

**Authors' response to Reviewer 2's comments for HESS-2025-6244 entitled
'Spatially variable wildfire impacts on sediment mobilization: event-scale evidence
from eastern Australian catchments'**

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Note: the review comments are reproduced below in black. Our responses are presented in blue, within which, proposed revisions are underlined.

Review Summary

The reviewed study presents the results of an investigation of fire impacts on water and fluvial sediment dynamics in 14 watersheds impacted by the 2019/20 Black Summer fires in Australia. The authors analyzed high-resolution turbidity and water discharge data collected before and after the fire using Bayesian Hierarchical modelling to investigate the potential role of fire, watershed characteristics, and hydrologic conditions at the stormflow event scale. Overall, this work is novel and of potential interest to the broad international readership of HESS, and the scientific approach appears to be generally sound. I have reservations, however, regarding some of the authors' choices when structuring their analysis, a general disregard of the relationship between turbidity, fluvial suspended sediment concentration, and flux, as well as the lack of in-depth discussion of their results in terms of processes and the vast body of literature on this topic produced in the last 30+ years, and some of their interpretations. More minor quibbles included some structural choices, such as introductory material in the already sparse discussion section. For these reasons I recommend major revisions. See detailed commentary below.

We appreciate the thorough evaluation of our manuscript and the constructive feedback provided by the reviewer. Detailed responses for all the comments and our proposed revisions are outlined below.

Detailed Comments

1. Line 23: 'location' is too vague – be more specific
We propose replacing 'location' with 'distance from extreme burning to catchment outlet'.
2. Line 30: This sentence is poorly structured – revise
We propose revising the sentence to "These events can alter the hydrological and biogeochemical processes in forested catchments, including reduced canopy interception, increased soil erodibility, and loss of surface cover, which enhance runoff and sediment mobilization".
3. Line 35: This appears to be your only mention of sediment flux in the entire paper. Why do we care about turbidity – only as a water quality parameter or as an analog for suspended sediment and the mass flux of solids through watershed systems? You appear to be framing this work as a post-fire water quality paper,

but much of the post-fire fluvial sediment dynamics work has considered this issue through the lens of earth surface processes, and hence with a focus on sediment flux.

Thank you for the insightful comment. We agree that the motivation for examining turbidity in relation to sediment export and sediment flux was not sufficiently articulated in the original manuscript. Our broader interest is in understanding how wildfire alters sediment mobilisation and export at the event scale. Ideally, this would be examined directly using high-frequency measurements of suspended sediment concentration and sediment flux during individual flow events. However, such event-scale sediment measurements are relatively scarce across monitoring networks, particularly for studies requiring sufficiently long pre- and post-fire records. This motivated our use of turbidity, which is much more widely monitored at high temporal resolution and also commonly used as a surrogate for studying suspended sediment dynamics.

To clarify this, we propose adding text below to clarify how turbidity-flow relationships indicate sediment patterns at the start of the Methods section:

- *“Our interest on comparing event-scale sediment dynamics pre- and post-fire was facilitated by wider adoption of high-frequency water quality monitoring in the recent decade, particularly in turbidity. An important motivation for examining turbidity at the event scale is its potential to provide insight into suspended sediment mobilisation and export. Direct, high-frequency measurements of suspended sediment concentration and flux during individual flow events are relatively scarce, whereas turbidity is more widely monitored at high temporal resolution and is commonly used as a surrogate for suspended sediment concentration (Minella et al., 2008). We use the classic power-law C-Q model to represent the relationship between turbidity and flow during each event, and the model parameters are estimated for each event. The values of C-Q slopes between concentrations and flows indicate different types of riverine export dynamics: slopes close to zero indicate chemostatic behaviour, whereas negative and positive slopes indicate dilution or mobilisation / enrichment type behaviour (Knapp et al., 2020; Zhang, 2018).”*

4. Line 38: This statement is incorrect and also a very cursory treatment of the topic of fire-recovery timescales. Although perhaps most watersheds will return toward ‘baseline’ hydrologic and fluvial constituent dynamics within 5 years after fire, there are many exceptions. I suggest you revisit the literature.

Thank you for the comment. We propose revising the sentence after revisiting the literature, to: “Some changes could be observed for multiple years after fire (Rust et al. 2018), for example, the nitrogen and sediment show significant increases up to 8 years post-fire (Brucker et al., 2025).”

5. Line 57-58: There have been more of these studies, particularly over the past 10 years. Revisit the literature to setup your study more appropriately here in the introduction, and to consider in the context of your results in the discussion.

Thank you for the suggestion. We will investigate a restructuring of both the Introduction and Discussion Section 4.1 to allocate/revise materials appropriately.

6. Line 72: Must be a typo – a proportion of 0.1 or 10% rather than 0.1% of catchment area, right?

We propose to revise this value and add justification for it in the revision. Please see our response to your next comment for details.

7. Line 84: Okay, so not a typo? How is 0.1% of catchment burned at high severity a relevant threshold? Seems vanishingly small.

We agree that 0.1% of catchment area burnt at high severity is too low to be justified as a meaningful threshold, and the literature does not provide sufficient support for such a specific severity threshold. In response to the reviewer's suggestion, we have decided to use a higher 10% threshold and for total burnt area instead, which is better supported by literature. Accordingly, we propose adding the following clarification and justification of this decision in Methods Section 2.1 as:

- *“As the objective of this study was to examine sediment-dynamic changes associated with the 2019/2020 fire season, candidate catchments were screened to minimise potential interference from substantial fire disturbance during preceding years. We did not require catchments to have experienced no previous burning, as small or spatially limited fires would not necessarily produce a detectable catchment-scale response. Instead, catchments where $\geq 10\%$ of their area had burnt during the preceding fire seasons were not included. This value was used as a pragmatic screening criterion for substantial prior fire disturbance rather than as an assumed threshold for the onset of post-fire sediment responses. Evidence for post-fire hydrological change indicates that catchment responses can occur following relatively modest disturbance extents: effects on streamflow have been detected at disturbance levels as low as $\sim 7\%$ of catchment area (Buma and Livneh, 2017), although changes in annual water yield are more commonly reported when approximately $\geq 20\%$ of a catchment is disturbed. Evidence specifically for post-fire sediment and water-quality responses likewise demonstrates a strong dependence on burn extent and severity. For example, Rhoades et al. (2011) found that post-fire turbidity increased with both total burnt area and the proportion burnt at high severity, with catchments having $>45\%$ high-severity burning exhibiting approximately fourfold higher turbidity than less severely affected catchments; Wilson et al. (2021) similarly found increasing hillslope-to-*

stream sediment delivery and channel change with the proportion of catchment burnt at high severity. Reflecting this evidence, Murphy et al. (2023) recommended a minimum of 10% of drainage area burnt at moderate-to-high severity when selecting catchments for investigating post-fire water-quality responses. Collectively, these studies support the use of 10% burnt area as a conservative screening criterion for prior fire disturbance that could plausibly influence subsequent sediment dynamics, while also demonstrating that the magnitude of response depends strongly on fire severity and other catchment and hydroclimatic controls. We therefore did not impose a separate numerical threshold for high- or extreme-severity burning, for which a generally applicable catchment-scale threshold is not well established. Importantly, the 10% criterion was used only to screen for potentially confounding prior fires and was not imposed in the statistical model. Spatial variation in model-inferred post-fire sediment responses to the 2019/2020 fires was subsequently evaluated against continuous measures of catchment burn extent and severity (Section 2.4).”

8. Figure 1: It would be more informative to have a color-shade map illustrating the distribution of burn severities, rather than just extreme severity. An inset map of the continent/region would be helpful to orient the international audience of this journal. Also consider adding graticules.

Thank you. [Figure 1 will be revised to address these comments.](#)

9. Table 1: This is pretty confusing. The catchments that you have classified as extremely burnt have 43.1-99.2% unburned area. This seems like a poorly structured classification system.

Thank you for raising this concern. Following our response to your Comment #7, [we propose using a 10% total burnt area \(instead of 0.1% extreme burning\) as the threshold to identify burning in preceding years. Accordingly, we will revise this table to include the percentage of total burnt area for each catchment.](#) We believe this will address the reviewer’s concern on clarity of this table.

10. Line 146: I don’t agree with your conflation of turbidity and suspended sediment concentration. This may seem semantic, but although turbidity and SSC are often highly correlated, they are not the same thing. The relationship between turbidity and SSC also can change, for example after watershed disturbances such as wildfire

Thank you for the insightful comment. We agree that turbidity and SSC are not the same thing and the relationship between them can change when the due to watershed disturbances. However, SSC monitoring is largely limited at high-frequency required to explore event-scale dynamics, so this study uses turbidity – a commonly used surrogate for SSC – to infer sediment dynamics. [We propose adding the following discussion below to the start of Methods to justify our](#)

focus on turbidity:

- “Our interest on comparing event-scale sediment dynamics pre- and post-fire was facilitated by wider adoption of high-frequency water quality monitoring in the recent decade, particularly in turbidity. An important motivation for examining turbidity at the event scale is its potential to provide insight into suspended sediment mobilisation and export. Direct, high-frequency measurements of suspended sediment concentration and flux during individual flow events are relatively scarce, whereas turbidity is more widely monitored at high temporal resolution and is commonly used as a surrogate for suspended sediment concentration (Minella et al., 2008). We use the classic power-law C-Q model to represent the relationship between turbidity and flow during each event, and the model parameters are estimated for each event. The values of C-Q slopes between concentrations and flows indicate different types of riverine export dynamics: slopes close to zero indicate chemostatic behaviour, whereas negative and positive slopes indicate dilution or mobilisation / enrichment type behaviour (Knapp et al., 2020; Zhang, 2018).”

11. Line 153: Why did you decide to only evaluate the role of your selected predictors on slope? What about offset (intercept)?

Although both intercept and the slopes are parameters of the power-law C-Q model, we focused on the slope because it is more directly informative about the flow-dependent water quality and sediment mobilisation processes that are the focus of this study. Specifically, the C-Q slope characterises how turbidity changes with increasing discharge and is commonly used to distinguish different types of export behaviors. A slope close to zero indicating of chemostatic behaviour, whereas negative and positive slopes indicate dilution or mobilisation/enrichment behaviour, respectively (Knapp et al., 2020). In contrast, the intercept primarily represents the magnitude of turbidity at a single reference discharge and can be influenced by the scaling and units of discharge, making it less directly interpretable for comparisons among events and sites. Given our particular interest in how post-fire sediment mobilisation and export respond to flow during individual events, we therefore focused our predictor analysis on the C-Q slope rather than the intercept. We will clarify this rationale in the Methods in the revised manuscript, as:

- “We use the classic power-law C-Q model to represent the relationship between turbidity and flow during each event, and the model parameters are estimated for each event. The values of C-Q slopes between concentrations and flows indicate different types of riverine export dynamics: slopes close to zero indicate chemostatic behaviour, whereas negative and positive slopes indicate dilution or mobilisation / enrichment type behaviour (Knapp et al., 2020; Zhang, 2018). Considering the main

aim of our work - to examine how fire and short-term hydrologic conditions interact to shape sediment dynamics, the C-Q slope supports this aim by offering a direct and powerful assessment of event-scale sediment export.”

12. Line 154: Intense wildfire, or severe?

Yes, it should be ‘severe’ rather than ‘intense’. This will be revised accordingly.

13. Line 161: I don’t think that you are actually evaluating ‘sediment export.’ Rather, your approach is investigating the effect of certain variables on the slope of event-scale turbidity-Q relationships.

Thank you for this comment. We agree that our analysis does not directly quantify sediment export (e.g., suspended sediment flux or load), but instead examines event-scale turbidity-Q relationships and how their slopes vary with fire and hydrological conditions. Our intention in using the term “sediment export” was to refer more broadly to sediment mobilisation and export dynamics, for which concentration–discharge (C-Q) relationships provide useful information (Zhang, 2018). We propose adding a clarification in the Methods section as below, to make this distinction clearer and to avoid implying that sediment export or flux is directly quantified:

- “Our interest on comparing event-scale sediment dynamics pre- and post-fire was facilitated by wider adoption of high-frequency water quality monitoring in the recent decade, particularly in turbidity. An important motivation for examining turbidity at the event scale is its potential to provide insight into suspended sediment mobilisation and export. Direct, high-frequency measurements of suspended sediment concentration and flux during individual flow events are relatively scarce, whereas turbidity is more widely monitored at high temporal resolution and is commonly used as a surrogate for suspended sediment concentration (Minella et al., 2008). We use the classic power-law C-Q model to represent the relationship between turbidity and flow during each event, and the model parameters are estimated for each event. The values of C-Q slopes between concentrations and flows indicate different types of riverine export dynamics: slopes close to zero indicate chemostatic behaviour, whereas negative and positive slopes indicate dilution or mobilisation / enrichment type behaviour (Knapp et al., 2020; Zhang, 2018).”

14. Line 165: Why wasn’t time since fire included, or number of events since fire, or some cumulative metric such as total water discharged since fire?

This is a great idea. We will investigate and test these as additional predictors and revise our manuscript accordingly.

15. Line 169-172: The QS, lastvolume & QS, this volume variables appear to be in terms of total water volume discharged for a given event, but you refer to their

role as an indicator previous and current ‘sediment mobilization’, by which I think you mean mass flux? I agree that antecedent stormflow events can act to flush a system or prime it with more sediment depending on sediment supply and transport details. Why preload this with specific interpretation? I suggest you present more on the nuanced role that previous and current stormflow event magnitude can play in suspended sediment concentration – discharge behavior. Thank you for this helpful comment. We agree that our original descriptions of these predictors preloaded them with overly specific interpretations and did not adequately reflect the potentially nuanced effects of antecedent and current stormflow magnitude on sediment dynamics.

Our rationale for including the previous-event flow volume was primarily to account for antecedent sediment mobilisation and potential source exhaustion. A larger preceding event may mobilise and export a greater amount of available sediment, thereby reducing sediment availability for mobilisation during the subsequent event. However, we acknowledge that the influence of antecedent events is not necessarily unidirectional, as previous events may also alter sediment supply, connectivity, or redistribution in ways that affect subsequent C-Q behaviour. We therefore interpret previous-event volume more generally as an indicator of antecedent hydrological forcing that may influence sediment availability during the current event.

Current-event flow volume, in contrast, represents the magnitude of hydrological forcing during the event being analysed. Event magnitude can influence the capacity to mobilise and transport available sediment and therefore affect the observed turbidity–discharge relationship. Importantly, the resulting response will depend on both transport conditions and sediment availability, rather than event magnitude alone.

Accordingly, we will revise the manuscript on the description of the two predictors and explain their roles more carefully in terms of antecedent sediment availability and current-event hydrological forcing:

- “• $Q_{s,lastvolume_e}$: total flow volume during the previous storm event, representing antecedent hydrological forcing that may affect sediment availability for the current event through processes such as prior sediment mobilisation, source exhaustion, redistribution, or changes in sediment connectivity;
- • $Q_{s,thisvolume_e}$: total flow volume during the current storm event, representing current-event hydrological forcing and its potential influence on the mobilisation and transport of available sediment.”

16. Table 3: Your choice of watershed variables has some notable gaps – what about geology, geomorphic metrics (e.g., slope), total burn area, burn area distance

from the channel...

Thank you for the suggestion. [We will include these important catchment characteristics and revise our manuscript accordingly.](#)

17. Figure 3: Please change figure symbols to better illustrate both pre- and post-fire values. The current version obscures pre-fire values by overlaying dense post-fire data clouds.

Thank you for the suggestion. [We will revise this figure to improve its clarity.](#)

18. Section 4.1: This overview of fire impacts on hillslope water and sediment dynamics is background material and more suitable for the introduction rather than the discussion section.

Thank you for the suggestion. [We will investigate a restructuring of both the Introduction and Discussion Section 4.1 to allocate/revise materials appropriately.](#)

Section 4.2: The discussion is very brief and does not adequately explore the study findings in the context of the potential mechanisms at play and findings from previous literature.

Thank you for the comment. [We propose expanding Discussion Section 4.2 to more explicitly compare the catchment and fire characteristics associated with variation in post-fire sediment responses in our study with those identified previously.](#) This will include hydroclimatic and antecedent conditions (Marcotte et al., 2024), vegetation and soil characteristics (Hall et al., 2022), spatial configuration of burnt and unburnt areas (Brown & Hunt, 2025; Raelison et al., 2023), burn extent and severity (Richardson et al., 2024; Wilson et al., 2021), sediment connectivity (Clark et al., 2025), and time since fire (Johnston & Maher, 2022). [These comparisons will be used to interpret the catchment characteristics identified as important in our analysis and to discuss why post-fire sediment responses may differ substantially among catchments.](#)

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