Supplementary Information

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S1. MBT'$_{5ME}$ Calibration to Temperature

The Basin Pond MBT'$_{5ME}$ record is presented without calibration to temperature. Because almost all published calibrations use an analytical protocol that results in coelution of five- and six-methyl brGDGTs, a correction based on CBT had to be applied to MBT before temperature could be calculated. New developments in chromatographic separation schemes (Hopmans et al., 2016) have eliminated this requirement by achieving full separation between five- and six-methyl brGDGTs. Unfortunately, global calibrations of MBT measured with this new method (on lake sediments) do not yet exist. Recently, Russel and colleagues (2018) produced a regional calibration using this new method for African lakes. While this calibration has been developed for a region vastly different than the NE US, it could potentially be applied to our MBT'$_{5ME}$ record, and can be seen below. A preliminary lake-specific calibration for MBT'$_{5ME}$ to temperature using SPM samples collected in this study shows promise. We compared MBT'$_{5ME}$ values to average daily temperatures recorded from the closest weather station over each collection interval (Table S1, Figure S1). We note that during the June 2015 (late fall through spring) sample, only temperatures from ice-free dates were used in the average, as brGDGT production likely decreases drastically or ceases during times when the lake is ice covered. While this is an assumption about brGDGT production, more information is needed about production timing to be able to more accurately constrain the average temperature used during this 264-day sample. Ice-in and ice-out dates were provided by the Maine Volunteer Lake Monitoring Program (MVLMP).

Through linear regression, we find a positive relationship between MBT'$_{5ME}$ and average temperature for each time period, with a correlation coefficient of ~ 0.4 (Fig S1). We applied this calibration downcore and compared to a past lakes calibration using the old analytical method (Fig S1b) (Sun et al. 2011), as well as the new MBT'$_{5ME}$ African lakes calibration. The Sun et al. (2011) calibration incorporates temperate-zone lakes similar to Basin Pond and yields temperatures similar to meteorological station fall measurements at Basin Pond. Additionally, this calibration was also applied in the Loomis et al. (2014) study of *in situ* brGDGT production in Lower King Pond, Vermont. The Russell et al. (2018) calibration produces slightly cooler than observed. The Basin Pond calibration has a similar slope to that of Sun et al. (2011) and Russell et al. (2018), resulting in nearly identical reconstructed temperature trends, with temperature values offset by ~1-2^{o}C (Figure S1b). Although the dataset is too short for a proper lake-specific calibration of MBT'$_{5ME}$ against temperature, the initial results are

promising, and provide support for future efforts to develop a calibration of MBT'$_{5ME}$ to air temperature at Basin Pond. Currently, a new multi-year sampling campaign is underway in Basin Pond, with the goal of getting more data for a MBT'$_{5ME}$ -temperature correlation to produce a reliable calibration.

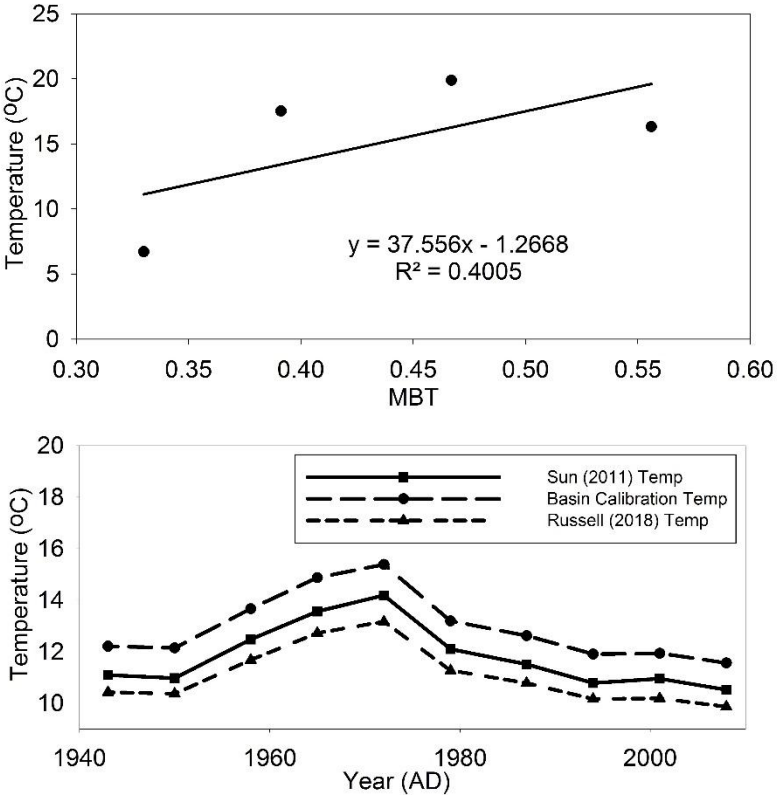

Figure S1: top) Comparison of MBT'$_{5ME}$ values from all SPM samples (averaged for each date range) to average temperatures during each time period. The equation for the plotted linear regression line, along with the correlation coefficient, are shown. bottom) Downcore reconstructed temperatures (in ºC) from the Basin Pond calibration (long dashed line), the Russell et al. 2018 African lakes calibration (short dashed line), and from the Sun et al. 2011 lakes calibration (solid line).

ID	Site Name	Type of Proxy	Lat	Lon	Avg. yr/sample	Citation
BP	Basin Pond	Pollen (Summer Temperature)	44.47	-70.05	24	Gajewski (1988)
BP	Basin Pond	Charcoal (Fire)	44.47	-70.05	7	Miller et al. (2017)
LI	Little Pond	Hydrogen Isotopes (Hydroclimate)	42.68	-72.19	25	Gao et al. (2017)
GH	Great Heath Bog	Testate Amoeba (Water Table Level)	44.7	-67.81	11	Clifford & Booth (2013)
SB	Saco Bog	Testate Amoeba (Water Table Level)	43.55	-70.46	5	Clifford & Booth (2013)
GH	Great Heath Bog	SVR (Hydroclimate)	44.7	-67.81	14	Nichols & Huang (2012)

Table S2: Detailed information of sites discussed in the main text for comparison with the Basin Pond record.

Start Date	End Date	Avg Temp (°C)
05/27/2014	07/01/2014	16.31
07/02/2014	08/15/2014	19.90
08/16/2014	09/13/2014	17.52
09/14/2014	06/05/2015	6.71
excluding ice-cover dates (12/2/14-4/26/15)		
09/14/2014	06/05/2015	0.56

Table S2. Data used for calculating MBT'_{5ME} to temperature calibration at Basin Pond, ME from June 2014 through June 2015.