

The Geochemical Impact of Wildfire and Mining on the Fourmile Creek Watershed, CO



Sarah Beganskas, Amherst College, sbeganskas12@amherst.edu; David Dethier, Williams College; Will Ouimet, University of Connecticut; Anna Martini, Amherst College; Sheila Murphy, USGS Boulder



Introduction

Abandoned mines and wildfire both have profound geochemical and geomorphic effects on a watershed. Wildfires change short-term geomorphic, hydrologic, and chemical processes, causing increased runoff and transport of sediment to streams (Swanson 1981). Mine drainage affects long-term stream chemistry by contributing acidity, heavy metals, and precipitates (Bradley 2008). However, the combined impact of these two disturbances is not well-studied. In September 2010, a severe wildfire burned 26 km² of the Fourmile Creek catchment in the Colorado Front Range, followed several months later by a large storm event (Murphy and Writer 2011). Located in the Colorado Mineral Belt, the area was historically mined for gold and is still affected by mine drainage and the erosion of tailings (Murphy et al. 2000). This study examines how the combined disturbances of wildfire and mining affect water chemistry in this watershed.

Site Description

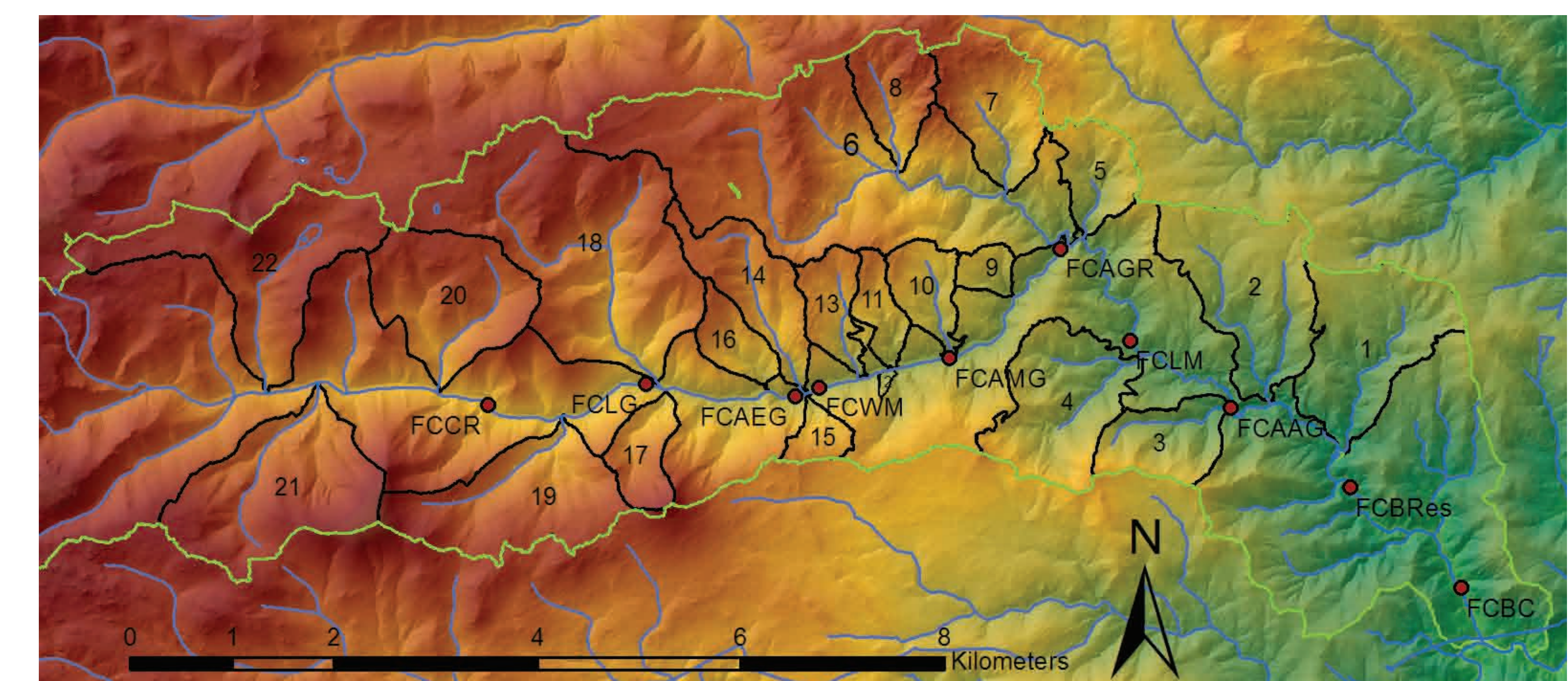


Figure 1. Top: Map of Fourmile Creek (outlined in green), the watersheds of all sampled tributaries, and sample sites along Fourmile Creek (red bullets). Right: Fourmile Creek is a major tributary of Boulder Creek. The catchment is characterized by sparse human population, forested land cover, steep slopes, and Precambrian metamorphic and granitic bedrock (Murphy et al. 2000).

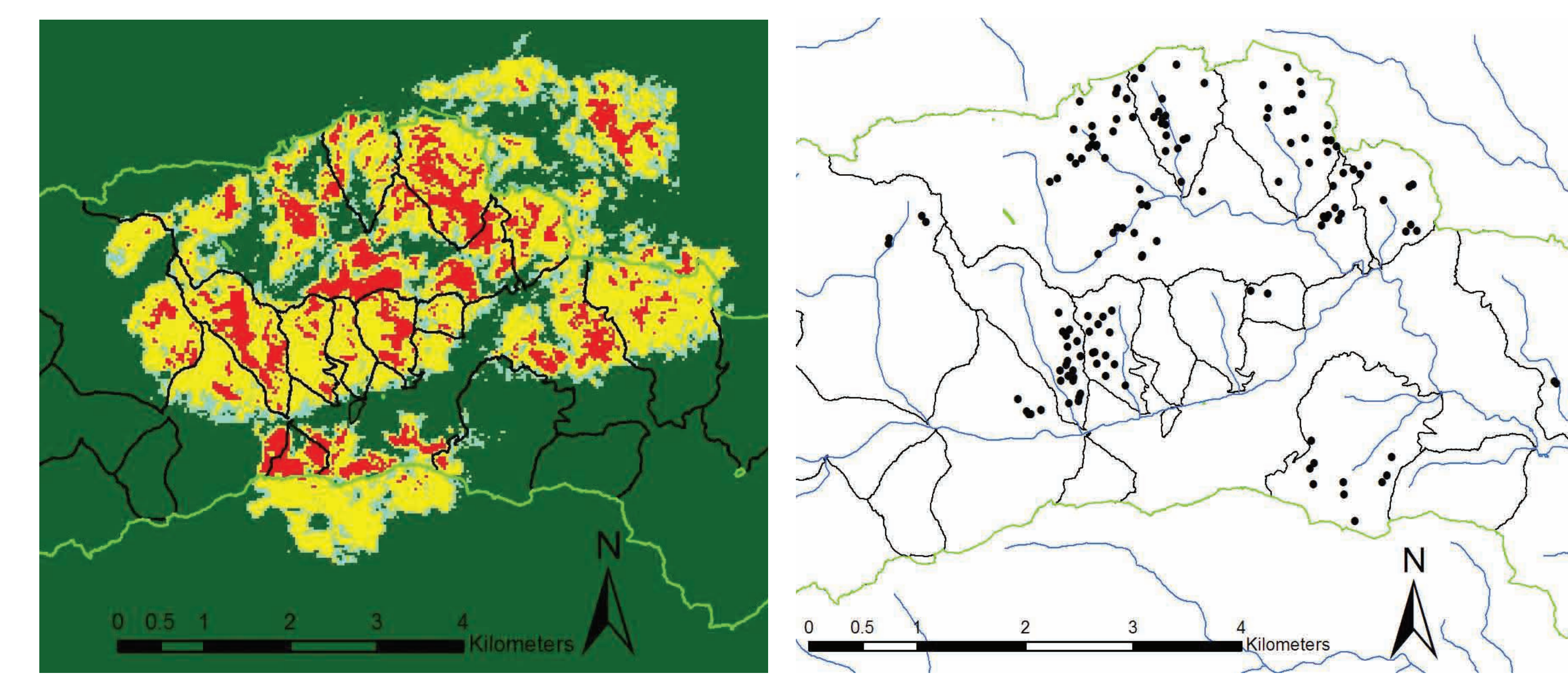


Figure 2. Left: Map of burn intensity calculated using differenced Normalized Burn Ratio (dNBR). Dark green = unburned, light green = low, yellow = moderate, red = high. Right: Map of mines and tailings in tributary watersheds.

Tributary Water Chemistry

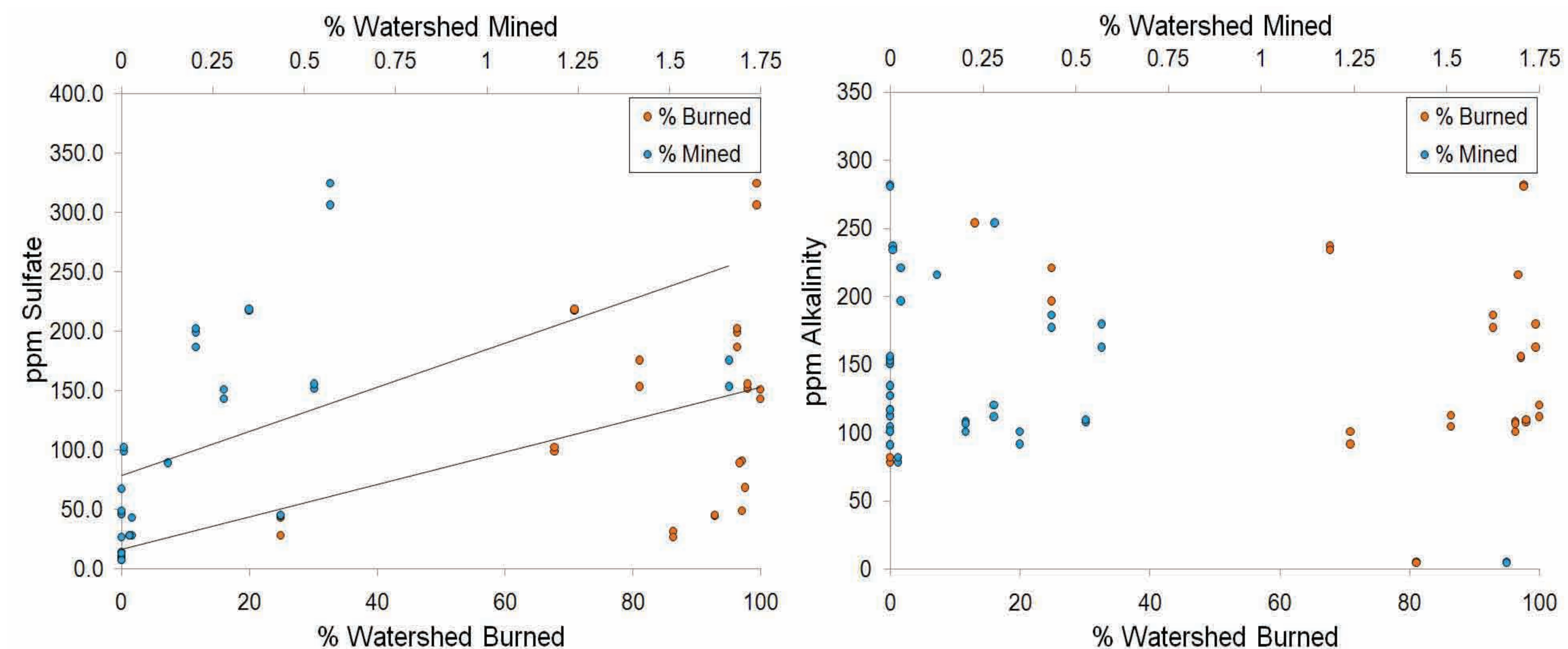


Figure 3. Left: SO₄²⁻ concentrations had a positive correlation with fire intensity, as did those of many other solutes (Ca²⁺, K⁺, Mg²⁺, Na⁺, NO₃⁻, F⁻, and SiO₂). The degree of mining disturbance correlated with only SO₄²⁻. Right: Alkalinity did not correlate with either fire intensity or mining disturbance.

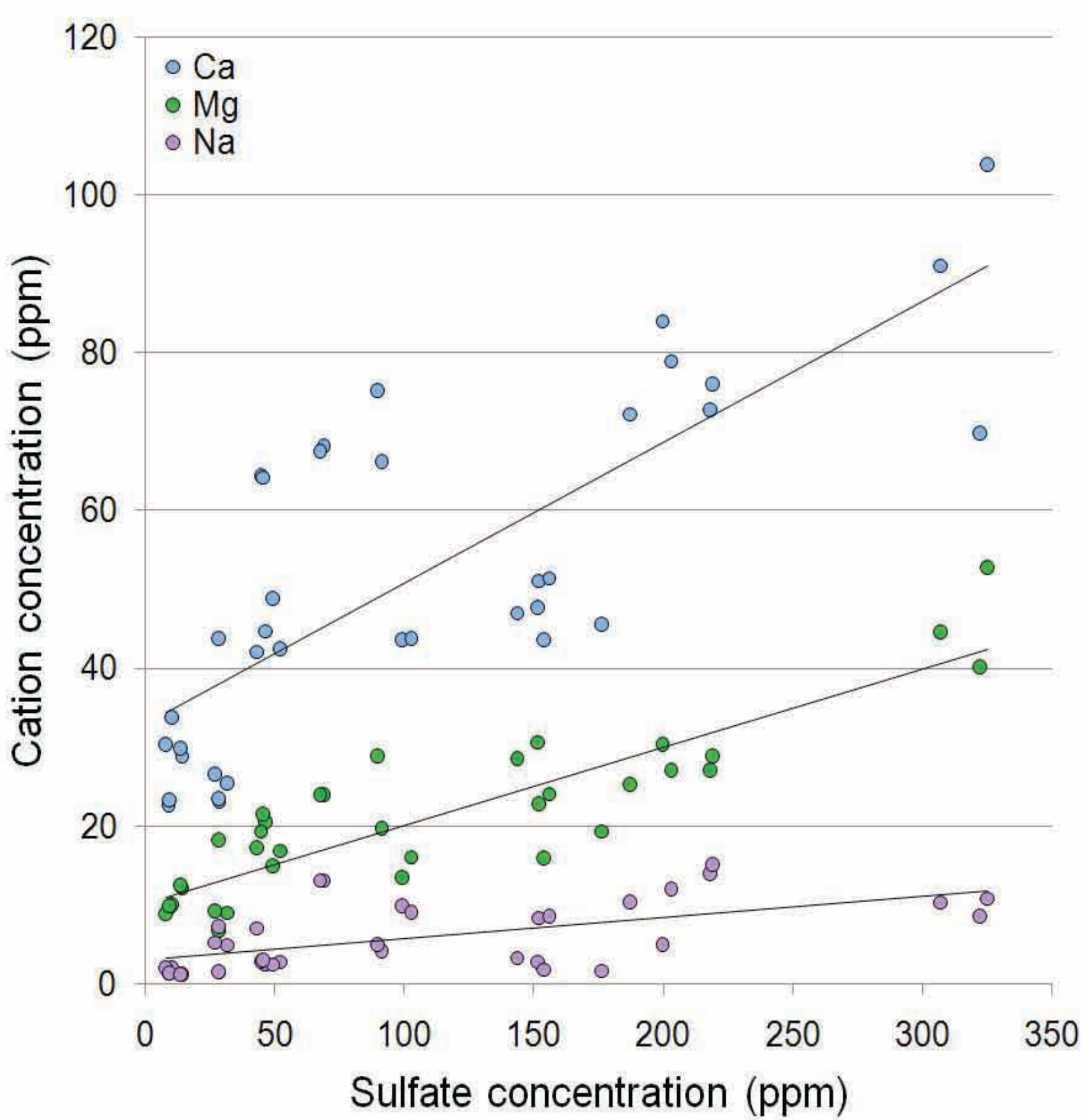


Figure 4. Concentrations of major cations in tributary streamwater correlated with concentrations of SO₄²⁻, but not with other anions.

Fourmile Creek Water Chemistry

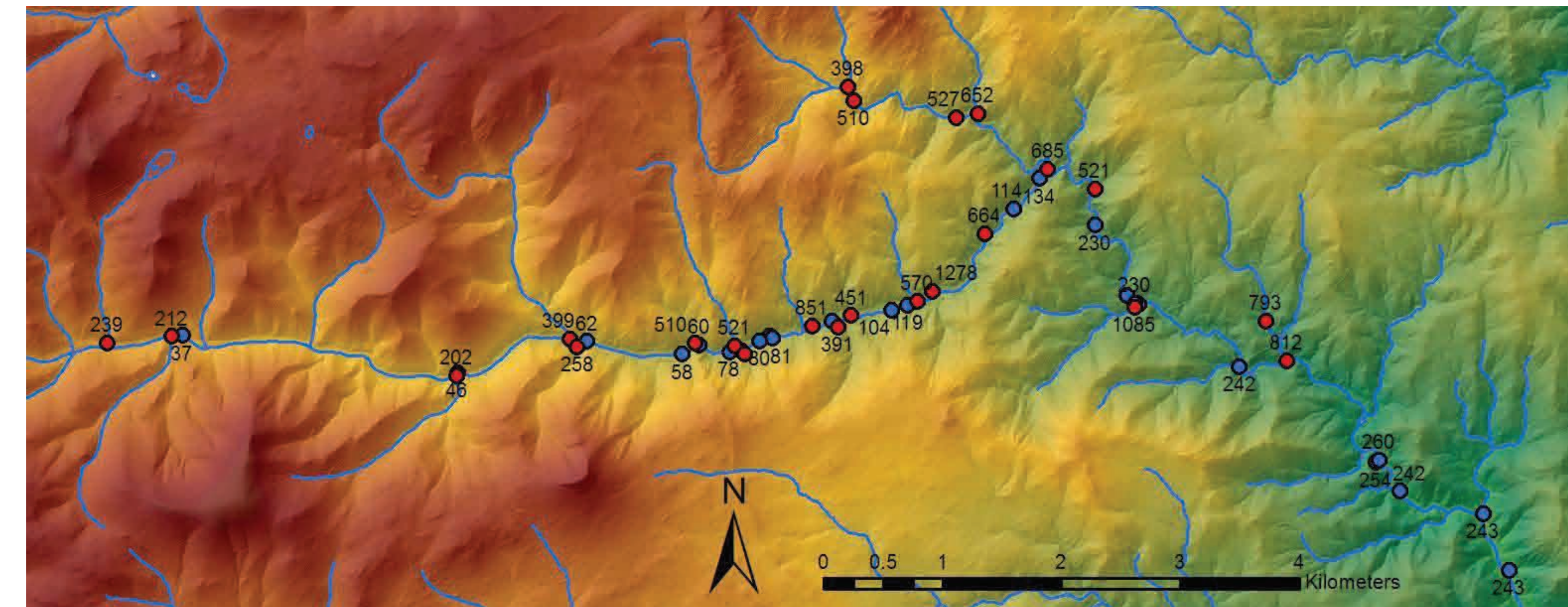


Figure 5. Map of conductivity measurements taken along Fourmile Creek (blue bullets) and at the mouths of tributaries (red bullets). Fourmile conductivity increases downstream, with a notable increase after input from its largest and most developed tributary. Tributary conductivity correlated with burn intensity but not with mining disturbance.

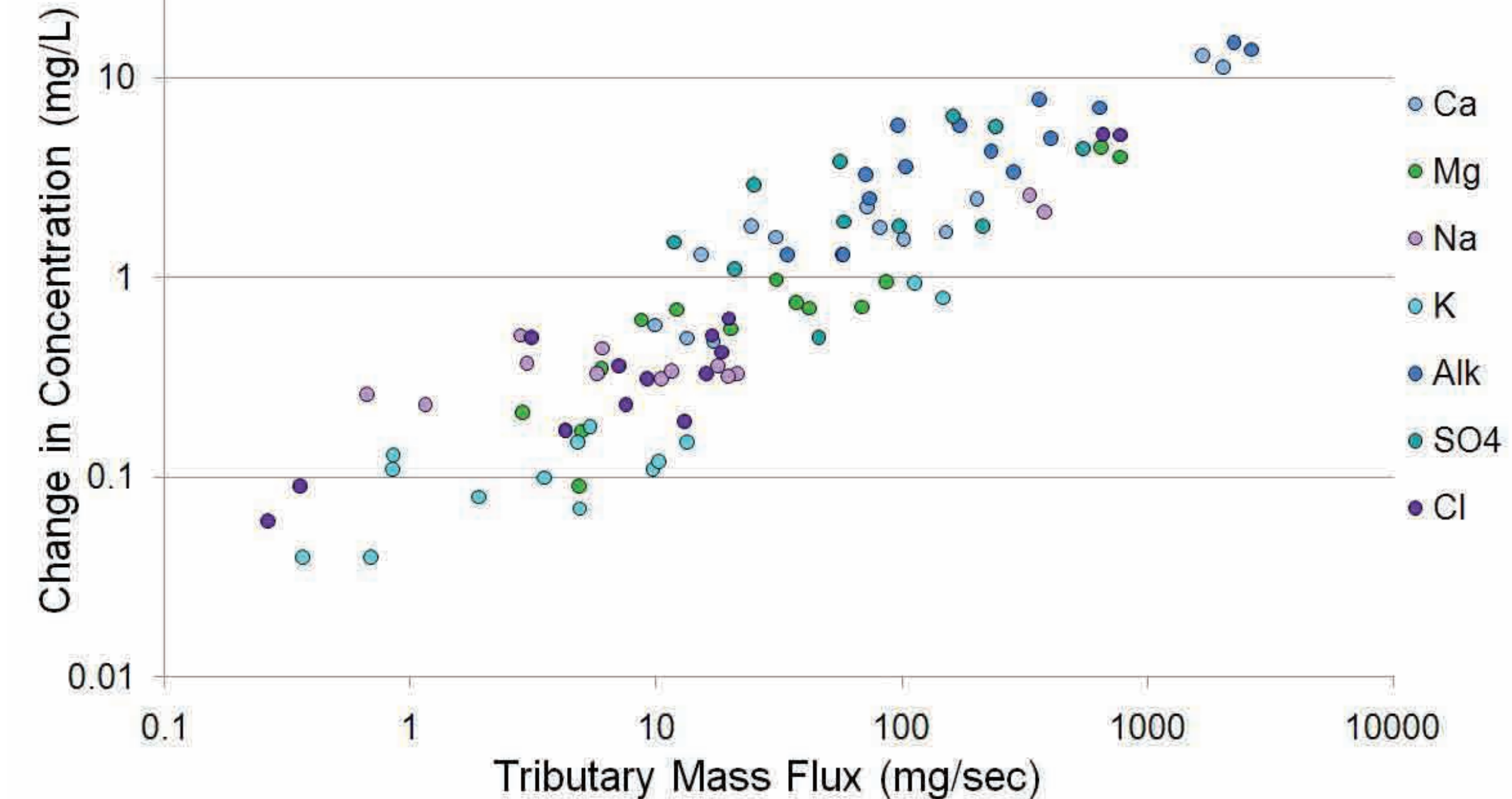


Figure 6. The mass flux of tributary input between sampling sites for each major ion (the sum of the ion's mass fluxes for all tributaries entering between sites) plotted against the change in concentration for each ion between sites. There is a strong positive correlation for every ion considered.

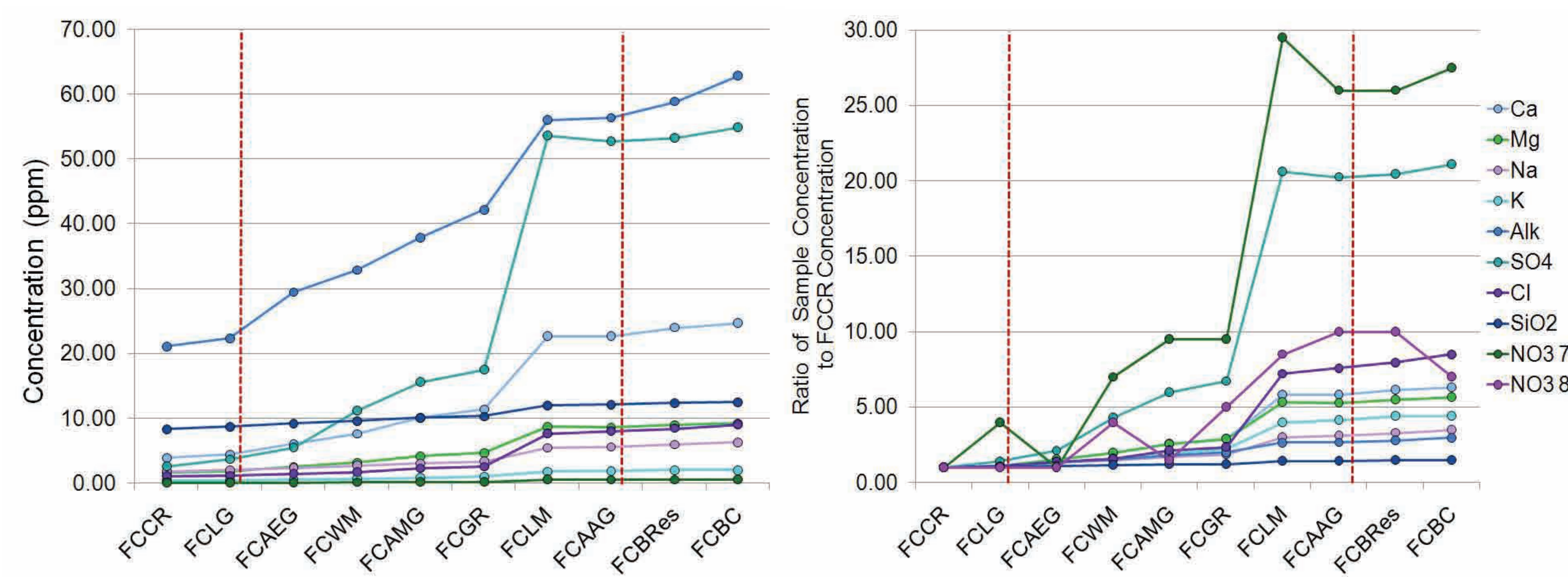


Figure 7. Left: Concentrations of solutes downstream along Fourmile Creek on the first sampling date. Red dashed lines indicate the burned area. The concentrations of all solutes except NO₃⁻ increased continually downstream, with a dramatic increase at site FCLM, just after input from Gold Run. Not all solutes increase at the same rate, causing the relative abundance to change downstream. Patterns were similar for all solutes on the second date. Right: Concentrations of solutes on the first date plotted as a ratio to upstream, undisturbed concentrations at site FCCR. Patterns were similar on the second date, except for NO₃⁻, which is plotted for both dates.

Discussion and Conclusion

- The chemistry of water samples collected from Fourmile Creek and its tributaries reveals the influence of fire and mining disturbance to the catchment.
- Burned watersheds had an average sulfate concentration that was 621% greater than unburned watersheds, which is greater than commonly observed after wildfire (Smith et al. 2011). This is likely due to the additional disturbance of mining.
- While most reported water chemistry impacts of fire and mining are additive, mining increases acidity and wildfire increases alkalinity. Interestingly, neither of these well-documented responses was observed.
 - In this area, mine drainage does not contribute much acidity, because carbonate in the ore-bearing veins can buffer the acid, producing HCO₃⁻ and Ca²⁺ (Murphy et al. 2000).
 - The lack of increase in alkalinity in burned watersheds may be due to the opposing effect of acidity produced from mine drainage or because the baseline alkalinity concentration in the area is high, and contribution from the fire did not make a significant difference.
- The concentration of nitrate was greater in burned watersheds, but in Fourmile Creek the concentrations were also responding to other, biotic factors.
- The patterns of increased concentrations downstream along Fourmile Creek seem to be controlled by input from burned and mined tributaries. Downstream changes in concentration correlated strongly with the mass fluxes of solutes entering Fourmile Creek between sampling sites. The relative abundances of many solutes are also impacted.

References

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