nitrogen and phosphorus in lake sediments and their response to different sources of organic matter: a case study of Dianchi Lake (in Chinese, with English abstract). Master Thesis. Nanjing Normal University.

Taylor, D., Dalton, C., Leira, M., Jordan, P., Chen, G., León-Vintró, L., Irvine, K., Bennion, H., and Nolan, T., 2006. Recent histories of six productive lakes in the Irish Ecoregion based on multiproxy palaeolimnological evidence. *Hydrobiologia* 571, 237–259.

Thevenon, F., de Alencastro, L.F., Loizeau, J.L., Adatte, T., Grandjean, D., Wildi, W., and Poté, J., 2013. A high-resolution historical sediment record of nutrients, trace elements and organochlorines (DDT and PCB) deposition in a drinking water reservoir (Lake Brêt, Switzerland) points at local and regional pollutant sources. *Chemosphere* 90, 2444–2452.

Triplett, L.D., Engstrom, D.R., and Edlund, M.B., 2009. A whole-basin stratigraphic record of sediment and phosphorus loading to the St. Croix River, USA. *J. Paleolimnol.* 41, 659–677.

Urrutia, R., Araneda, A., Torres, L., Cruces, F., Vivero, C., Torrejón, F., Barra, R., Fagel, N., and Scharf, B., 2010. Late Holocene environmental changes inferred from diatom, chironomid, and pollen assemblages in an Andean lake in Central Chile, Lake Laja (36 S). *Hydrobiologia* 648, 207–225.

Vaalgamaa, S. and Conley, D.J., 2008. Detecting environmental change in estuaries: Nutrient and heavy metal distributions in sediment cores in estuaries from the Gulf of Finland, Baltic Sea. *Coast. Shelf Sci.* 76, 45–56.

Vaalgamaa, S. and Korhola, A., 2007. Geochemical signatures of two different coastal depositional environments within the same catchment. *J. Paleolimnol.* 38, 241–260.

Van Metre, P.C., and Horowitz, A.J., 2013. An 80-year record of sediment quality in the lower Mississippi River. *Hydrol. Process.* 27, 2438–2448.

Wang, C. and Morrison, R., 2014. Phosphorus speciation and changes with depth in the sediment of Lake Illawarra, New South Wales, Australia. *Environ. Earth Sci.* 71, 3529–3541.

Wang, F., Liu, C., Wu, M., Yu, Y., Wu, F., Lü, S., Wei, Z., and Xu, G., 2009. Stable Isotopes in Sedimentary Organic Matter from Lake Dianchi and their Indication of Eutrophication History. *Water Air Soil Pollut.* 199, 159–170.

Wang, X., Yang, H., Gu, Z., Zhang, M., and Yang, B., 2018. A century of change in sediment accumulation and trophic status in Lake Fuxian, a deep plateau lake of Southwestern China. *J. Soils Sediments* 18, 1133–1146.

Wang, X., Yang, H., Gu, Z., and Zhang, M., 2014. Vertical distribution and correlation of nutrients and grain size in sediment cores of Lake Fuxian (in Chinese, with English abstract). *J. Environ. Eng. Tec.* 4, 353–360.

Waters, N., Piehler, F., Smoak, M., and Martens, S., 2010. The development and persistence of alternative ecosystem states in a large, shallow lake. *Freshw. Biol.* 55, 1249–1261.

Winston, B, Hausmann, S., Escobar, J., and Kenney, F., 2014. A sediment record of trophic state change in an Arkansas (USA) reservoir. *J. Paleolimnol.* 51, 393–403.

Wu, J., Ma, L., Yu, H., Zeng, H., Liu, W., and Abuduwaili, J., 2013. Sediment geochemical records of environmental change in Lake Wuliangsu, Yellow River Basin, north China. *J. Paleolimnol.* 50, 245–255.

Wu, Y., Lücke, A., and Wang, S., 2008. Assessment of nutrient sources and paleoproductivity during the past century in Longgan Lake, middle reaches of the Yangtze River, China. *J. Paleolimnol.* 39, 451–462.

Wu, Y., and Wang S., 2006. Estimate of anthropogenic nutrient element fluxes recorded in lacustrine sediments: a case study in Longgan Lake (in Chinese with English abstract). *Quat. Sci.* 5, 843–848.

Wu, H., Zhang, H., Li, Y., Chang, F., Duan, L., Zhang, X., Peng, W., Liu, Q., Liu, F., and Zhang, Y., 2021. Plateau lake ecological response to environmental change during the last 60 years: a case study from freshwater Lake Yangzong, SW China. *J. Soils Sediments* 21,1550–1562.

Xu, C., Peng, Z., Zhang, H. and He, Z., 2021. Study of Comprehensive Utilization of Water Resources of Urban Water Distribution Network. *Water* 13, 2791.

Yamamuro, M. and Kanai, Y., 2005. A 200-year record of natural and anthropogenic changes in water quality from coastal lagoon sediments of Lake Shinji, Japan. *Chem. Geol.* 218 51–61.

Yan, D, Xu, H, Yang, M., Lan, J., Hou, W., Wang, F., Zhang, J., Zhou, K., An, Z., and Goldsmith, Y., 2019. Responses of cyanobacteria to climate and human activities at Lake Chenghai over the past 100 years. *Ecol. Indic.* 104, 755–763.

Yang, H. 2020. Relationship between phytoplankton succession history and human activities in watershed: a case study of Qilu lake (in Chinese, with English abstract). Doctoral Thesis. Central China Normal University.

Yang, H., Yi, C., Xing, Y., and Yang, T., 2004. A comparative study of modern sedimentation rates in East lake of Wuhan by ^{210}Pb and ^{137}Cs methods. *Journal of Central China Normal University (Natural Science Edition)* 1, 109–113.

Yang, X., Shen, J., Dong, X., and Liu, E., 2005. Historical trophic evolutions and their ecological responses from shallow lakes in the middle and lower reaches of the Yangtze River: Case studies on Longgan Lake and Taibai Lake (in Chinese, with English abstract). *Sci. China Ser. D Earth Sci.* 0(S2), 45–54.

Yao, S. and Xue, B., 2014. Recent environmental evolution of Shijiuhu lake inferred from lake sediments (in Chinese, with English abstract). *Quat. Sci.* 29, 248–255.

Yao, S., Xue, B., and Wang, X., 2008. Environmental changes of Gucheng Lake under the influence of human activities (in Chinese, with English abstract). *Lake Science* 1, 88–92.

Yuan, H., An, S., Shen, J., and Liu, E., 2014. The characteristic and environmental pollution records of phosphorus species in different trophic regions of Taihu Lake, China Environ*. Earth Sci.* 71, 783–792.

Zan, F., Huo, S., Xi, B., Zhang, J., Liao, H., Wang, Y., and Yeager, M., 2012a. A 60-year sedimentary record of natural and anthropogenic impacts on Lake Chenghai, China. *J. Environ. Sci.* 24, 602–609.

Zan, F., Huo, S., Xi, B., Zhu, C., Liao, H., Zhang, J., and Yeager, M., 2012b. A 100-year sedimentary record of natural and anthropogenic impacts on a shallow eutrophic lake, Lake Chaohu, China. *J. Environ. Monit.* 14, 804–816.

Zeng, L., Ning, D., Xu, L., Mao, X., and Chen, X., 2015. Sedimentary Evidence of Environmental Degradation in Sanliqi Lake, Daye City (A Typical Mining City, Central China) Bull. Environ. *Contam. Toxicol.* 95, 317–324.

Zhang, H. and Shan, B., 2008. Historical distribution and partitioning of phosphorus in sediments in an agricultural watershed in the Yangtze-Huaihe region, China. *Environ. Sci. Technol.* 42, 2328–2333.

Zhang, M. 2015. Lake sedimentation and environmental changes along the Middle Reaches of the Yangtze River-Chiba Oxbow lake in the past 100 years. Master Thesis (in Chinese, with English abstract). Shanghai Normal University.

Zhang, Y., Liao, J., Pei, Z., Lu, X., Xu, S., and Wang, X., 2019. Effect of dam construction on nutrient deposition from a small agricultural karst catchment. *Ecol. Indic.* 107, 105548.

Zhang, Y., Su, Y., Liu, Z., Sun, K., Kong, L., Yu, J., and Jin, M., 2018. Sedimentary lipid biomarker record of human-induced environmental change during the past century in Lake Changdang, Lake Taihu basin, Eastern China. *Sci. Total Environ.* 613-614, 907–918.

Zhang, H., Huo, S., Yeager, K.M., Xi, B., Zhang, J., He, Z., Ma, C., and Wu, F., 2018. Accumulation of arsenic, mercury and heavy metals in lacustrine sediment in relation to eutrophication: Impacts of sources and climate change. *Ecol. Indic.* 93, 771–780.

Zhang, K., Yang, X., Kattel, G., Lin, Q., and Shen, J., 2018. Freshwater lake ecosystem shift caused by social-economic transitions in Yangtze River Basin over the past century. *Sci. Rep.* 8, 1–9.

Zhang, Q., Dong, X., Yao, M., Chen, S., and Yang, X., 2013. Environmental changes in response to altered hydrological connectivities with the Yangtze River in Lake Zhangdu (Hubei Province) over the past 200 years (in Chinese, with English abstract). *J. Lake Sci.* 25, 463–470.

Zhen, Z., 2016. Environment and climate changes since 2100 cal. a BP during the Holocene recorded in Dali-Nor Lake (in Chinese, with English abstract). Master Thesis. Inner Mongolia Agricultural University.

Zhou, J., 2019. Study on the variation characteristics of diatoms and the driving factors of eutrophication in Xiannv Lake over the past 60 years (in Chinese, with English abstract). Master Thesis. Nanchang Institute of Engineering.