Supplementary Material

Postglacial Reconstruction of Fire History from a Small Lake in Southwest Yukon using Sedimentary Charcoal and Pollen

Tyler J. Prince[1], Michael F.J. Pisaric[2*] and Kevin W. Turner[2]

[1]Environmental Sustainability Research Centre, Brock University, St. Catharines, Ontario, Canada

[2]Department of Geography and Tourism Studies, Brock University, St. Catharines, Ontario, Canada

[*]Corresponding author: Department of Geography and Tourism Studies, Brock University.
Email address: mpisaric@brocku.ca

Macroscopic Charcoal

Contiguous subsamples were measured at $1cm^3$ and were placed in a deflocculating solution overnight. This solution contained 30 ml of distilled water mixed with Sparkleen® to disaggregate the sediment and 10 ml of 3% hydrogen peroxide to bleach any organic material, in order to help distinguish charcoal from organics. After soaking overnight the solution was carefully washed through a 150µm mesh sieve using distilled water. The remaining material was then washed into a gridded petri dish to be counted under a microscope for total number of charcoal pieces per $1cm^3$. Manipulating the charcoal pieces with a metal probe under the microscope was useful for correct identification. Charcoal was identified as black, opaque, angular and typically planar fragments (Whitlock and Larsen, 2001).

The bCHAR and C_{Peak} parameters were chosen based on existing literature (Cleveland, 1979; Gavin et al., 2006 & Higuera et al., 2010) suggesting they are the best models to not only eliminate bias and variability between models within a charcoal study, but also across studies (Higuera et al, 2010). Higuera et al. (2010) suggest that choosing a locally defined model will reduce the amount of variability between models in a charcoal study, and the NR model is the simplest and typically the most appropriate. Also, the index model was not applicable in this study as there were values of 0 throughout the record in the bCHAR. This does not work mathematically because the index model is a ratio where bCHAR is the denominator (CHAR ÷ bCHAR), therefore the residual model was chosen. Applying these local parameters will allow for more accurate charcoal studies, as well as the ability to compare results from different studies around the world with the increased accuracy and consistency in the detrending process (Higuera et al., 2010). The robust LOWESS smoother (Figure 4.2) was chosen for the bCHAR as it should be robust to outliers (Cleveland, 1979), and a window of 500 years was applied as it is narrow enough to capture the centennial-scale variation in CHAR, but wide enough to not be effected by large peaks (Gavin et al., 2006).

A second model was run in CharAnalysis to address any concern of bias in the record due to changing sedimentation rates. As seen by the age-depth model, sedimentation rates change throughout this record with low sedimentation in the early Holocene portion of the record and higher sedimentation rates during the last ~1000 years. As a result of the increase in sedimentation rates, the resolution also increased, potentially creating a bias towards higher fire frequency as the higher resolution may produce more peaks. Therefore, sedimentation rates were standardized before the second model was run in CharAnalysis to test for any potential bias. This was done by averaging multiple 0.5cm interval charcoal counts. During the late Holocene (0-1000 yr BP), where sedimentation rates were 6-7 years per 0.5cm, 3 samples were combined and average. During the middle Holocene (1000-6000 yr BP), sedimentation rates were ~10 years per 0.5cm, therefore 2 samples were combined and average. Finally, during the early Holocene (6000-12449 yr BP) no adjustments were applied as every 0.5cm interval represented ~20 years. Results of this model were very similar to the initial model. The trends in fire frequency were comparable as all the major changes resulting from the top-down and bottom-up controls were still detected. However, during the late Holocene some of the peaks had decreased in magnitude as a result of averaging multiple 0.5 cm intervals. The initial model was used for all analyses since the results of the second model were not considerably different and no bias was detected. The initial model interpolated the record to constant temporal resolution of 10-years, which is an important step to account for unequal sampling intervals as a result of changing sedimentation rates (Higuera, 2010).

The SNI is a way to quantify the separation between the large peaks and the slowly varying background noise. Kelly et al. (2011) suggest that a charcoal record with a SNI > 3 is suitable for peak detection analysis. However, it is important to note that the SNI does not validate that the peaks are a result of a fire, but that the record itself is suitable for peak detection analysis. Therefore, a record with a SNI > 3 still has the potential for peaks to be a result of other factors such as large erosion events for example. Also, a record with a SNI < 3 is not suggesting that fires are not present in the record, rather they are not detectable using peak analysis as the peaks are not distinguishable from the slowly varying background noise (Kelly et al. 2011). This reinforces the importance of quality site selection to ensure primary charcoal is maximized and secondary charcoal influx is minimized.

Surficial and Piston core alignment

The overlap between the piston and gravity cores was determined primarily via the macroscopic charcoal data (Figure S1).

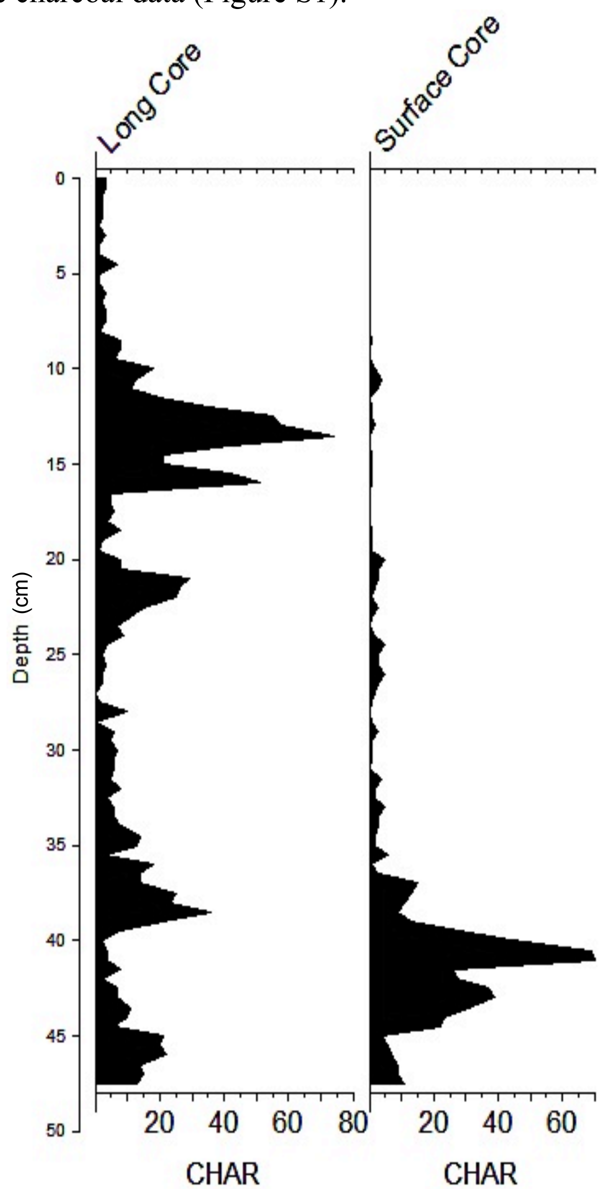

Figure S1– Macroscopic charcoal in CHAR (pieces per cm^2 per year) for both sediment cores. The overlap was found at 0cm (piston core) and 27.5 (surface core).

Bacon Model

Bacon breaks the core into many vertical sections to apply the MCMC simulations. This was set to res = 50 (50cm thickness), an increase from the default settings, which is suggested for cores longer than a few meters (Blaauw and Christen, 2013). The accumulation mean (acc.mean) was increased to 50 from the default of acc.mean = 20, this was to account for the slower sedimentation rates at the bottom of the core. Calculating sedimentation rates for every cm on long cores (over 500 cm) can take a long time to process; accordingly Bacon offers alternate intervals (d.by) that require less time. However, sedimentation rates were needed every 0.5 cm for the macroscopic charcoal analysis, therefore d.by was set to 0.5 and the alternate interval prompt was denied. This provides the necessary sedimentation rates every 0.5cm, with each trial averaging ~30 minutes in processing time. The Bacon default depth for maximum calculation (maxcalc) is 500 cm, which had to be extended to maxcalc = 539.5 as the core was longer than 500 cm. All other parameters were kept at their default values.

Several models were developed using Bacon v2.2. After reviewing the models, one of the bulk sediment dates (UOC – 3591) was omitted from the age-depth model. While the date fit chronologically with the other dates, its inclusion in the age-depth model resulted in a rapid change in sedimentation. However, observation of the sediment core itself did not suggest a rapid change in sedimentation had occurred (i.e., no visible change in sediment texture or other discernable indicators). A radiocarbon date from a piece of charcoal recovered from the core at 492.5 cm fit the model well and suggested that the bulk sediment sample was an incorrect age, potentially from old age offset. Although the old age offset was adjusted for using the calibrated sample from the tephra layer, the amount of offset can change over time. Therefore, it was assumed that this sample varied too much from the calibrated sample and it was consequently omitted from the model.

The sediment core chronology is based on a series of ^{14}C dates and the accepted age of the WRA tephra layer (Figure S2). With this record spanning over 12 500 years, ^{210}Pb dates were not used as they would only represent a small fraction of the record. It was determined that opting for additional ^{14}C dates over the ^{210}Pb dates would be more useful to develop an accurate model throughout the entire record.

To adjust for the freshwater reservoir effect, a bulk sample (UOC – 3173) was dated directly after the WRA layer, which has a known date of deposition of 1147 yr BP. UOC – 3173 was dated at 1702 ^{14}C yr BP or 1625 cal yr BP. Therefore, after calibration, the old age offset from the reservoir effect was estimated at 478 years. This was then applied to all the bulk sediment samples to adjust for old age offset (Patterson et al., 2017). The adjustment was made after calibration, as the varying atmospheric ^{14}C levels over time would skew the adjustment value if it were applied before calibration. It is important to note that the old age offset will not be consistent throughout the record, and therefore sample UOC – 3591 was omitted, as the age did not fit the Bacon model. It is assumed that this old age offset differs from the 478 year offset, which is supported by a nearby (11cm apart) charcoal date that accurately fit the model. Considering these two factors it was felt that UOC – 3591 could be safely omitted from the model.

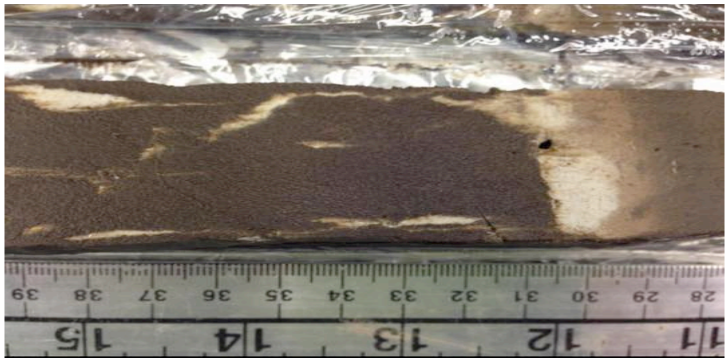

Figure S2 – Photograph of the long core retrieved with the Livingston piston core, showing the presence of the White River Ash deposit.

References

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