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Key Points:
- Dissolved organic carbon concentrations in stream water were driven by local hydrology during the first post-fire storm event
- Burn severity was a primary control on dissolved organic matter composition delivered to streams
- Spatial variation in dissolved organic matter composition in streams overprinted hydrological controls

Spatiotemporal Controls on the Delivery of Dissolved Organic Matter to Streams Following a Wildfire

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Abstract Warmer and drier climate has contributed to increased occurrence of large, high severity wildfires in the Pacific Northwest, drawing concerns for water quality and ecosystem recovery. While nutrient fluxes generally increase post-fire, the composition of organic matter (OM) transported to streams immediately following a fire is poorly constrained, yet can play an integral role in downstream water quality and biogeochemistry. Here, we quantified the spatiotemporal patterns of dissolved OM (DOM) chemistry for five streams burned by wildfires in Oregon, USA in 2020. We sampled over a 24 hr storm event 1 month after the fire revealing DOM dynamics were temporally variable, but spatially linked with burn severity. Specifically, nitrogen and aromatic character of DOM increased in streams burned at greater severity. Our results suggest spatially distinct gradients of burn severity impact DOM dynamics immediately following fire activity and highlight a key gap in our knowledge of post-fire DOM transport to streams.

Plain Language Summary Wildfires are increasing in frequency and intensity in the Pacific Northwest. Following a wildfire, rain events can mobilize large amounts of charred material from the ground and transport to local water bodies, thus leaving major concerns for how changes in wildfires will impact local water quality. Our study aimed to understand how the water quality of small streams that have been impacted by varying degrees of burn severity responds to major storm events immediately following a wildfire. To achieve this objective, we collected water samples throughout a storm event for 24 hrs in 1 hr intervals from five streams impacted by the 2020 Holiday Farm Fire in Oregon, USA. We found differences in the dissolved materials that were delivered to the streams that was directly related to how severe the fire burned. These results will help improve our understanding of how streams respond to wildfire activity and be able to predict how more frequent and intense fires impact local water quality.

1. Introduction

Fire regimes in the western US are changing, with patterns in burn area and burn severity becoming disconnected from historical fire regimes (Haugo et al., 2019). These shifting fire patterns are of increasing concern for watershed biogeochemical processes when considering the known impacts of wildfire on water quality and aquatic ecosystem health, which can persist for years post-fire (Bladon et al., 2014; Emelko et al., 2016; Niemeyer et al., 2020). The intermediate- and long-term influences of wildfires on water quality are diverse across affected watersheds (Rhoades et al., 2019; Santos et al., 2019; Sherson et al., 2015). Post-fire stream water chemistry, for example, is thought to result from an interplay between biogeochemical and hydrologic processes impacted by fire, such as water availability and soil water repellency (Niemeyer et al., 2020). In fact, the environmental fate of fire-impacted materials—also termed pyrogenic organic matter (PyOM)—is thought to be determined by its first interactions in water post-fire (Masiello & Berhe, 2020). The short-term hydrological response to fires is also regionally dependent. For example, high hydrological connectivity between hillslopes and streams in highland regions of the western US accelerates the delivery of water to streams post-fire (Hallema et al., 2017). This immediate hydrologic response is dependent on a complexity of factors that alter the chemical and physical properties of the watershed soils, including burn severity (Moody et al., 2016).

Shifts in the hydrological response of watersheds post-fire is often accompanied by an immediate increase in the delivery of materials to aquatic systems, seen through increasing in-stream turbidity and elevated nutrient inputs (Dahm et al., 2015). The increased mobilization of materials post-fire is most notable during storm events (Murphy et al., 2012). However, little is known of how storm events alter the mobilization of organic matter to streams post-fire as few studies exist that identify such controls. For example, dissolved organic matter (DOM) exports following a prescribed fire in South Carolina, USA were greatest during the first post-fire storm events, returning to pre-fire concentrations by the fourth storm (Olivares et al., 2019). In unburned watersheds, storm events can also mobilize greater amounts of DOM of varying composition (Fellman et al., 2009; Raymond et al., 2016) due to increased surface runoff and altered hydrologic flow paths (Inamdar et al., 2011), both of which are influenced by wildfires.

The spatial heterogeneity of wildfire impacts within a landscape further complicates our understanding of post-fire hydrological and biogeochemical responses. Wildfires create a mosaic of burn severities upon watersheds, with extremely localized impacts on soil hydrologic properties (McGuire et al., 2018) and alterations in organic matter dynamics (Smithwick et al., 2005). This results in the post-fire transport of materials into streams related not only to burn severity (McGuire et al., 2021), but also watershed characteristics (Santos et al., 2019). While large rivers generally act as an integrator of catchment-scale processes (Raymond et al., 2016), the redistribution of pyrogenic materials to river corridors is directly related with burn characteristics (Abney et al., 2019; Cotrufo et al., 2016; McGuire et al., 2021). As headwater streams are closely connected to their terrestrial landscapes (Pereira et al., 2014), such systems may experience varying impacts of a single wildfire event through space and time. The impact of wildfires on headwater streams is therefore likely a result of complex interactions between watershed characteristics, wildfire characteristics, and hydrologic responses.

The changing fire regimes in the western US highlight the importance of this region for studying the immediate wildfire impacts on stream water chemistry (Haugo et al., 2019). Herein, we aimed to identify short-term spatial and temporal controls on DOM composition in headwater streams during early flushing events following a wildfire in Oregon, USA. We used high resolution sampling (1 hr intervals) across one of the first major storm events following a wildfire in five streams whose drainage areas were engulfed entirely within the burn perimeter. Our study focused on the short-term (storm event occurring post-fire) hydrological response of DOM delivery to streams post-fire, and how those responses varied spatially over gradients of burn severity and catchment characteristics. Results from this regional study will help improve our mechanistic understanding of localized wildfire disturbances on stream water biogeochemistry and will help inform future studies on the immediate post fire impact on stream water quality across scales.

2. Materials and Methods

2.1. Watershed and Wildfire Characterization

The McKenzie River Sub-basin (Oregon, USA) drains a land area of 1300 km^2 and is a primary tributary to the Willamette River within the larger Columbia River basin. Between September and October 2020, the Holiday Farm Fire burned approximately 700 km^2 of the McKenzie River watershed just east of Eugene, Oregon (Figure 1). Climate in the region is Mediterranean, with dry summers and wet winter seasons with around 150–230 cm of annual precipitation. Steep hillslopes within the burn perimeter averaged ~35° and the soils primarily consisted of weakly developed inceptisols.

Vegetation data was obtained from the 2018 Oregon Statewide Habitat Map provided by the Oregon Spatial Data Library and credited to the Oregon Biodiversity Information Center, Portland State University (Kagan et al., 2019). Within the burn perimeter, vegetation was predominantly western hemlock (*Tsuga heterophylla*) with some mixed conifer and Douglas-fir (*Pseudotsuga menziesii*) (Table S1 in Supporting Information S1).

Soil burn severity was obtained from the United States Forest Service as a part of the Holiday Farm Burn Area Emergency Response (BAER) assessment (BAER Imagery Support Data Download, 2020) (Figure 1). Burn severity was designated along a spectrum ranging from light charring of the ground surface (low severity) to the complete consumption of pre-fire ground cover and surface organic matter with visible charring on large roots (high severity). Post fire watershed conditions suggested about 70% of the affected area was burned at moderate to high severity (Table S1 in Supporting Information S1, Figure 1).
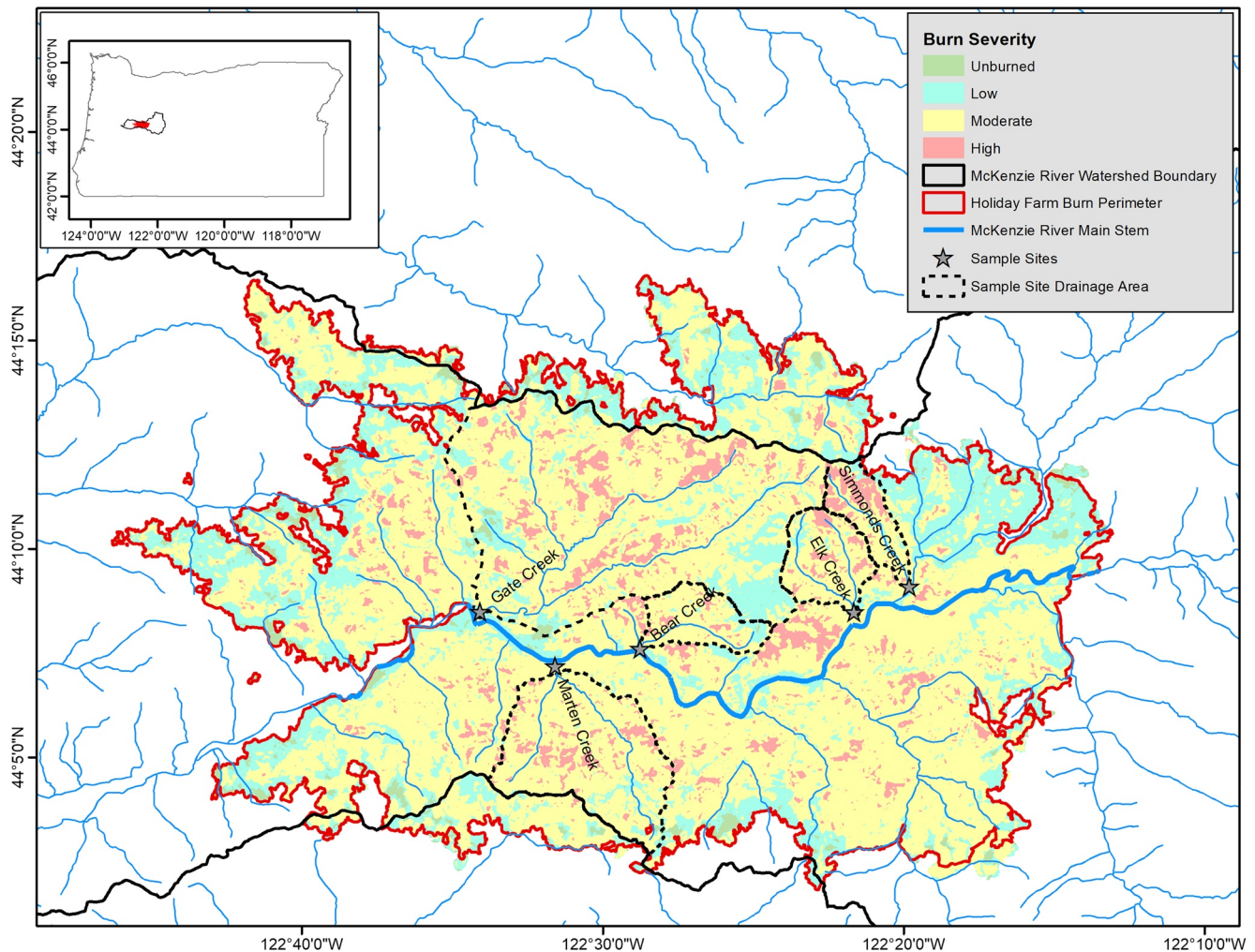
Figure 1. The Holiday Farm Fire burned approximately 700 km² of the McKenzie River watershed just east of Eugene, Oregon (burnt area outlined in red). Five sampled sub-catchments from left to right within the perimeter are Gate Creek, Marten Creek, Bear Creek, Elk Creek, and Simmonds Creek. The burn severity is represented spatially by shading on the map, where the unburnt areas are green, low severity is blue, moderate severity is yellow, and high severity is red. Watershed boundaries are delineated in the black solid and dashed lines.

2.2. Sample Collection and Processing

Five small tributaries to the McKenzie River whose drainage areas were completely engulfed within the burn area were sampled during the first major post-fire precipitation event (52 mm) on 13 November 2020. Yellow Springs Instruments (YSI) EXO2 water quality sondes were installed in stream sections generally representative of the overall flow to quantify turbidity at 10-min intervals (Data Set S1). We also collected stream water samples hourly over a 24 hr period with autosamplers (ISCO 3700 or 6712 autosampler, Data Set S2) into HCl acid cleaned polypropylene bottles. The samples were then passed through a muffled (500°C, 5 Hours) 0.7 μm Whatman GF/F filter followed by a 0.2 μm Pall Supor Membrane filter. A small aliquot of filtrate was acidified with 20% phosphoric acid and analyzed for dissolved organic carbon (DOC) as non-purgeable organic carbon and total dissolved nitrogen (TDN) with a Shimadzu TOC-L Total Organic Carbon Analyzer equipped with a Total Nitrogen unit. We acidified 20 mL of the remaining filtrate to pH 2 with concentrated hydrochloric acid and concentrated via solid phase extraction (SPE) as described by Dittmar et al. (2008). Briefly, Bond Elut PPL cartridges were conditioned with methanol followed by pH 2 Milli-Q water. The samples were then loaded onto the cartridge followed by an additional rinse with pH 2 Milli-Q water to remove salts. Finally, the cartridges were vacuum dried followed by sample elution with methanol. Methanol extracts were stored at −80°C until further analysis.

2.3. FTICR-MS Analysis

SPE extracts were analyzed on a 12 Tesla (12T) Bruker SolariX Fourier transform ion cyclotron resonance mass spectrometer (FTICR-MS) (Bruker, SolariX, Billerica, MA) located at the Environmental Molecular Sciences Laboratory (EMSL) in Richland, WA. Details on the analytical methods used are available in Supporting Information S1. Briefly, chemical formulae were assigned to detected peaks using Formularity (Tolić et al., 2017), an in-house software. Chemical formulae were assigned based on the following criteria: S/N >7, and mass measurement error <0.5 ppm, taking into consideration the presence of C, H, O, N, S, and P and excluding other elements. Molecular formulae were categorized into molecular compound groups as described Seidel et al. (2015) and are presented in Table S2 in Supporting Information S1. The elemental composition (e.g., %CHO, %CHON, etc.) and molecular compound groups were determined from the presence-absence of individual peaks and thus represent the total number of identified peaks that meet each criterion.

2.4. Statistical Analyses

Multivariate statistical analyses were performed within the R statistical platform version 4.0.5 (R Core Team, 2015). Non-metric multi-dimensional scaling (NMDS) was performed with the Vegan package (Okansen et al., 2020) on Bray-Curtis dissimilarity matrix for presence-absence transformed FTICR-MS data to reveal unique clusters of samples/sites based on differences in DOM composition. Significance was tested across sites at 10,000 permutations via permutation multivariate analysis of variance (PERMANOVA) with the pairwise Adonis package (Pedro, 2017). FTICR-based elemental composition and molecular compounds groups were used as complements to the NMDS analysis and, in conjunction with the environmental data (e.g., DOC, TDN, etc.), overlain across NMDS space using the envifit function in the Vegan package (Okansen et al., 2020) to reveal potential linkages with each identified clustering of samples. Redundancy analysis (RDA) was also performed with the Vegan package (Okansen et al., 2020).

3. Results

Post-fire water quality in the McKenzie River tributaries was spatially reflective of catchment burn severity. Turbidity maximums ranged from 80 to 300 FNU across all tributaries. We measured the highest turbidity values in Simmonds Creek, which was the most severely burned sub-catchment (Table S1 in Supporting Information S1). At all sites, incoming precipitation led to elevated DOC and TDN responses. DOC increased from ~1.5 to ~3 mg C/L at all sites with no apparent differences in peak concentrations (Figure 2a and comparable figures in Supporting Information S1). Peak concentrations in TDN, however, were more variable ranging from 0.25 mg N/L in the high burn severity catchments to 1.2 mg N/L in less severely burned catchments (Figure 2b and comparable figures in Supporting Information S1). Tight coupling between DOC and TDN with turbidity was observed at all sites (Figures 2c and 2d and comparable figures in Supporting Information S1).

DOM composition, characterized by FTICR-MS, was largely decoupled from trends in DOC and displayed more complex spatio-temporal heterogeneity. Elemental composition ranged from 55% to 85% for CHO, 10%–35% for CHON, and less than 10% for CHOS and CHONS throughout the data set (Data Set S2). Notable molecular compounds groups, such as polycondensed aromatics (Group 1) and highly aromatic compounds (Group 4) accounted for up to 2.5% and 12% of the identified molecular formulae, respectively. Highly unsaturated compounds (Group 6) and unsaturated aliphatics with heteroatoms, including peptide-like formulas (Group 9) represented up to 57% and 22.5%, respectively. The elemental composition and molecular compound group time series distributions were highly variable and displayed predominantly chemostatic trends throughout the storm at each of the sites (Figures S4 and S5 in Supporting Information S1).

Nonmetric multidimensional scaling (NMDS) derived from the total identified molecular formula across the data set revealed an overprinting of spatial controls on DOM composition post-fire compared to temporal controls. Two distinct clusters among sites (Figure 3) were identified and generally included sites with elevated proportions of mature forest growth and more severe burn conditions (Elk and Simmonds Creek). At these sites, the DOM composition generally had elevated proportions of aromatic compounds and N-containing functionality. This is compared to the second cluster, which was represented predominantly by sites with less severe burn conditions (Gate, Marten, and Bear Creek) that were elevated in less aromatic CHO and CHOS type compounds. The role of burn severity and hydrological parameters (e.g., turbidity) as explanatory variables for post-fire DOM
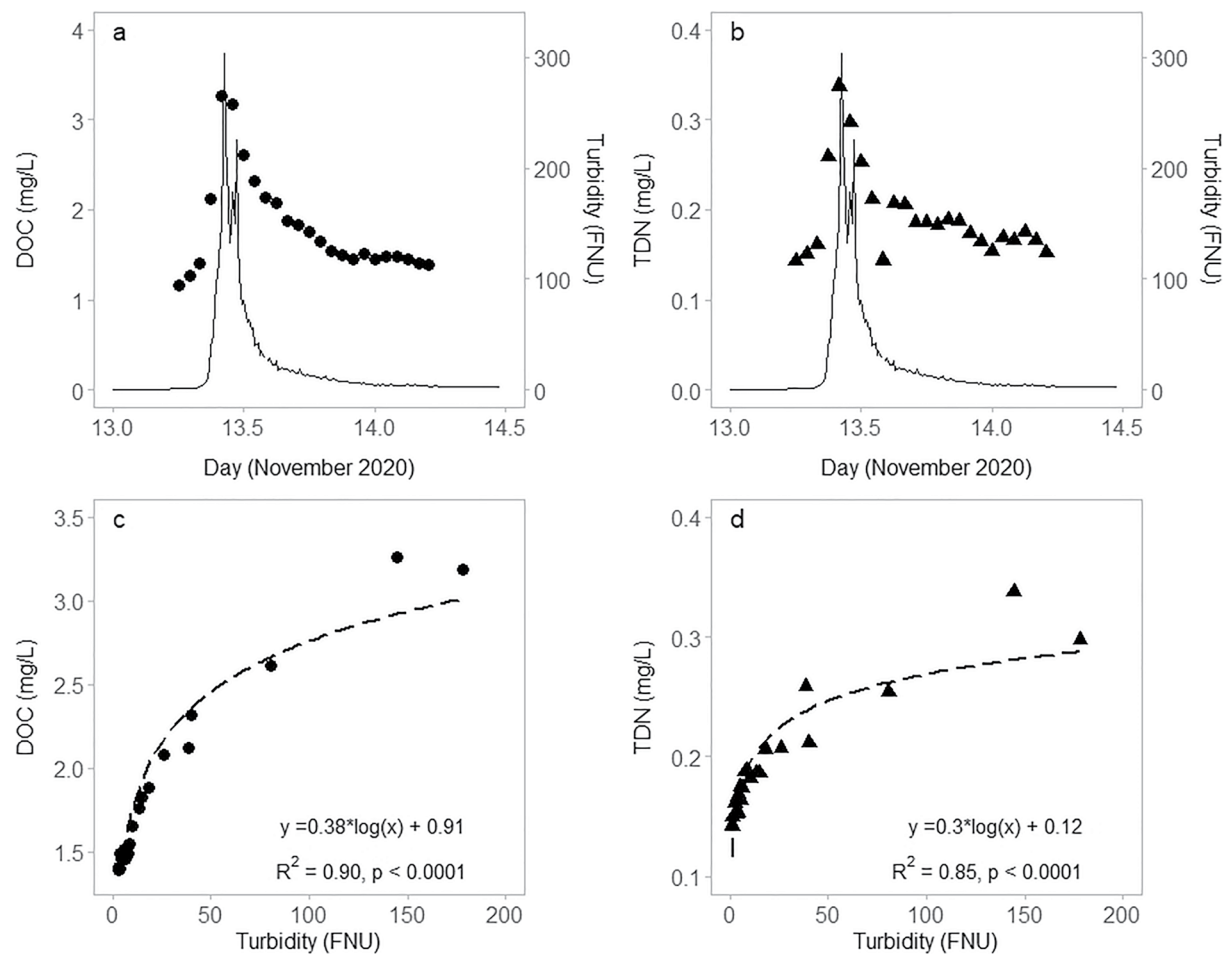
Figure 2. Time series of dissolved organic carbon (DOC) and total dissolved nitrogen (TDN) with turbidity (a and b) and x-y relationships between DOC and TDN with turbidity (c and d) for Simmonds Creek. Equivalent plots for the remaining sites are available in Supporting Information S1.

composition was explored through constrained ordination (redundancy analysis, Table S3 in Supporting Information S1). Collectively, burn severity explained ∼30% of DOM composition among the sampling locations while hydrological parameters were not significant ($p > 0.05$). The large proportion of unexplained variability highlights the complex spatio-temporal controls on DOM mobilization to streams immediately following fire activity.

4. Discussion

4.1. Post-Fire Controls on Stream Water Quality

Wildfires significantly impact water quality by altering water pathways and the transport of organic nutrients to streams. In the monitored McKenzie River sub-catchments, DOC concentrations peaked during the storm around ∼3 mg C/L. In contrast, peak TDN concentrations were more variable and related with burn severity. More severely burned catchments (Elk Creek and Simmonds Creek) peaked at ∼0.3 mg N/L whereas less severely burned catchments (Gate Creek, Marten Creek, and Bear Creek) peaked at ∼1.1 mg N/L. The DOC and TDN were each tightly coupled with turbidity (Figures 2c and 2d and comparable figures in Supporting Information S1). It is characteristic in the Western Cascades that with incoming precipitation, primary nutrient sources shift from deeper groundwater to subsurface pathways through organic rich surface horizons, which can lead to elevated nutrient concentrations (Hood et al., 2006; Tague et al., 2008). However, wildfires are destructive to surface organic layers and inhibit water infiltration into soils through pore clogging and increased surface hydrophobicity, leading to elevated surface runoff in streams in the short-term following fire activity (Cerdà & Robichaud, 2009). Thus, the tight coupling of DOC and TDN with turbidity at these sites suggest the elevated
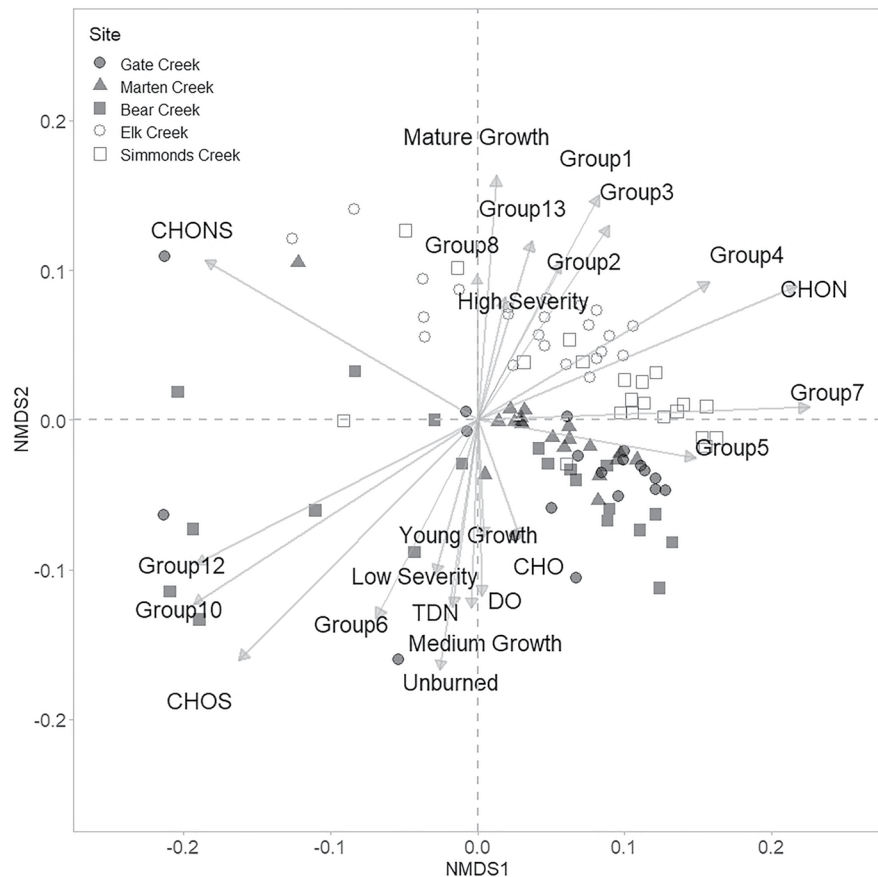
Figure 3. Nonmetric multidimensional scaling (NMDS) analysis, illustrating the spatial distribution of dissolved organic matter quality throughout the McKenzie River catchments that were impacted by the Holiday Farm Fire. Fourier transform ion cyclotron resonance mass spectrometer (FTICR-MS) groups are defined in more detail in Table S2 in Supporting Information S1. Arrows for environmental parameters, watershed characteristics, and FTICR-MS related parameters represent correlation coefficients with each NMDS axis and are scaled to fit the axis range.

concentrations observed are most likely derived from mobilized surficial materials generated from post-fire runoff and erosion.

While DOC concentrations increased during the storm, concentrations were comparatively low with respect to regional observations for unburned forests in the region. For example, DOC concentrations typically exceed 6 mg C/L at peak flow during autumn storms in neighboring WS10 within HJ Andrews Experimental Forest (van Verseveld et al., 2009), located approximately 40 km from our burn sites. The lower observed DOC can be explained by the loss and transformation of surface soils to more refractory charred materials during the wildfire, which leaves a less soluble pool of OC available to streams post-fire (Bostick et al., 2018; Santín et al., 2016). While we recognize a directly comparable reference site is not available for this study, the lower DOC concentrations compared to historical records for the region are consistent with other studies that report lower stream DOC concentrations post-fire (Rodríguez-Cardona et al., 2020; Santos et al., 2019).

For TDN, the lower concentrations in the more severely burned catchments were unexpected. It is often reported that N concentrations peak following severe fire activity, which is often attributed to increased nitrification and mineralization of soil organic N (Knoep & Swank, 1993). However, these processes are complex and often depend on a series of factors including the severity of the fire, time since fire, and the location of the fire within the proximity to a steam (Rust et al., 2019; Wan et al., 2001). Ammonium for example, can increase significantly in soil layers post fire, however, a significant response in streams may be dependent on source location and transport mechanisms (Knoep & Swank, 1993; Rust et al., 2019). Additionally, processes that stimulate peak nitrate production can take months after a fire before a significant response is observed (Covington & Sackett, 1992)

with nitrate often reported to peak around 1–2 years post-fire (Bladon et al., 2008; Santos et al., 2019). We note that our study was conducted roughly 1 month following the Holiday Farm Fire, and thus we suspected that our observations for TDN is reflective of severe transformations in surface organic horizons that leave less nitrogen available for transport to the streams immediately post-fire (Boby et al., 2010). This hypothesis should be confirmed with future studies that more directly quantifies nutrient concentrations in streams post-fire in relation to availability in surface soils.

4.2. Post-Fire Controls on DOM Composition

At each of the five streams sampled, DOM composition measured by FTICR-MS was largely decoupled from DOC concentration shifts. Contrary to the observed DOC concentrations, the proportion of CHO and CHON type compounds showed no clear temporal trends and were not correlated with turbidity at any of the sites (Figure S4 in Supporting Information S1). Similarly, when assigning FTICR-MS molecular formula into groups based on perceived DOM functionalities (see Section 2.3), these groups also showed no clear hydrogeological trends at any of the sites (Figure S5 in Supporting Information S1). Admittedly, these trends were largely unexpected. DOM compositional trends are often well correlated with DOC across hydrological gradients as sources shift from DOC poor groundwater at baseflow to aromatic DOC rich sources mobilized from surficial pathways at peak flow (Stutter et al., 2012). Molecular scale trends in small streams identified by FTICR-MS further link the flushing of highly aromatic compounds from surficial pathways during storm events (Wagner et al., 2019). In fire impacted systems, the export of pyrogenic materials following a wildfire is also linked with hydrological processes (Myers-Pigg et al., 2017; Roebuck et al., 2018; Wagner et al., 2015). As observed in the present study, however, short-term impacts of fire within the catchment add significant complexity to the interpretation of DOM transport processes across hydrological gradients at each site. This is consistent with other studies, for example, that have also reported a decoupling of bulk DOC and fire-impacted DOC export (Myers-Pigg et al., 2017; Roebuck et al., 2018). Pyrogenic materials can easily be redistributed following a fire, and precipitation is a key driver in this process (Bellè et al., 2021; Masiello & Berhe, 2020; Moody & Martin, 2001). Our results strongly support through linkages with turbidity that DOC is made available for transport in this post-fire system through the dissolution and mobilization of particles via surface runoff, which has been observed in other systems where storm pulses contribute to increased DOC through dissolution of particles transported during rain events (Jung et al., 2014). As the storm in the current study represent the first major flush, occurring roughly 1 month following the Holiday Farm Fire, we suspect the heterogeneity of easily redistributed charred materials mobilized to the stream likely explain the significant degree of DOM compositional complexity and decoupling with bulk DOC concentration in this system.

Despite the high degree of temporal complexity observed at each of the five streams, when assessed holistically across the whole sample set, we found that DOM composition was most reflective of spatially distinct catchment features. NMDS analysis based on the DOM molecular formula revealed all samples collected throughout the storm were split into two clusters that represent a clear separation based on forest stand and burn severity within each catchment (Figure 3). Simmonds Creek and Elk Creek notably cluster together differentiating themselves as a region within the burn perimeter where the high proportion of mature forest stands was likely a catalyst for more severe fire activity. As such, these sites saw elevated proportions of highly aromatic and polycondensed aromatic molecular formula in addition to elevated proportions of N-containing compounds. These observations are in comparison to the remaining three sites (Gate Creek, Marten Creek, and Bear Creek) whose molecular make-up was elevated in less aromatic (e.g., unsaturated aliphatic) type compounds. It is important to note the contrast for this group where burn severity was relatively less severe in these catchments (Table S1 in Supporting Information S1). The observed spatial differences in DOM composition however are consistent with our expectations based on the known evolution of pyrogenic organic matter chemistries along temperature gradients, most specifically with the generation of polycyclic aromatic hydrocarbons at high temperatures in addition to the release of more soluble and bioavailable byproducts at lower temperatures (Bostick et al., 2021; Masiello, 2004; Norwood et al., 2013; Wagner et al., 2018). Previous studies have indicated, for example, that highly aromatic compounds account for up to 60% of the functionality in sediments impacted by high burn severities (Knicker et al., 2006; Mastrolonardo et al., 2015; Miesel et al., 2015; Nave et al., 2011). Furthermore, the increase in N-containing molecular formulae at higher temperatures can also be explained via this temperature evolution as amide-N can be directly converted into pyrogenic nitrogen. Coupled with the selective loss of unstable carbonaceous species (e.g., cellulose) at higher combustion temperatures, charred materials will often have a lower C:N

ratio compared to their original source material (Knicker, 2010). This is further transcribed into the dissolved phase where elevated N-containing compounds have been observed in high temperature char leachates compared to the leachates of lower temperature chars (Wozniak et al., 2020).

Collectively, our results suggested that the spatial complexity in burn characteristics (e.g., burn severity) and catchment physiography masked the influence of hydrological gradients on the quality of DOM delivered to streams. For instance, redundancy analysis showed that burn severity alone explained ∼30% of the variability in DOM composition. Comparatively, hydrologically related indices (e.g., turbidity) were not significantly related to DOM composition. The composition of eroded material from catchments burned at high severity are often preferentially enriched with pyrogenic carbon (Abney et al., 2019) and the heterogeneity of this pyrogenic material is likely a primary factor in the quality of DOM leached and transported in these streams during storm events. Catchment geomorphology, including soil type and slope steepness, as well as climatic variables (e.g., aridity) can further dictate the redistribution and transport of pyrogenic material post fire (Abney et al., 2019; Bellè et al., 2021; Rust et al., 2019). We emphasize that the close proximity of our sampling locations allows us to study fire related controls on stream DOM quality outside of these typical geomorphological constraints. Thus, these results highlight that at localized scales absent of major geomorphological variations, burn severity is a major control on the quality of DOM available and delivered to streams post-fire.

5. Implications

The data presented suggest a complex interplay across spatial and temporal scales that govern the quality of organic materials delivered to streams immediately following a wildfire. The fate of pyrogenic materials is directly linked with its first interactions with the hydrological cycle (Masiello & Berhe, 2020) and the ease of redistribution and composition of pyrogenic materials are directly related with burn characteristics following a fire (Abney et al., 2019; Cotrufo et al., 2016). Our results highlight this transferability into organic materials solubilized and delivered to streams post-fire. DOC concentrations were strongly linked with hydrological processes and the delivery of surface particles during the storm, yet the composition delivered was strongly governed spatially by burn severity among sampled catchments. As wildfires burn larger areas and become more severe in the Western United States (Abatzoglou et al., 2021), concerns over the quality of DOM delivered to streams post-fire will continue to increase. For instance, the interactivity of highly aromatic compounds generated at high burn severity with heavy metals and pollutants can pose challenges for downstream water quality (McIntyre & Guéguen, 2013; Yamashita & Jaffe, 2008). Furthermore, the high variability in pyrogenic constituents generated across burn severities may have significant short- and long-term implications for aquatic hydrobiogeochemical processes. Highly aromatic compounds are strong light attenuators and can have significant implications for instream autotrophic activity (Cory et al., 2015; Creed et al., 2018; Zhang et al., 2007), whereas pyrogenic materials generated at low temperatures can be more directly utilized in microbial mediated processes in-stream (Myers-Pigg et al., 2015; Norwood et al., 2013). Finally, the incorporation of fire impacts in multiscale models to make a predictive understanding of disturbances on terrestrial to aquatic hydrobiogeochemical processes requires short- and long-term analyses. Studies on the hydrological transport of DOM and dissolved PyOM in burned watersheds typically occur long after the first storm flush event (Myers-Pigg et al., 2017; Roebuck et al., 2018; Wagner et al., 2015) at which point pyrogenic materials have become more directly integrated in soil structures and export becomes disconnected from time since fire within the catchment (Ding et al., 2013). The high spatio-temporal variability in DOM composition observed following the Holiday Farm Fire highlights a significant short-term complexity in aquatic biogeochemical responses post-fire that likely evolves with ecosystem recovery and time since fire. Thus, to better represent disturbance impacts on aquatic biogeochemical cycles in multiscale models, future efforts should continue to address the immediate response of DOM chemistries in fire-impacted systems while also aiming to assess the evolution of these responses with ecosystem recovery.

Data Availability Statement

All data used to support this manuscript is available in Supporting Information S1. Individual sample International Generic Sample Numbers (IGSNs) are provided in Data Set S2. A comprehensive data package that accompanies this work is freely available on ESS-DIVE (Roebuck et al., 2022).

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