

## The impact of wildfire on biogeochemical fluxes and water quality on boreal catchments

Granath et al., 2020, Biogeosciences Discussions

This study reports on the impacts on wildfire on water quality and CO<sub>2</sub> fluxes from a boreal forest catchment in Southern Sweden (which had been monitored pre-fire) by using paired before-after measurements for the decade prior to the fire and three years post-fire to construct elemental budgets. I did enjoy reading this paper and this work appears poised to make a valuable contribution to the literature of the effects of wildfire by leveraging existing pre-fire measurements. As the authors point out, studies on the effects of forest wildfire recovery often lack pre-fire measurements and rely on space-time substitution as a proxy for 'pre-fire' and 'post-fire' conditions, which carries its own set of nebulous assumptions which are avoided in the present study design here. The novel partitioning of post-fire solute fluxes into fast and slow decay pools should be of wide interest as a normalised metric of water quality recovery to baseline post-fire across environments.

It appears the authors have been forthcoming with the history of this manuscript as submitted to a previous journal for peer-review and, as a result, had made substantial revisions and provided a thorough response to previous reviewer comments. I recommend this paper for publication following some primarily minor revisions, focused around language, clarity, and more explicit outline of assumptions and methodological choices throughout.

Abstract: Might be worth including range of study years (including pre-fire monitoring) and year of wildfire in abstract?

Pg 1 Line 18 – 'during the first 12 months' – the first 12 months-post fire?

Pg 1 Line 20 – curious of this terminology, 'ecologically relevant' increases – what criterion is used to determine this? Perhaps (if statistically applicable) 'significant'? Not that statistical testing is required, but if it were carried out, this may be the appropriate venue to specify.

Pg 1 Line 22 – does the partitioning of these pools into 'slow' and 'fast' and the values of these half-lives apply to all analytes?

Pg 1 Line 24 – given this is a study largely of using pattern to infer process, perhaps a stretch to say 'biogeochemical cycles have largely returned to...' and rather best to comment on what precisely was measured in this work, ie, 'dissolved fluxes of nutrients have largely returned to....'

Pg 2 Line 35 – Perhaps best here and throughout introduction/discussion to quantify 'long-term' (one year, ten years, 100 years?) and contextualise in fire return interval for the cited study regions

Pg 3 Line 4 – 'runoff' vs 'run-off' inconsistently stylised throughout

Pg 4 First paragraph – unclear to be how the second half of the first objective (i) "hydrologically exported C, N, S, Ca, K the first three years post-fire," differs from the second objective (i) "post fire water quality trends in five streams...." – are these two separate objectives?

Pg 4 Lines 25 – While topography is certainly a consideration in hydrology this statement might either be reinforced by citation to evidence, or, rather stated as an assumption for watershed delineation, given that in other boreal environments, perhaps 'topography is the last thing to consider' (ie, Devito et al., 2005)

Devito, K., Creed, I., Gan, T., Mendoza, C., Petrone, R., Silins, U., & Smerdon, B. (2005). A framework for broad-scale classification of hydrologic response units on the Boreal Plain: Is topography the last thing to consider? *Hydrological Processes* 19(8), 1705-1714.

Pg 5 Line 6 – Given the attempt in the paper to perform an elemental balance, is there any concern that this first major precipitation event post-fire may have performed some flushing mechanism where a considerable proportion of the post-fire elemental budget for any analyte in this study may have been exported from the catchment while this event was not sampled? Perhaps worthy a caveat in the discussion of why this may or may not be likely?

Pg 5 Line 8 – “high temporal resolution”, “longer intervals”, “lake was sampled slightly less frequently”, here and elsewhere, define each of these precisely. Hourly? Daily? Weekly? Monthly? Was the sampling regularly spaced or focused around precipitation events? Was the sampling design/frequency rooted in literature? Based off or paired with the pre-fire sampling frequency? Given the objective was to estimate export, sampling design can have a significant impact of these estimates (and varies by solute of interest), see for example:

Johnes, P. J. (2007). Uncertainties in annual riverine phosphorus load estimation: Impact of load estimation methodology, sampling frequency, baseflow index and catchment population density. *Journal of Hydrology*, 332(1-2), 241-258.

Richards, R. P., & Holloway, J. (1987). Monte Carlo studies of sampling strategies for estimating tributary loads. *Water Resources Research*, 23(10), 1939-1948.

Aulenbach, B. T., Burns, D. A., Shanley, J. B., Yanai, R. D., Bae, K., Wild, A. D., ... & Yi, D. (2016). Approaches to stream solute load estimation for solutes with varying dynamics from five diverse small watersheds. *Ecosphere*, 7(6), e01298.

Pg 5 Line 21 – What is meant by each ‘intersection’? Were the 300 m x 300 m grids divided into subgrids, every, say, 50 or 100 m?

Pg 5 Line 31 – Glad to see the careful considerations and limitations of this method which appears sound and consistent with literature. Is there a quick and transparent back-of-the-envelope calculation that could be included here to contextualise this ‘likely small’ overestimation of carbon loss (ie, as a potential error) relative to the estimated values, even to just to give a rough order of magnitude, to inform if we are roughly in the territory of, say, 0.1%, 1%, or 10% overestimation?

Pg 8 Line 11 – inconsistent formatting throughout of ions - use of subscripts/superscripts, and including charge, ie NH<sub>4</sub> vs NH<sub>4</sub><sup>+</sup>

Pg 8 Line 18 – What was the basis for model selection following ruling out a single (simple) exponential decay curve? Ie why the partitioning into exactly two pools of fast- and slow-decay superimposed on the baseline – why not three pools and include a ‘medium’-decay? Is the two-pool model rooted in literature? Does some information criterion inform that two pools is superior to three (or more) on an added complexity cost analysis? How sensitive would the analysis be to additional complexity?

Pg 9 Line 1 – It appears pH measurements taken to validate this model, but no detail given in methods? Were these measurements in-situ, coincident with the water samples?

Pg 9 Line 8 – Presuming, then, that extended surface water coverage was not an issue at these sites then in terms of pixel removal?

Pg 10 Line 9 – Perhaps for clarity change “Nitrate and ammonium increased...” to “Nitrate and ammonium concentrations in streamflow increased...” and similarly throughout

Pg 10 Line 31 – I am wondering back to the initial question on sampling frequency (Pg 5 Line 8) and how the resolution of sampling overlays with this estimate of the ‘fast’ decay pool (4-20 days). Would more high-frequency sampling during what seems to have been identified as a critical short-term post-fire period yield finer estimates of this critical period length? Further, is it possible that the omission of the first post-fire precipitation event (Pg 5 Line 6) from the sampling design yielded a considerable portion of this ‘fast’ pool that was unaccounted?

Pg 11 Lines 2-6 – Were these sequences of inequalities statistically assessed? Perhaps including values of each of these peak/baseline ratios here would be informative and a useful normalised metric for other post-fire studies to compare against.

Page 11 Line 16 – Hanging parentheses

Page 12 Line 5-6 – This may be a stretch to generalise from two studies, if no other annual-basis studies of NEE are available.

Page 13 Line 2 – Is this meant to read ‘first year’ singular?

Page 14 Line 14 – an interesting observation on similar impacts from such different types of disturbance – what mechanisms would be responsible for these similarities?

Figure 2 – perhaps the fire could be delineated as a horizontal line on the figure as similar to Figure 3?

Figure 6 – this inclusion of methods/assumptions (text on right of figure) is an excellent contribution to laying out the fluxes in an integrated way such as this.