Comment on egusphere-2022-1418

Anonymous Referee #2

Referee comment on "Seasonal controls override forest harvesting effects on the composition of dissolved organic matter mobilized from boreal forest soil organic horizons" by Keri L. Bowering et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-1418-RC2, 2023

This study follows up on an earlier case study evaluating fluxes of DOC from harvested (10 years post harvest) and unharvested black spruce forest plots (n=4), in evaluating the composition of the dissolved organic matter through the season (n=3). A suite of solutes and DOM composition indices (absorbance spectrometry) were analyzed through four seasons. The harvest treatment effects were quite muted in comparison to seasonal changes, which is perhaps surprising given the purportedly different litter inputs between a 10 year-old aggrading forest and a mature forest. There was higher DON and DOC exported from organic horizons in the harvest treatment, but the effect size of this was small compared with seasonal changes. In agreement with other work, this work also demonstrated the diagenesis of DOM in surface soils through the winter, owing to snow buffering soil temperatures. The conclusions are, for the most part, supported by the work and the writing is clear and should be of broad interest. I offer minor comments by line number, and hope they are helpful in publishing this work.

Response: Thank you for your constructive feedback. We found it instructive in improving this paper.

Line 35 (abstract): How does this study inform on climate change effects?

Response: We agree that this later portion of the abstract could be more direct and explicitly state how the work informs on climate change impacts. We will edit the last part of the abstract to indicate that the results (i.e. seasonal differences in O horizon DOM composition observed here, particularly between winter/spring melt and fall periods) indicate the trend of warmer winters and increased fall precipitation observed and anticipated with climate change has the potential to enhance delivery of DOM that is likely more reactive with mineral soils or bioreactive in the downstream freshwater environment. However, the impacts of this shift (soil OM sequestration or delivery to aquatic) will depend upon hydrology and specifically infiltration relative to lateral flow in these boreal landscapes.

Line 90-95 (and throughout): There is a bit of text explaining the consequences of DOM quality from the O horizons for stabilization in the mineral soil, which seems like conjecture for the present study, which did not characterize organo-metallic complexation or stabilization in the mineral soil. I recommend tempering this. Moreover, soil type (for example, Podzols vs. Cambisols) is very important in mediating these processes.

Response: We only make mention of the potential consequences of O horizon derived DOM composition within the mineral soil as a means to explain one important potential for the changes in composition. For example, in this specific case (Line 90-95) DOM with a higher aromaticity is more likely to form organo-mineral complexes with reactive metals within the mineral soil environment. We agree, in this study we are not investigating fate of DOM in *mineral soils nor organo-mineral processes and what controls them. Therefore, we will review the paper and make revisions necessary to be certain that this is clearer.*

Line 125: Some detail on the type of soil (taxonomy would be great) is needed. Even mean depths of L, F, H... type of parent material would be helpful

Response: Thanks for raising this. We agree that this information is helpful and will add the soil type/classification (humo-ferro podzols; Canadian Soil Classification Work Group), mean depths of the O horizon (8.2 cm forested plots; 4.3 cm harvested plots; Bowering et al. 2020), and the parent material (till composition; generally less than 3 m, poorly sorted, with clasts of granites, porphyry, sandstone and siltstone (Batterson and Catto, 2003) *with quartz most abundant, followed by plagioclase, muscovite, chlorite, K-feldspar and biotite (Patrick et al. 2023) for the study site and plots. This will be added to the site description section.*

Line 144: I thought there were four plots?

Response: Indeed there are four plots of each treatment at the study site. However, in this study two pairs of lysimeters (four lysimeters) located in each of three forested and three harvested plots were used (n=12 per treatment or n=24 total). We will revise the study site and lysimeter sampling description to clarify this. Also note here that this design is illustrated in supplementary figure S1 and we will be sure to refer to that figure more explicitly to clarify.

Line 170: Here, I was hoping to see some detail on typical snowpack for the region.

Response: We should have included the information on regional climate (30-year normals) including snowfall and snowpack duration within the site description section and will do so within the site description section. We will also provide the range of values for the study period itself such as the 1402 mm of total precipitation with 516 mm (37%) of that as snowfall in water equivalents within a region where snow typically represents ~40% of total precipitation.

Line 196: What's a typical peak snow water equivalent at the freshet?

Response: The snow water equivalent of the snowpack at the start of snowmelt period during the study was 83-110 mm as measured within the study plots, and was higher in the harvested plots (Bowering et al. 2020). We will include those values in the study site description. We will also provide the 30-year mean snow on the ground water equivalent for the relevant period of snowmelt or freshet to provide that context. We know from the analysis of hydrographic data from three nearby stations, monitored by Environment Climate Change Canada (ECCC), and our own smaller headwater catchment sites, that ice jamming during this period precludes accurate estimation of the total freshwater discharge without use of conductivity and geomorphic information not available for the ECCC station data where some records for the region go back to 1963. Therefore, we feel it would be most informative to provide the snow on the ground water equivalent for the period of study as well as the longer term average from the local weather station to provide this information and its context.

Line 213: It is too bad that a conservative ion wasn't measured to act as a "tracer" (like Cl, or Br), as flux is likely to go down in H, yet solute concentrations are likely to go up, detracting from nailing down the mechanism for any changes (or not) in export in response to harvest treatment that account for concentration or dilution effects.

Response: Indeed, utilizing a tracer in this study would have been helpful had we had access to precipitation and throughfall samples to define the tracer inputs which would vary significantly with time particularly in this maritime region.

Line 362: It is interesting that summer fluxes were so high- as high as fluxes during the freshet!

Response: Yes, we agree and our previous study suggests production limitation of the DOC flux over both the wet autumn and snowmelt periods (in contrast with summer when highest DOC concentrations are observed) likely controls the magnitude of DOC fluxes seasonally. This is important as it suggests that the impact of the current and project increasing trend in precipitation in the region on DOC mobilization from these landscapes will depend on the type and intra-annual distribution of that increased precipitation (Bowering et al. 2020).

Line 378: Interesting. Why would the snow be different by treatment? Is this owing to differences in throughfall?

Response: Yes, given the evidence for greater DOC concentration and HMW CDOM within the snowpack of forest plots relative to the snow collected from the harvested plots we suspect a greater source of litterfall derived DOM. For example, we observe greater needle litterfall on the snow surface and higher input of DOC from snow in the forest plots (2.1 versus 1.3 g DOC m^{-2} y^{-1}*, forest and harvest, respectively). We will add a phrase in that section to help convey that point, briefly, citing the snow DOC contents reported by plot type in Bowering et al. (2020).*

Figure 3: Do you think part of the autumnal differences could be owing to changes in litterfall between the harvest treatments?

Response: Not exactly sure what differences are being referred to in this comment. Fig. 3 depicts treatment differences in water and DOC flux (elevated in harvested relative to forested) in autumn, and it also demonstrates that overall autumn fluxes of DOC and water are greater than in summer or winter, and similar to that observed over the snowmelt period. In the first instance (treatment effect) we hypothesize that the harvested plots exhibit a greater flux of DOC due to the enhanced water flux. In the second (seasonal), the combined effects of DOM source and water availability controls this flux, and explains the contrasts with the snowmelt attributed to the decomposition of soil OM under the insulated snowpack. However, this comment may also be referring to the large variation in values for the water, DOC and DON fluxes which certainly is likely capturing the variation in litterfall and throughfall across the plots overall as observed by the individual lysimeters. We will insert a comment to direct the reader to this possibility.

Line 346: What is the mechanism for "inconsistent snowpack" increasing soil water fluxes? Does this have to do with soil freezing, which has been shown to increase [DOC]? I'm assuming that this is meant to prime the reader, and you'll get to this later?

Response: Thank you for raising the question as it is an important point to clarify. The reference to an inconsistent snowpack at the start of the discussion was meant to prompt the reader to *consider how shifts in precipitation and form can result in changes to how much and what is mobilized by these soils. Here we are using "inconsistent" to refer to a dynamic snowpack, one that experiences melting, rather than just accrual, over the winter period; thus contributing to soil water fluxes during the winter period and less so to the larger spring melt period. In this region exposure of soil to freezing is not observed in these plots (at least not yet!). Our compositional results suggest such a shift, toward a more dynamic snowpack, could have consequences such as increasing mobilization of DOM that may have otherwise been decomposed over the course of the winter period under the insulation of snowpack (which generally prevents freezing in these soils as observed through soil T probes). We will edit this section to help clarify this.*

Line 565: Could you please provide a reference for rhizodeposited DOM having LMW?

Response: Yes, we will add (Giesler et al., 2007) *to support this point.*

Line 610: This is indeed very interesting, and has been observed in peatlands as well (a negative relationship between SUVA254 and DOM oxidation, as well as DOM molecular weight). It could also be that relatively low molecular weight compounds are being polymerized (mainly by fungi). See for example, "polyphenol theory" described by F.J. Stevenson; "Humus Chemistry- genesis composition, reactions". 1994. pp: 188-211.

Response: Thanks for this comment. We will briefly add reference to these congruent observations in peatlands and the fact that these observations are consistent with the initial steps in the theory for the generation of humic substances, namely the breakdown of lignocellulose (original plant polymers) into simpler lower molecular weight components that then contribute to reactions that form humic substances. Here we will refer to Stevenson (1994) and (Prijac et al., 2022) *in this section.*

Line 638: I think it is also relevant to mention the importance of texture and parent material type for DOM adsorption and infiltration.

Response: We will revise to include more specific reference to the dependency of formation of organo-mineral complexes (OMCs) via DOM and metal co-precipitation and adsorption on to OMCs as a control on mineral soil adsorption of DOM as well as references (e.g. Oades, 1988; Slessarev et al., 2022; Patrick et al., 2022; Marschner and Kalbitz, 2003).

References cited in responses:

Batterson, M. J. and Catto, N. R.: Topographically-controlled Deglacial History of the Humber River Basin, Western Newfoundland, 1–16, 2003.

Giesler, R., Högberg, M. N., Strobel, B. W., Richter, A., Nordgren, A., and Högberg, P.: Production of dissolved organic carbon and low-molecular weight organic acids in soil solution driven by recent tree photosynthate, Biogeochemistry, vol. 84, 84, 1–12, https://doi.org/10.1007/s10533-007-9069-3, 2007.

Hensgens, G., Laudon, H., Peichl, M., Gil, I. A., Zhou, Q., and Berggren, M.: The role of the understory in litter DOC and nutrient leaching in boreal forests, Biogeochemistry, vol. 149, 149, 87–103, https://doi.org/10.1007/s10533-020-00668-5, 2020.

Huntington, T. G., Balch, W. M., Aiken, G. R., Sheffield, J., Luo, L., Roesler, C. S., and Camill, P.: Climate change and dissolved organic carbon export to the Gulf of Maine, Journal of Geophysical Research-Biogeosciences, vol. 121, 121, 2700–2716, https://doi.org/10.1002/2015jg003314, 2016.

Jones, D. L. and Kielland, K.: Amino acid, peptide and protein mineralization dynamics in a taiga forest soil, Soil Biology Biochem, vol. 55, 55, 60–69, https://doi.org/10.1016/j.soilbio.2012.06.005, 2012.

Marschner, B. and Kalbitz, K.: Controls of bioavailability and biodegradability of dissolved organic matter in soils, Geoderma, vol. 113, 113, 211–235, https://doi.org/10.1016/s0016-7061(02)00362-2, 2003.

Oades, J. M.: The retention of organic matter in soils, Biogeochemistry, vol. 5, 5, 35–70, https://doi.org/10.1007/bf02180317, 1988.

Patrick, M. E., Young, C. T., Zimmerman, A. R., and Ziegler, S. E.: Mineralogic controls are harbingers of hydrological controls on soil organic matter content in warmer boreal forests, Geoderma, vol. 425, 425, 116059, https://doi.org/10.1016/j.geoderma.2022.116059, 2022.

Prijac, A., Gandois, L., Jeanneau, L., Taillardat, P., and Garneau, M.: Dissolved organic matter concentration and composition discontinuity at the peat–pool interface in a boreal peatland, Biogeosciences, vol. 19, 19, 4571–4588, https://doi.org/10.5194/bg-19-4571-2022, 2022.

Slessarev, E. W., Chadwick, O. A., Sokol, N. W., Nuccio, E. E., and Pett-Ridge, J.: Rock weathering controls the potential for soil carbon storage at a continental scale, Biogeochemistry, vol. 157, 157, 1–13, https://doi.org/10.1007/s10533-021-00859-8, 2022.