Electronic Supplementary Material (ESI) for Environmental Science: Processes & Impacts.

Wildland-Urban Interface Wildfire Increases Metal Contributions to Stormwater Runoff in Paradise, California

Lauren J. Magliozzi [a], Sandrine J. Matiasek [b], Charles N. Alpers [c], Julie A. Korak [a], Diane McKnight [a], Andrea L. Foster [d], Joseph N. Ryan [a], David A. Roth [e], Peijia Ku[f], Martin Tsz-Ki Tsui [g], Alex T. Chow [h], Jackson P. Webster [i*]

[a] Environmental Engineering Program, University of Colorado Boulder;
[b] Department of Earth and Environmental Sciences, California State University Chico;
[c] U. S. Geological Survey, California Water Science Center, Sacramento, CA
[d] U. S. Geological Survey Geology, Minerals, Energy, and Geophysics Science Center, Menlo Park, CA
[e] U. S. Geological Survey Water Mission Area, Boulder, CO
[f] Environmental Sciences Division, Oak Ridge National Laboratory
[g] School of Life Sciences, State Key Laboratory of Agrobiotechnology, The Chinese University of Hong Kong;
[h] Department of Forestry and Environmental Conservation, Clemson University;
[i] Department of Civil Engineering, California State University Chico

Supplemental Information

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1. Methods

1.1. Sampling Locations and GIS data sources

Detailed references for GIS are also in the references at the end of the SI. Land use characteristics were obtained from the California Department of Conservation (2022a) “Butte County Important Farmland”. Burned structures were identified and mapped using CAL Fire (2020) “Camp Fire Structure Status Map”, and mines were identified with the California Department of Conservation (2022b) “mines online”.

Table S1 provides the GPS coordinates for each sampling location.

Table S1. Longitudes and latitudes of sampling sites. The horizontal datum is WGS 84.

Watershed	Sub Location	Longitude	Latitude
Clear Creek	-	-121.64573	39.642124
Butte Creek	-	-121.70885	39.725599
Big Chico Creek	-	-121.77818	39.768971
Dry Creek	-	-121.63368	39.622116
Butte Creek	Little Butte Creek Trailer Park	-121.67986	39.740438
Butte Creek	Paul Byrne Aquatic Park	-121.61475	39.749509

1.2. Total Suspended Solids

A known volume of sample (70 to 750 mL) was filtered with 0.3 μm pre-combusted glass fiber filters (Advantec) of known weight. Filters and retained TSS were dried at 105°C for 48 h in pre-weighed aluminum sleeves to determine mass of retained TSS and calculate a TSS concentration. (Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.)

1.3. Dissolved Organic Carbon

Subsamples for dissolved organic carbon (DOC) were filtered using pre-combusted glass fiber filters (0.3 μm pore size, Advantec), acidified to pH 2 with concentrated HCl, and stored at 4°C until analysis. DOC was determined as non-purgeable organic carbon by high-temperature catalytic oxidation with a Shimadzu TOC-L. Three replicate injections (100 μL) were selected among up to five injections to maintain a coefficient of variance <2%. Reported concentrations are the mean of three injections corrected for the instrument blank (<60 μg/L C).

1.4. Major Anions

Anion concentrations were measured using a Dionex Integrion ion chromatograph with an AS-DV autosampler. All reagents (eluent, standard) were prepared with deionized (DI) water with 18 MΩ-cm resistance or better (Milli-Q Direct 8, Millipore, USA). Ion separation used a carbonate eluent 4.5

mM Na_2CO_3/1.4 mM $NaHCO_3$ at a flow rate of 1.2 mL/min and was injected into a AG22-fast-4 µm guard column (4×30 mm) followed by a AS22-fast-4 µm separator column (4×150 mm). All sample runs included a series of check standards, blanks, and duplicates.

1.5. Major and Trace Metals

1.5.1. Analysis performed at University of Colorado Boulder

Alkali and alkaline earth metals, assumed to be representative of major cations (Ca, K, Mg, Na) and major and trace metals (Al, Co, Cr, Fe, Mn, Ni, Pb, Zn) were analyzed in 140 water samples by inductively-coupled plasma mass spectrometry (ICP-MS) at the University of Colorado Boulder. Samples for filter-passing metals and major elements analysis were filtered with 0.45 µm cellulose acetate filters within 48 h of collection. Unfiltered and filtered 125 mL subsamples were acidified to 3% HNO_3 (trace metal grade) and stored at 4°C in low-density polyethylene bottles. Total metal samples (i.e., unfiltered) were acid-heat digested (3% HNO_3, 65°C oven, 12 h) then filtered with 0.45 µm cellulose acetate filters. Particulate concentrations were obtained by subtracting filter-passing concentration from total concentration.

Elemental analysis was performed using an Agilent 7900 ICP-MS with high matrix introduction. Either helium or hydrogen gas was used in a collision cell to reduce molecular ion interferences. All samples and standards were prepared in 3% nitric acid (HNO_3). Internal standardization (Agilent 5188-6564) was conducted by continuous addition before sample introduction (recovery 70-130%). Samples with internal standard recovery outside of the accepted range were diluted and reanalyzed. The instrument was tuned and calibrated daily. The initial calibration was verified using an independent standard (recovery 90-110%). Quality control samples were measured every 10-15 samples, including continuous calibration verification (recovery 90-110%), continuous calibration blank (less than method reporting limit), and spectral interference check (recovery 85-115%). Analytical duplicates and matrix spikes were analyzed every 10-15 samples (relative percent difference < 20%, spike recovery 75-125%, respectively). Additional analytical details on gas modes for each element, tune modes, RF power settings, and gas flow rates are provided in Table **S2**–Table **S4**).

Hardness (as mg/L $CaCO_3$) was used to calculate EPA aquatic life criteria when applicable and was calculated in Equation S1. Concentrations of Ca and Mg are in mg/L.

$$Hardness = \frac{[Ca]}{1000} \times 2.497 + \frac{[Mg]}{1000} \times 4.118 \qquad \textbf{Eqn. S1}$$

Method settings for the elemental analysis are summarized in Table **S2**. The instrument was auto tuned with a 10-ppb tuning standard (Agilent 5188-6564) in 3% HNO_3 solution before each batch. Two gas modes were analyzed sequentially with a stabilization period between each one. Table S3 summarizes the acquisition parameters for each element. The concentration of lead was calculated as the sum of three masses (206, 207, and 208). Method detection limits were calculated following EPA method 6020b (EPA, 2014). A spectral interference standard was a mixture of Interference Check Solution A (Agilent 5188-6526) and Interference Check Solution B (SPEX CL-INT-B1) that had the final concentrations shown in Table S4. Matrix spikes were prepared targeting a spiked concentration at least 50% of the unfortified concentration.

1.5.2. Analysis Performed at U.S. Geological Survey, Boulder, Colorado

Major cations were analyzed using a Perkin Elmer Optima 5300 inductively coupled plasma-optical emission spectroscopy (ICP-OES) and trace elements and rare earth elements were analyzed using a Perkin Elmer Nexion 300Q inductively coupled plasma-mass spectrometry (ICP-MS). Sample results represent the mean of triplicate analysis and checked with quality control samples (QC) that represented approximately 50% of the analysis run. QC for both ICP-OES and ICP-MS analyses consists of calibration standards, blanks, interference standards, blanks spike, and standard reference materials including National Institute of Standards and Technology 1645d, Environment and Climate Change Canada, USGS T standards T201, T205, T209, T213, T215, T219, T221, T223, T227, T231, T233, M206, and M220. Rare earth standards include PPREE and SCREE in addition to several of the USGS T standards previously listed. Elements were calibrated using between 4 and 7 standards for most elements and detection limits were calculated for the run based on n = 18 blanks. More information and the analytical methods for both major cations and trace elements and rare earth elements are described in detail in Roth, et al. 2022.

Table S2. Instrument tune parameters for each gas mode measured sequentially.

Gas Mode	**He**	**H_2**
Tune Mode	Auto	Auto
RF Power (W)	1600	1600
Dilution gas (L/min)	0.26	0.26
Auxiliary gas (L/min)	0.9	0.9
Cell gas flow rate (mL/min)	5.0	6.0
Energy discriminator (mV)	3.7	3.7

Table S3. Data acquisition parameters and method detection limits for each element.

Name	Gas Mode	Analyte Mass	Integration Time (s)	ISTD Mass	Method Reporting Limit (µg/L)
Na	He	23	0.3	45	100
Mg	He	24	0.3	45	30
Al	He	27	0.3	45	10
K	He	39	0.3	45	400
Ca	H_2	40	0.3	45	10
V	He	51	0.3	45	1
Cr	He	52	0.3	45	3
Mn	H_2	55	0.6	45	0.1
Fe	H_2	56	0.6	45	10
Co	He	59	0.6	45	0.1
Ni	He	60	0.6	72	0.5
Cu	He	63	0.6	72	1
Zn	He	66	0.9	72	2
As	He	75	1.2	72	1
Se	H_2	78	1.2	72	2
Cd	He	111	0.3	115	0.1
Ba	He	137	0.3	159	0.5
Tl	He	205	0.3	209	0.5
Pb	He	208	0.3	209	0.3
U	He	238	0.3	209	0.1

Table S4. Elemental composition of spectral interference check solution.

Element	Concentration (ppb)
Cl	80,000
Ca	12,000
Fe, Na	10,000
Al, K, Mg	4,000
Ti	80
Co, Cr, Cu, Mn, Ni, V	40
As, Cd, Se, Zn	20
Ag	10

1.6. Total Mercury (THg)

Water samples for analysis of total Hg were collected in acid-cleaned 500-mL fluorinated ethylene propylene (FEP) bottles and transported on ice. Samples were completely oxidized for analysis of THg.[36] Samples were quantified for Hg with a cold-vapor atomic fluorescence spectrometer (Brooks and Rand Model III; USEPA Method 1631E, U.S. EPA, 2002).

2. Results

2.1. Water Quality Statistics

This section reports the aggregate statistics for the water quality, including bulk water measurements (Table S5) total mercury (Table S6), and elemental analysis (Table S7). Table S8 reports the percentage of each element that was above the method detection limit (MDL).

Table S5. Overview of dissolved organic carbon (DOC), total suspended solids (TSS), nitrate, sulfate, and pH results for each watershed and end-member sites.

		Aquatic Park	Big Chico Creek			Butte Creek			Clear Creek			Dry Creek			Little Butte Creek Trailer Park
Parameter			Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	
DOC	n =	2	31			43			34			19			2
	(mg/L)	0.80, 0.73	2.06	0.55	5.89	1.80	0.38	4.68	4.61	1.48	11.8	4.49	1.29	9.16	3.73, 2.73
TSS	n =	1	9			11			12			13			1
	(mg/L)	187	14.5	1.00	112	12.7	1.87	436	34.8	2.81	315	257	1.32	699	78.6
Anions	n =	1	24			34			28			14			1
Nitrate (N)	(mg/L)	3.91	0.020	0.00	1.43	0.682	0.044	2.46	2.57	0.346	8.19	1.90	0.105	5.67	4.59
Sulfate	(mg/L)	1.29	1.53	0.00	6.00	2.04	0.880	5.86	3.33	1.69	10.6	7.79	0.730	14.1	68.9
pH	n =	2	24			36			26			14			2
		7.13, 7.81	7.61	6.85	8.12	7.56	6.87	9.46	7.63	6.99	8.29	7.38	7.05	7.66	7.18, 7.25

Table S6. Summary of total Hg results for watersheds Big Chico Creek, Butte Creek, Clear Creek, and Dry Creek. The number of samples (Tot n=) as well as the median (med), minimum (min), and maximum (max) concentrations are reported for each watershed.

	Big Chico Creek			Butte Creek			Clear Creek			Dry Creek		
Total n =	8			8			9			13		
	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max
THg (ng/L)	2.06	1.29	5.70	7.32	1.52	93.0	3.09	0.870	11.6	51.2	2.04	665

Table S7. Overview of major and trace metals for watersheds Big Chico Creek, Butte Creek, Clear Creek, and Dry Creek and end-member sites Paul Byrne Aquatic Park and the Little Butte Creek Trailer Park. The number of total metals samples (Total n), filtered metals samples (Filter-passing n), as well as the median (med), minimum (min), and maximum (max) concentrations for both total and filter-passing (Filter) fractions are reported.

	Aquatic Park			Big Chico Creek			Butte Creek			Clear Creek			Dry Creek			Little Butte Creek Trailer Park		
Total n =	4			27			39			28			18			1		
Filter-passing n =	4			30			41			34			19			2		
Element	**Med.**	**Min**	**Max**	**Med.**	**Min**	**Max**	**Med.**	**Min**	**Max**	**Med.**	**Min**	**Max**	**Med.**	**Min**	**Max**	**Med.**	**Min**	**Max**
Ca (Total)	4920	3420	7300	8160	5404	16300	10300	558	24400	15200	3640	23300	15900	9140	22000	28100	28100	28100
Ca (Filter)	4090	2920	5530	7870	4560	15800	9490	5110	14100	14500	7120	22700	12600	6180	20300	17700	12000	23400
K (Total)	542	598	127	662	477	1490	630	17.5	1200	1870	203	4560	1690	76.6	2500	2840	2840	2840
K (Filter)	721	475	1030	660	415	1600	739	454	1460	1930	1050	4280	1610	853	2430	1930	1520	2340
Mg (Total)	2640	1790	3140	4670	2940	9430	5050	256	7360	8300	1990	12000	8390	4800	12400	8740	8740	8740
Mg (Filter)	2320	1610	2740	4450	2360	9090	4740	2480	6170	8210	3750	12000	8030	3060	11800	6640	5530	7760
Na (Total)	2610	1890	2920	4080	2210	15700	3380	933	5740	7080	1460	8430	5270	2560	7440	4570	4570	4570
Na (Filter)	2374	1710	2950	4100	2000	15300	3510	1770	4710	6700	2970	9500	5440	2080	6920	3850	3720	3990
Al (Total)	2690	610	5000	166	5.99	2300	733	8.12	10900	532	8.40	10300	1480	11.5	14200	2670	2670	2670
Al (Filter)	21.7	9.99	69.7	21.6	3.37	145	36.1	3.27	153	85.2	6.53	528	13.94	4.87	61.73	172.8	7.82	338
Fe (Total)	1800	386	3250	125	15	1550	557	20.7	7490	528	45	10000	3670	408	27700	2470	2470	2470
Fe (Filter)	25.0	11.3	40.5	22.1	4.04	127	37.4	4.67	189	139	16.2	4030	189	18.0	456	132	6.55	257
Mn (Total)	75.0	25.7	157	8.47	1.91	85.8	31.6	2.85	307	29.8	9.56	599	192	80.5	4549	117	117	117
Mn (Filter)	6.96	1.34	16.3	1.25	0.45	3.31	2.19	0.37	10.8	5.46	0.27	552	40.16	0.36	170	10.83	5.33	16.3
Ba (Total)	42.3	20.2	68.3	5.34	3.52	23.8	10.2	1.55	69.3	32.0	8.55	78.1	57.3	22.3	254	63.8	63.8	63.8

	Aquatic Park			Big Chico Creek			Butte Creek			Clear Creek			Dry Creek			Little Butte Creek Trailer Park		
Total n =	4			27			39			28			18			1		
Filter-passing n =	4			30			41			34			19			2		
Element	**Med.**	**Min**	**Max**	**Med.**	**Min**	**Max**	**Med.**	**Min**	**Max**	**Med.**	**Min**	**Max**	**Med.**	**Min**	**Max**	**Med.**	**Min**	**Max**
Ba (Filter)	24.5	15.8	31.3	9.59	5.44	59.1	10.1	5.17	53.8	24.9	19.9	47.8	32.4	22.2	43.2	34.3	28.7	40.0
Co (Total)	1.71	0.460	3.11	0.110	0.020	4.00	0.750	0.030	55.9	0.650	0.120	9.60	4.22	0.400	27.8	2.66	2.66	2.66
Co (Filter)	0.126	0.090	0.206	0.030	0.000	0.110	0.060	0.010	3.20	0.230	0.080	8.38	0.32	0.080	0.610	0.170	0.170	0.180
Cr (Total)	5.07	1.65	10.5	1.11	0.63	8.4	3.41	0.64	59.8	3.38	0.640	55.9	8.70	0.070	40.6	12.3	12.3	12.3
Cr (Filter)	0.462	0.45	5.38	0.600	0.37	3.91	0.74	0.22	2.21	0.920	0.250	18.6	0.580	0.340	3.01	1.75	1.25	2.26
Cu (Total)	5.56	0.900	24.4	0.89	0.01	4.39	1.9	0.2	22.6	2.75	0.030	36.6	10.3	0.040	41.9	25.0	25.0	25.0
Cu (Filter)	7.96	1.78	8.94	1.46	0.22	9.17	2.96	0.41	20.2	8.49	1.55	35.5	8.17	0.910	21.3	10.9	8.28	13.5
Ni (Total)	3.78	0.85	6.98	0.900	0.27	5.14	3.26	0.39	27.6	3.96	0.840	28.4	13.4	1.05	47.9	11.3	11.3	11.3
Ni (Filter)	0.546	0.200	0.687	0.49	0.32	3.71	0.83	0.29	1.69	2.37	0.900	17.6	2.50	0.750	4.61	1.09	0.980	1.19
Pb (Total)	3.54	0.800	14.9	0.07	0.01	1.91	0.55	0.03	7.38	0.550	0.030	6.52	2.02	0.070	10.2	6.45	6.45	6.45
Pb (Filter)	0.406	0.100	0.558	0.09	0.02	3.44	0.19	0.02	0.69	0.46	0.060	2.80	0.510	0.090	2.81	0.440	0.440	0.450
Zn (Total)	189	12.7	258	8.07	3.02	166	42.3	2.99	1940	16.9	2.36	693	141	3.54	478	1080	1080	1080
Zn (Filter)	12.9	7.32	81.0	2.98	0.900	44.9	4.52	0.260	30.5	5.37	1.06	110	2.77	0.880	18.6	21.1	20.0	22.2

	Aquatic Park			Big Chico Creek			Butte Creek			Clear Creek			Dry Creek			Little Butte Creek Trailer Park		
Total n	4			27			39			28			18			1		
Filtered n	4			30			41			34			19			2		
Element	**Med.**	**Min**	**Max**	**Med.**	**Min**	**Max**	**Med.**	**Min**	**Max**	**Med.**	**Min**	**Max**	**Med.**	**Min**	**Max**	**Med.**	**Min**	**Max**
As (Total)	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	11.6	11.6	11.6
As (Filter)	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	6.82	6.82	6.82
V (Total)	10.2	2.22	12.6	4.18	2.84	9.78	4.30	2.05	21.6	11.2	2.74	33.7	21.1	3.44	49.8	13.3	13.3	13.3
V (Filter)	<MDL	<MDL	<MDL	3.35	2.05	5.97	2.28	2.01	3.53	8.48	4.08	19.3	2.47	2.04	3.68	4.97	4.15	5.79
Cd (Total)	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
Cd (Filter	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
U (Total)	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
U (Filter)	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
Tl (Total)	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
Tl (Filter)	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
Se (Total)	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
Se (Filter)	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL

Table S8. Percent of samples below the MDL for each metal in each watershed.

Metal	Sample Type	Aquatic Park	Big Chico Creek	Butte Creek	Clear Creek	Dry Creek	Little Butte Creek Trailer Park
		% of Samples Below MDL					
Al	Filter-passing	0	10	4.9	0	5.3	0
Al	Total	0	0	0	0	0	0
As	Filter-passing	100	100	100	100	100	50
As	Total	100	100	100	100	100	0
Ba	Filter-passing	0	0	0	0	0	0
Ba	Total	0	0	2.6	0	0	0
Ca	Filter-passing	0	0	0	0	0	0
Ca	Total	0	0	0	0	0	0
Cd	Filter-passing	100	96.7	100	100	100	100
Cd	Total	100	100	100	100	100	100
Co	Filter-passing	100	100	97.6	94.1	100	100
Co	Total	50	96.3	74.4	85.7	44.4	0
Cr	Filter-passing	75	100	100	97.1	100	100
Cr	Total	50	92.6	64.1	60.7	50	0
Cu	Filter-passing	25	60	41.5	8.8	10.5	0
Cu	Total	25	85.2	56.4	32.1	33.3	0
Fe	Filter-passing	100	96.7	90.2	32.4	36.8	50
Fe	Total	0	44.4	17.9	25	0	0
K	Filter-passing	0	0	0	0	0	0
K	Total	50	0	23.1	3.6	22.2	0
Mg	Filter-passing	0	0	0	0	0	0
Mg	Total	0	0	0	0	0	0
Mn	Filter-passing	0	33.3	12.2	2.9	5.3	0
Mn	Total	0	0	0	0	0	0
Na	Filter-passing	0	0	0	0	0	0
Na	Total	0	0	2.6	0	0	0
Ni	Filter-passing	100	96.7	100	76.5	63.2	100
Ni	Total	50	88.9	43.6	46.4	33.3	0
Pb	Filter-passing	100	96.7	100	97.1	89.5	100
Pb	Total	25	100	79.5	89.3	50	0

Se	Filter-passing	100	100	100	100	100	100
Se	Total	100	100	100	100	100	100
Tl	Filter-passing	100	100	100	100	100	100
Tl	Total	100	100	100	100	100	100
U	Filter-passing	100	100	100	100	100	100
U	Total	100	100	100	100	100	100
V	Filter-passing	100	3.3	48.8	2.9	31.6	0
V	Total	25	0	10.3	3.6	16.7	0
Zn	Filter-passing	0	70	48.8	26.5	73.7	0
Zn	Total	0	14.8	5.1	3.6	11.1	0

2.2. Mann-Whitney comparison tests

This section contains statistical test results for Mann-Whitney comparison tests by watershed (Table S9 and Table S11), filter cutoff (Table S10), and pre- vs. post-fire (Table S12).

Table S9. Mann-Whitney test results for watershed comparisons of non-metals

Parameter	Watershed 1	Watershed 2	p -Value
DOC	Big Chico Creek	Butte Creek	0.103
DOC	Big Chico Creek	Clear Creek	4.78E-06
DOC	Big Chico Creek	Dry Creek	7.18E-06
DOC	Butte Creek	Clear Creek	2.97E-09
DOC	Butte Creek	Dry Creek	1.44E-07
DOC	Clear Creek	Dry Creek	0.738
Hardness	Big Chico Creek	Butte Creek	0.822
Hardness	Big Chico Creek	Clear Creek	6.15E-06
Hardness	Big Chico Creek	Dry Creek	3.79E-03
Hardness	Butte Creek	Clear Creek	1.15E-09
Hardness	Butte Creek	Dry Creek	1.06E-03
Hardness	Clear Creek	Dry Creek	0.550
TSS	Big Chico Creek	Butte Creek	2.54E-04
TSS	Big Chico Creek	Clear Creek	6.75E-05
TSS	Big Chico Creek	Dry Creek	1.85E-05
TSS	Butte Creek	Clear Creek	0.654
TSS	Butte Creek	Dry Creek	0.0300
TSS	Clear Creek	Dry Creek	0.124
Nitrate	Big Chico Creek	Butte Creek	2.47E-03
Nitrate	Big Chico Creek	Clear Creek	5.11E-09
Nitrate	Big Chico Creek	Dry Creek	3.96E-04
Nitrate	Butte Creek	Clear Creek	1.95E-10
Nitrate	Butte Creek	Dry Creek	2.93E-03
Nitrate	Clear Creek	Dry Creek	3.51E-02
Sulfate	Big Chico Creek	Butte Creek	7.98E-02
Sulfate	Big Chico Creek	Clear Creek	1.98E-05
Sulfate	Big Chico Creek	Dry Creek	7.52E-05
Sulfate	Butte Creek	Clear Creek	2.29E-05
Sulfate	Butte Creek	Dry Creek	6.37E-06
Sulfate	Clear Creek	Dry Creek	6.24E-03

Table S10. Mann-Whitney test results for metals passing through filters of different size membranes.

Metal	Filter Size 1	Filter Size 2	p-Value
Al	0.22	0.45	0.015
Al	0.22	0.8	1.05E-03
Al	0.22	1.2	4.28E-04
Al	0.45	0.8	0.190
Al	0.45	1.2	0.068
Al	0.8	1.2	0.804
Co	0.22	0.45	0.505
Co	0.22	0.8	0.308
Co	0.22	1.2	0.234
Co	0.45	0.8	0.544
Co	0.45	1.2	0.467
Co	0.8	1.2	0.783
Cr	0.22	0.45	0.178
Cr	0.22	0.8	0.025
Cr	0.22	1.2	0.015
Cr	0.45	0.8	0.235
Cr	0.45	1.2	0.168
Cr	0.8	1.2	0.871
Cu	0.22	0.45	0.426
Cu	0.22	0.8	0.319
Cu	0.22	1.2	0.285
Cu	0.45	0.8	0.662
Cu	0.45	1.2	0.512
Cu	0.8	1.2	0.890

Metal	Filter Size 1	Filter Size 2	p-Value
Fe	0.22	0.45	0.118
Fe	0.22	0.8	0.012
Fe	0.22	1.2	0.010
Fe	0.45	0.8	0.167
Fe	0.45	1.2	0.198
Fe	0.8	1.2	0.818
Mn	0.22	0.45	0.739
Mn	0.22	0.8	0.452
Mn	0.22	1.2	0.396
Mn	0.45	0.8	0.610
Mn	0.45	1.2	0.528
Mn	0.8	1.2	0.782
Ni	0.22	0.45	0.797
Ni	0.22	0.8	0.544
Ni	0.22	1.2	0.409
Ni	0.45	0.8	0.661
Ni	0.45	1.2	0.526
Ni	0.8	1.2	0.782
Pb	0.22	0.45	0.068
Pb	0.22	0.8	4.16E-03
Pb	0.22	1.2	4.47E-03
Pb	0.45	0.8	0.225
Pb	0.45	1.2	0.174
Pb	0.8	1.2	0.836

Table S11. Mann-Whitney results for trace metal cross-watershed comparisons.

Metal	Total vs. Filtered	Watershed 1	Watershed 2	p-Value
Mn	Total	Big Chico Creek	Butte Creek	5.39E-03
Mn	Total	Big Chico Creek	Clear Creek	1.09E-11
Mn	Total	Big Chico Creek	Dry Creek	1.75E-06
Mn	Total	Butte Creek	Clear Creek	7.38E-09
Mn	Total	Butte Creek	Dry Creek	5.87E-06
Mn	Total	Clear Creek	Dry Creek	4.00E-03
Co	Total	Big Chico Creek	Butte Creek	5.59E-04
Co	Total	Big Chico Creek	Clear Creek	8.44E-16
Co	Total	Big Chico Creek	Dry Creek	2.07E-11
Co	Total	Butte Creek	Clear Creek	3.23E-10
Co	Total	Butte Creek	Dry Creek	4.24E-08
Co	Total	Clear Creek	Dry Creek	1.41E-01
Fe	Total	Big Chico Creek	Butte Creek	5.98E-02
Fe	Total	Big Chico Creek	Clear Creek	8.01E-12
Fe	Total	Big Chico Creek	Dry Creek	5.70E-07
Fe	Total	Butte Creek	Clear Creek	8.80E-10
Fe	Total	Butte Creek	Dry Creek	1.11E-05
Fe	Total	Clear Creek	Dry Creek	0.79
Cu	Total	Big Chico Creek	Butte Creek	5.22E-02
Cu	Total	Big Chico Creek	Clear Creek	2.09E-06
Cu	Total	Big Chico Creek	Dry Creek	1.23E-04
Cu	Total	Butte Creek	Clear Creek	8.04E-04
Cu	Total	Butte Creek	Dry Creek	5.54E-03
Cu	Total	Clear Creek	Dry Creek	0.80
Pb	Total	Big Chico Creek	Butte Creek	0.20
Pb	Total	Big Chico Creek	Clear Creek	1.28E-05
Pb	Total	Big Chico Creek	Dry Creek	7.47E-05
Pb	Total	Butte Creek	Clear Creek	2.63E-04
Pb	Total	Butte Creek	Dry Creek	1.86E-04
Pb	Total	Clear Creek	Dry Creek	0.54
Ni	Total	Big Chico Creek	Butte Creek	2.34E-04
Ni	Total	Big Chico Creek	Clear Creek	2.65E-13
Ni	Total	Big Chico Creek	Dry Creek	1.55E-09
Ni	Total	Butte Creek	Clear Creek	8.30E-14
Ni	Total	Butte Creek	Dry Creek	6.88E-10
Ni	Total	Clear Creek	Dry Creek	0.69

Metal	Total vs. Filtered	Watershed 1	Watershed 2	p-Value
Cr	Total	Big Chico Creek	Butte Creek	0.31
Cr	Total	Big Chico Creek	Clear Creek	6.97E-03
Cr	Total	Big Chico Creek	Dry Creek	0.33
Cr	Total	Butte Creek	Clear Creek	6.00E-02
Cr	Total	Butte Creek	Dry Creek	7.23E-02
Cr	Total	Clear Creek	Dry Creek	1.69E-03
Ba	Total	Big Chico Creek	Butte Creek	0.51
Ba	Total	Big Chico Creek	Clear Creek	3.96E-09
Ba	Total	Big Chico Creek	Dry Creek	3.21E-07
Ba	Total	Butte Creek	Clear Creek	1.31E-11
Ba	Total	Butte Creek	Dry Creek	6.88E-10
Ba	Total	Clear Creek	Dry Creek	1.02E-03
Zn	Total	Big Chico Creek	Butte Creek	0.29
Zn	Total	Big Chico Creek	Clear Creek	7.90E-03
Zn	Total	Big Chico Creek	Dry Creek	0.40
Zn	Total	Butte Creek	Clear Creek	3.41E-02
Zn	Total	Butte Creek	Dry Creek	0.15
Zn	Total	Clear Creek	Dry Creek	2.90E-03
Zn	Filtered	Big Chico Creek	Butte Creek	4.93E-03
Zn	Filtered	Big Chico Creek	Clear Creek	2.05E-02
Zn	Filtered	Big Chico Creek	Dry Creek	1.63E-03
Zn	Filtered	Butte Creek	Clear Creek	0.46
Zn	Filtered	Butte Creek	Dry Creek	0.20
Zn	Filtered	Clear Creek	Dry Creek	0.065
Ba	Filtered	Big Chico Creek	Butte Creek	8.36E-04
Ba	Filtered	Big Chico Creek	Clear Creek	3.58E-13
Ba	Filtered	Big Chico Creek	Dry Creek	2.33E-12
Ba	Filtered	Butte Creek	Clear Creek	6.15E-06
Ba	Filtered	Butte Creek	Dry Creek	9.03E-08
Ba	Filtered	Clear Creek	Dry Creek	2.64E-05
Cr	Filtered	Big Chico Creek	Butte Creek	1.25E-03
Cr	Filtered	Big Chico Creek	Clear Creek	0.056
Cr	Filtered	Big Chico Creek	Dry Creek	7.59E-03
Cr	Filtered	Butte Creek	Clear Creek	0.65
Cr	Filtered	Butte Creek	Dry Creek	0.37
Cr	Filtered	Clear Creek	Dry Creek	0.26
Cu	Filtered	Big Chico Creek	Butte Creek	4.24E-04
Cu	Filtered	Big Chico Creek	Clear Creek	1.03E-06

Metal	Total vs. Filtered	Watershed 1	Watershed 2	p-Value
Cu	Filtered	Big Chico Creek	Dry Creek	3.26E-06
Cu	Filtered	Butte Creek	Clear Creek	0.26
Cu	Filtered	Butte Creek	Dry Creek	0.015
Cu	Filtered	Clear Creek	Dry Creek	0.10
Pb	Filtered	Big Chico Creek	Butte Creek	3.10E-05
Pb	Filtered	Big Chico Creek	Clear Creek	7.99E-04
Pb	Filtered	Big Chico Creek	Dry Creek	6.12E-05
Pb	Filtered	Butte Creek	Clear Creek	0.54
Pb	Filtered	Butte Creek	Dry Creek	0.32
Pb	Filtered	Clear Creek	Dry Creek	0.14
Ni	Filtered	Big Chico Creek	Butte Creek	4.8E-06
Ni	Filtered	Big Chico Creek	Clear Creek	4.8E-06
Ni	Filtered	Big Chico Creek	Dry Creek	1.1E-07
Ni	Filtered	Butte Creek	Clear Creek	0.79
Ni	Filtered	Butte Creek	Dry Creek	0.016
Ni	Filtered	Clear Creek	Dry Creek	0.024
Co	Filtered	Big Chico Creek	Butte Creek	1.5E-03
Co	Filtered	Big Chico Creek	Clear Creek	5.9E-05
Co	Filtered	Big Chico Creek	Dry Creek	2.1E-08
Co	Filtered	Butte Creek	Clear Creek	0.95
Co	Filtered	Butte Creek	Dry Creek	3.0E-03
Co	Filtered	Clear Creek	Dry Creek	2.1E-03

Table S12. Mann-Whitney results for pre-fire vs post-fire data indicating statistically significant increases in every case ($p < 0.5$).

Metal	Watershed	Pre-Fire Median (ppb)	Post-Fire Median (ppb)	p-Value
Cr	Clear Creek	1.08	7.45	5.70E-03
Ni	Clear Creek	1.34	5.90	2.34E-03
Cu	Clear Creek	1.39	5.05	0.017
Zn	Clear Creek	1.15	85.4	4.25E-08
Pb	Clear Creek	0.173	0.958	0.012
Cr	Dry Creek	1.13	13.6	6.27E-03
Ni	Dry Creek	2.08	17.9	4.30E-03
Cu	Dry Creek	1.46	12.7	0.023
Zn	Dry Creek	1.11	159	1.28E-06
Pb	Dry Creek	0.123	2.69	2.36E-03

2.3. Water quality time series and phase histograms

This section contains elemental time-series measured during the sampling campaign overlaid with the Butte Creek hydrograph (Figure S1–Figure S3). Figure S4 to Figure S7 compare the time-series plots for data collected post-fire to available historical data. Figure S8 and Figure S9 show histograms of particulate and filter-passing percentages by element.

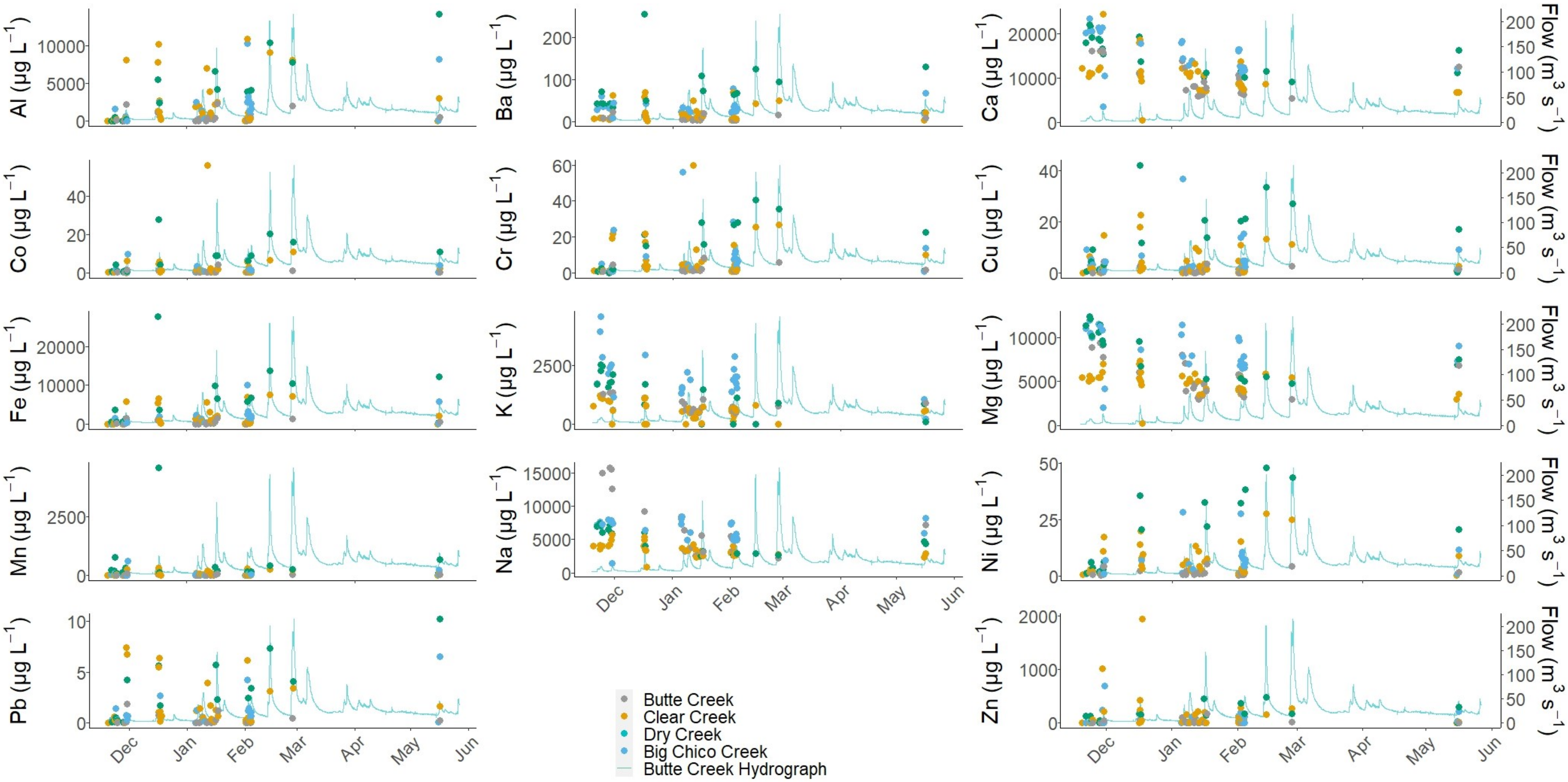


Figure S1. Time-series of total metal concentrations in each watershed overlaid with the Butte Creek hydrograph (right y-axis).

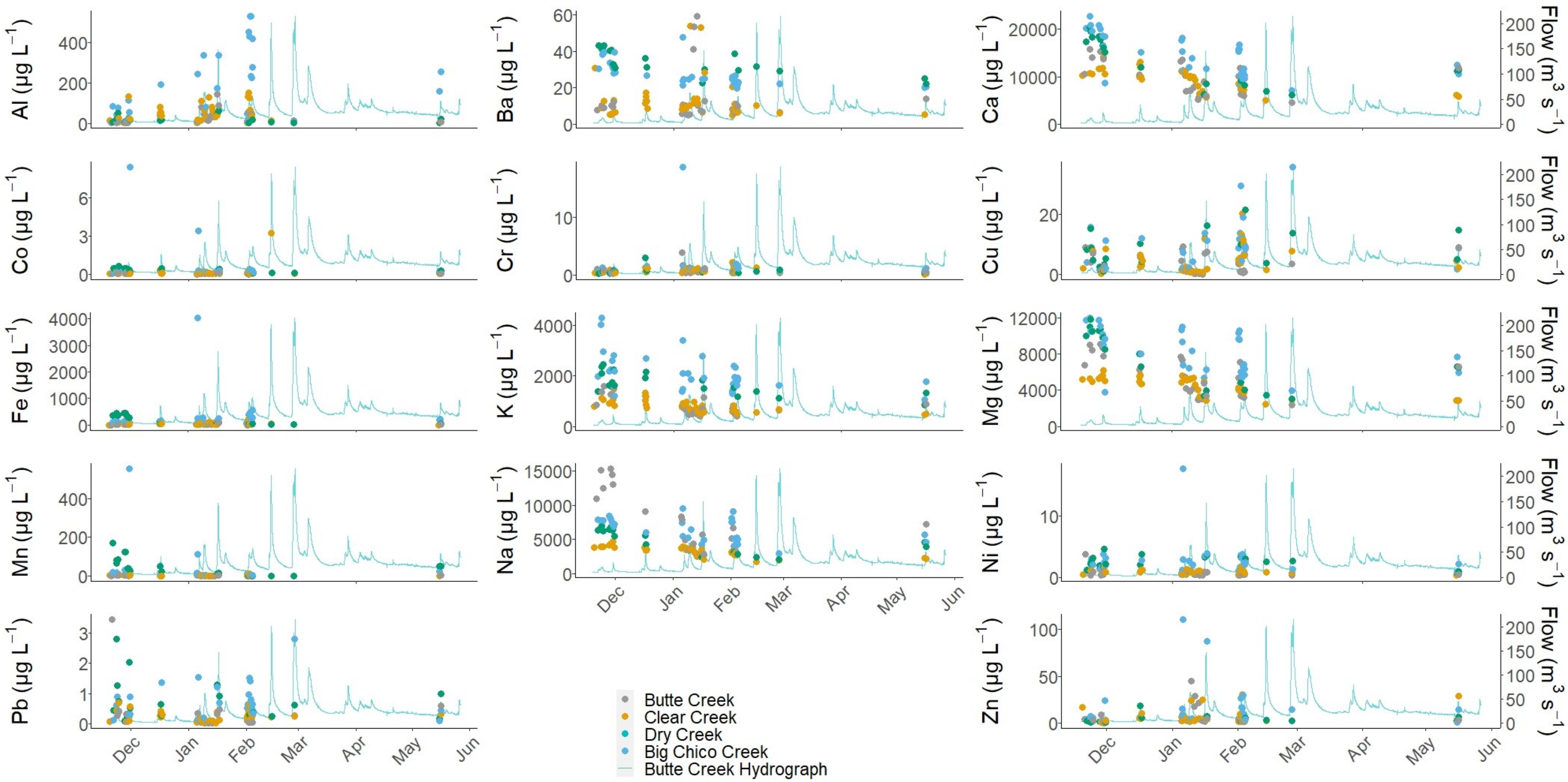


Figure S2. Time-series of filter-passing metal concentrations in for each watershed overlaid with the Butte Creek hydrograph in light blue (right y-axis).

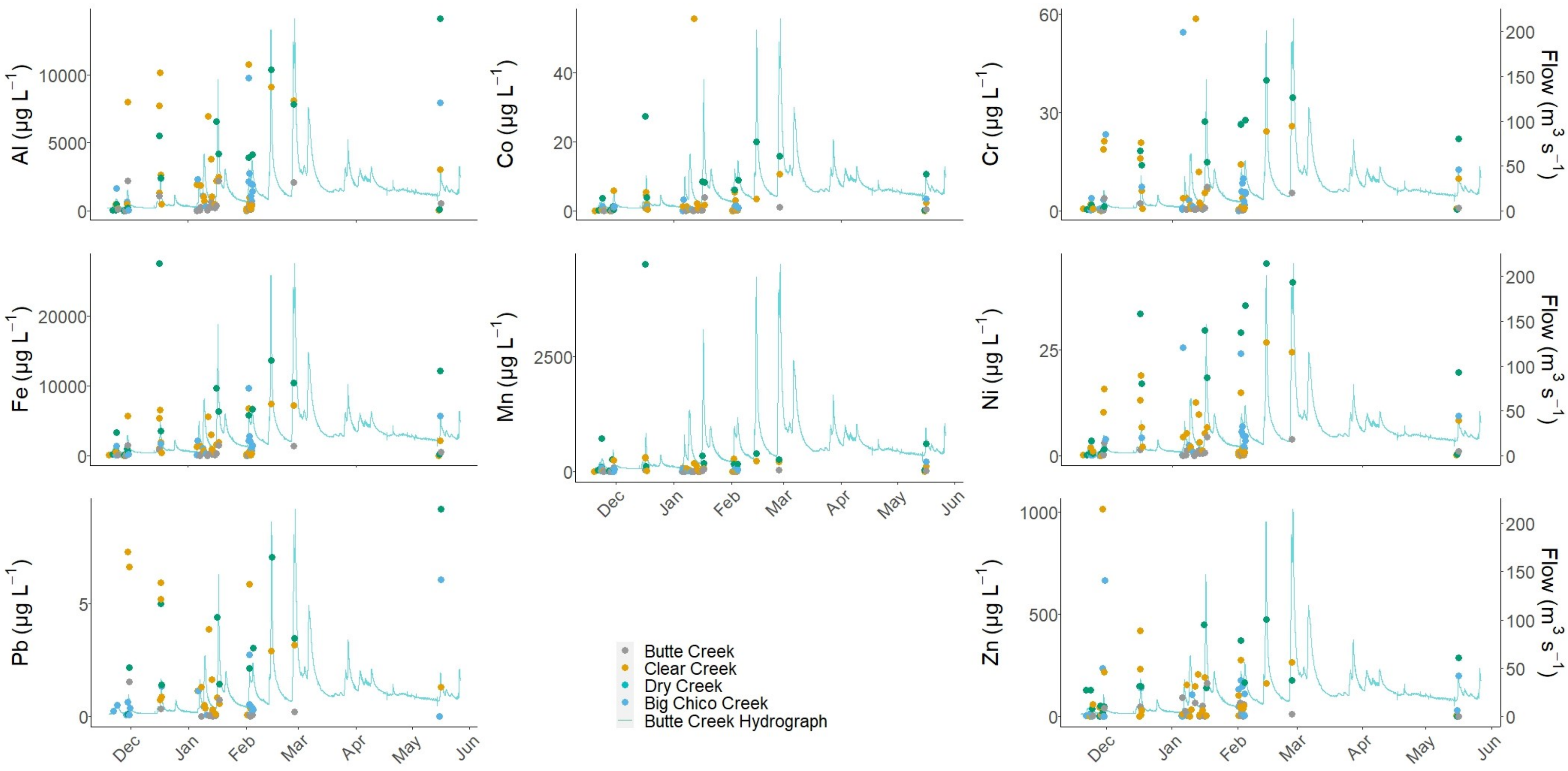


Figure S3. Time-series of particulate metal concentrations in each watershed overlaid with the Butte Creek hydrograph in light blue (right y-axis).

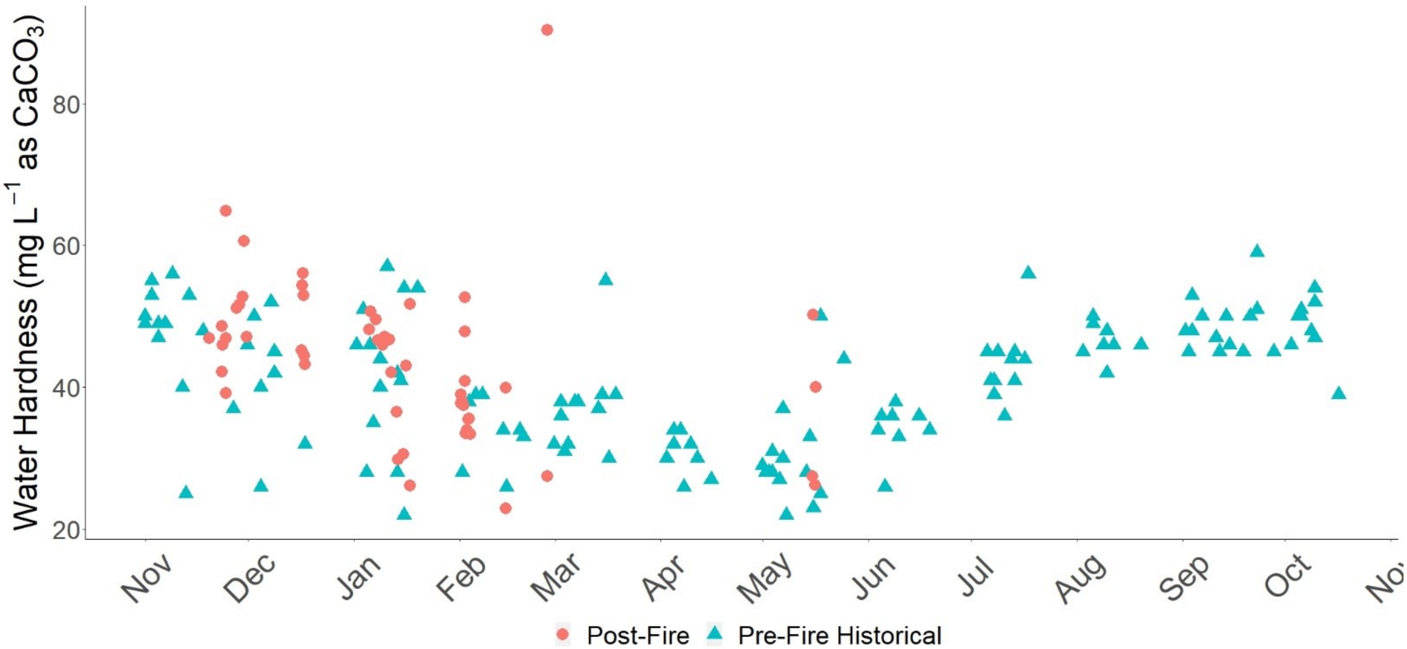


Figure S4. Pre-fire[42] and post-fire water hardness in Butte Creek.

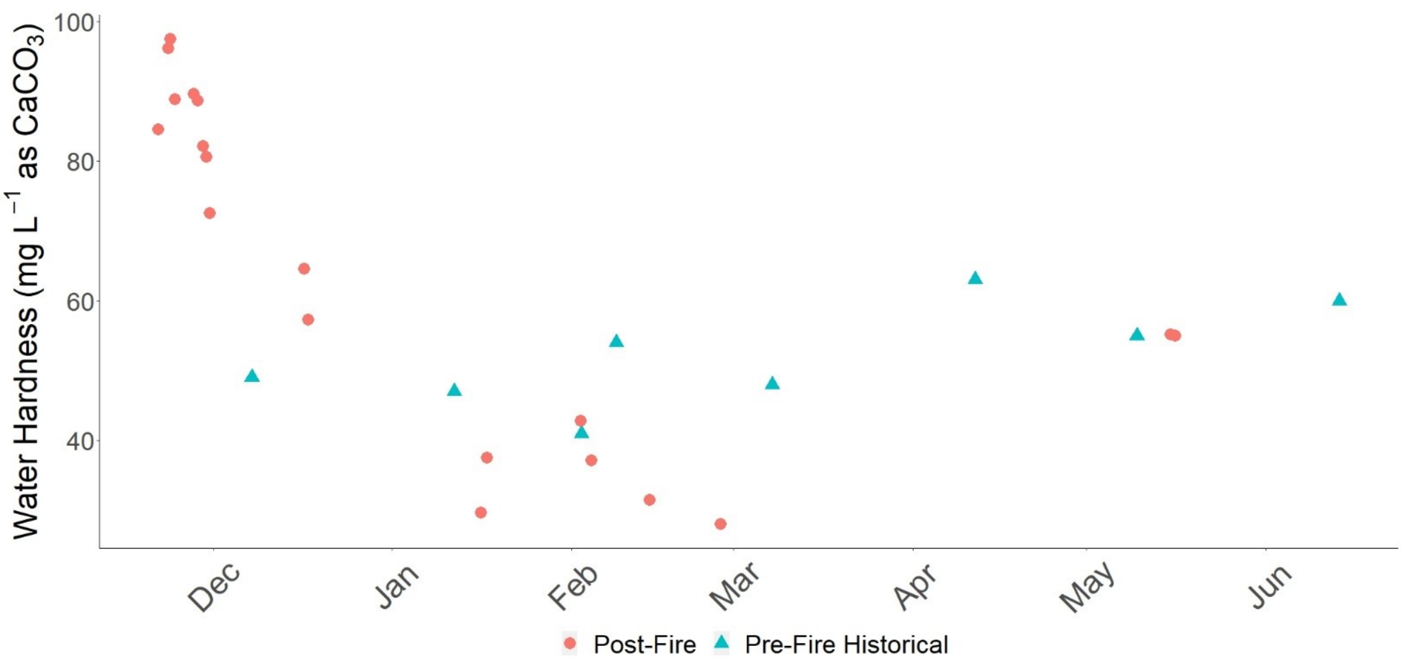


Figure S5. Pre-fire[42] and post-fire water hardness in Dry Creek.

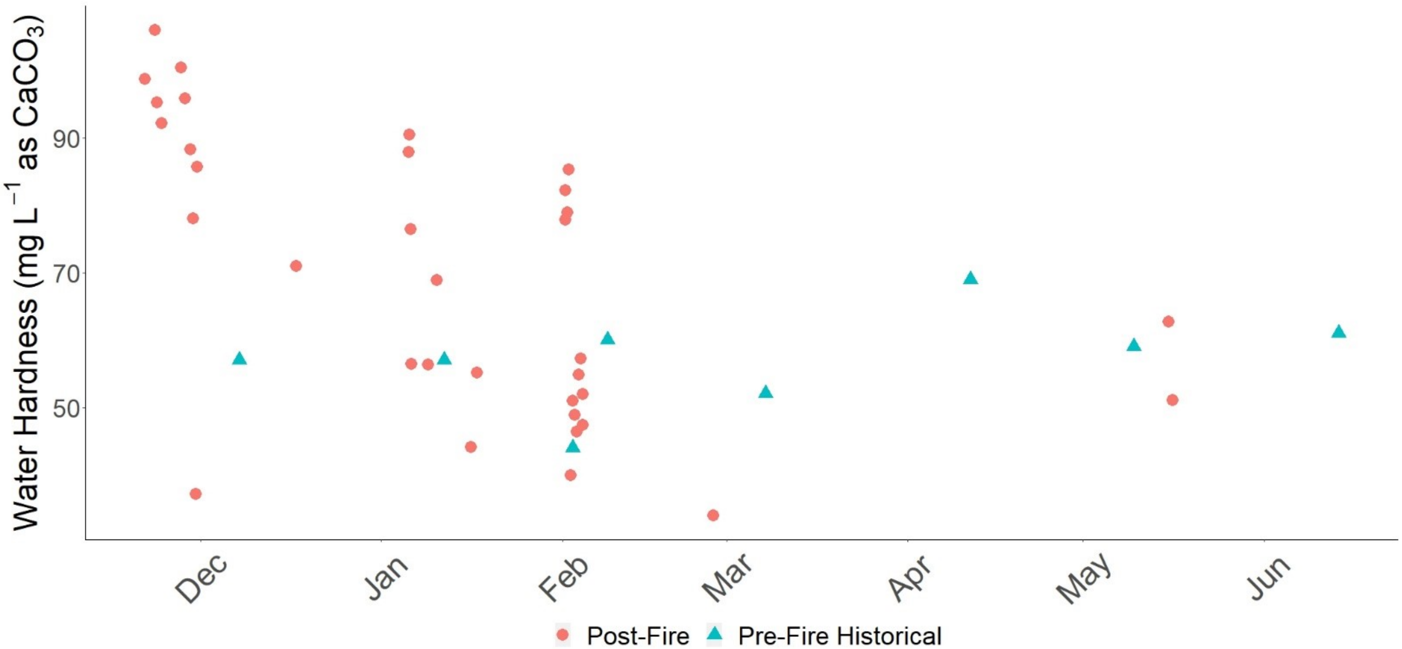


Figure S6. Pre-fire[42] and post-fire water hardness in Clear Creek.

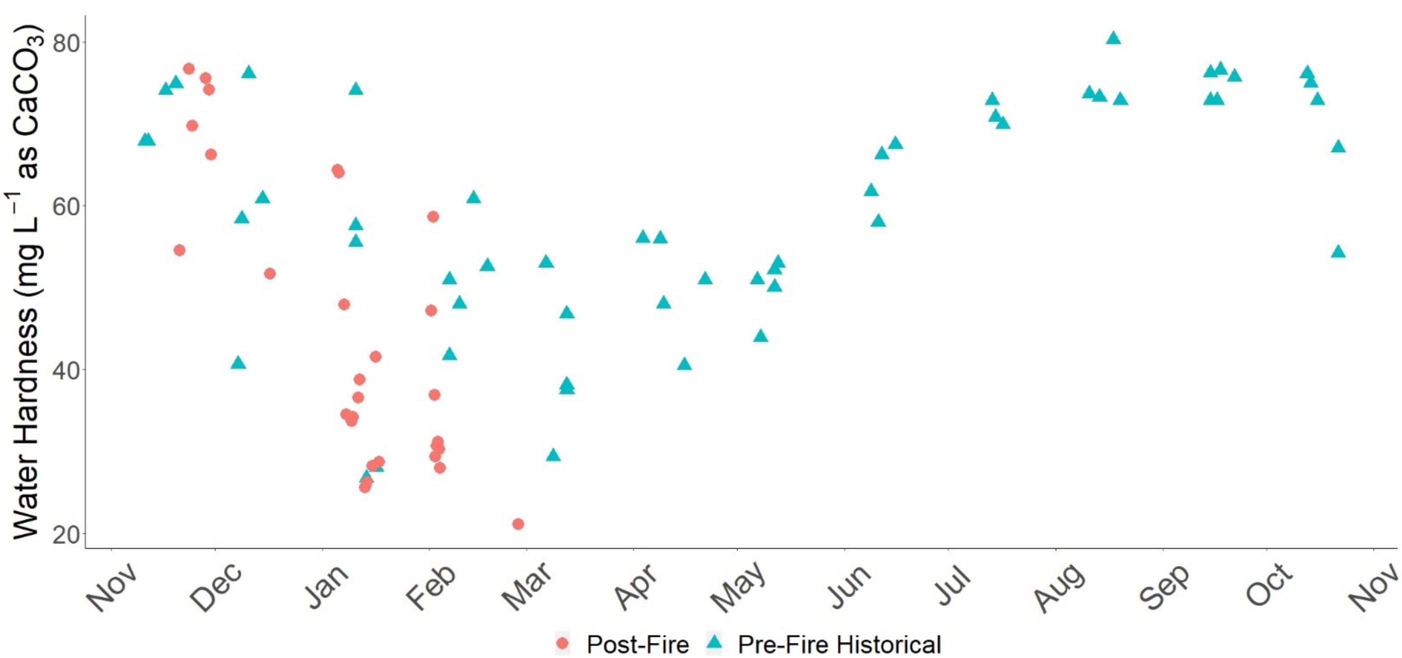


Figure S7. Pre-fire[42] and post-fire water hardness in Big Chico Creek.

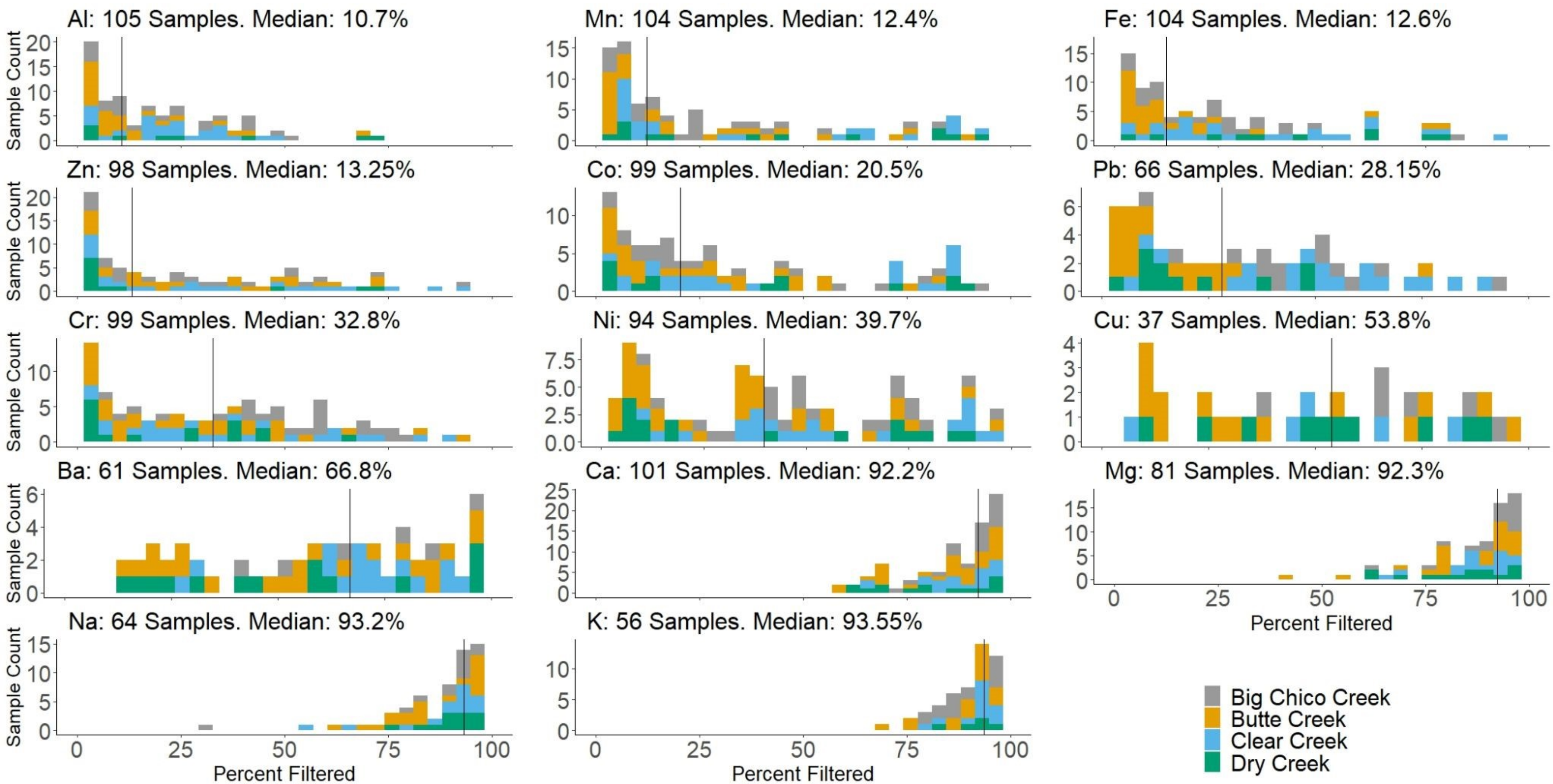


Figure S8. Histograms of number of samples plotted as percent filter-passing metal concentration (x-axis reads percent filtered for brevity) for each metal presented in the study. “Percent filter-passing" is the filter-passing concentration divided by the unfiltered concentration, expressed as a percentage. Colored bars represent watershed-specific data. The total number of samples and median percent filter-passing metal concentration are listed in the heading for each plot.

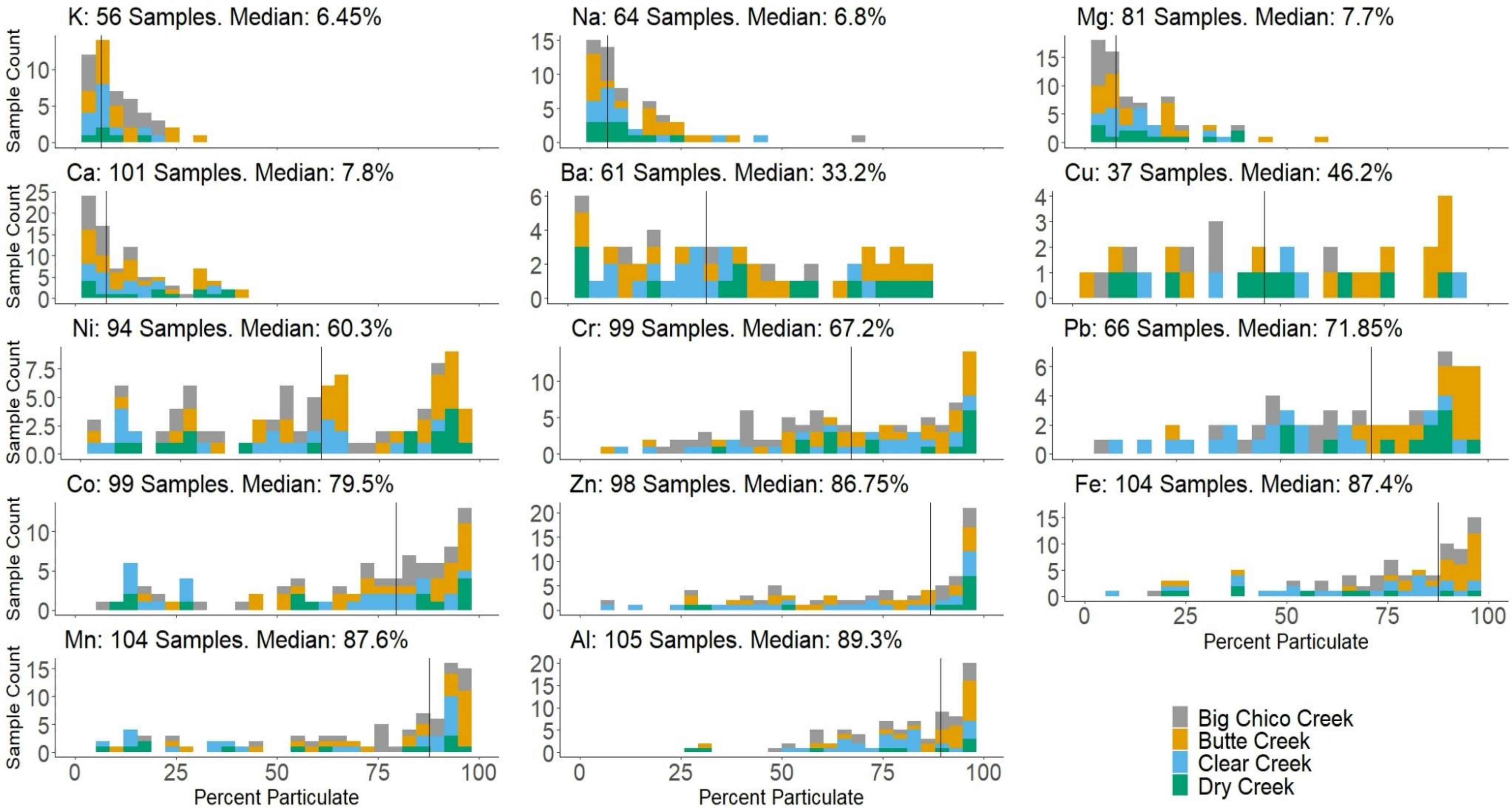


Figure S9. Histograms of number of samples grouped by percent particulate metal concentration (x-axis) calculated by subtracting measured filter-passing concentration from total concentration for available samples. The total number of samples and median percent particulate metal concentration are listed in the heading for each plot.

2.4. Spearman's rank correlations

Figure S10 to Figure S18 present heat maps of pair-wise Spearman's rank correlations. The first set compares total concentrations in all watersheds combined (Figure S10), burned watersheds (Figure S11) and the unburned reference watershed (Figure S12). The second set compares the same subsets for filter-passing concentrations (Figure S13–Figure S15), and the third set compares correlations for particulate concentrations (Figure S16–Figure S18).

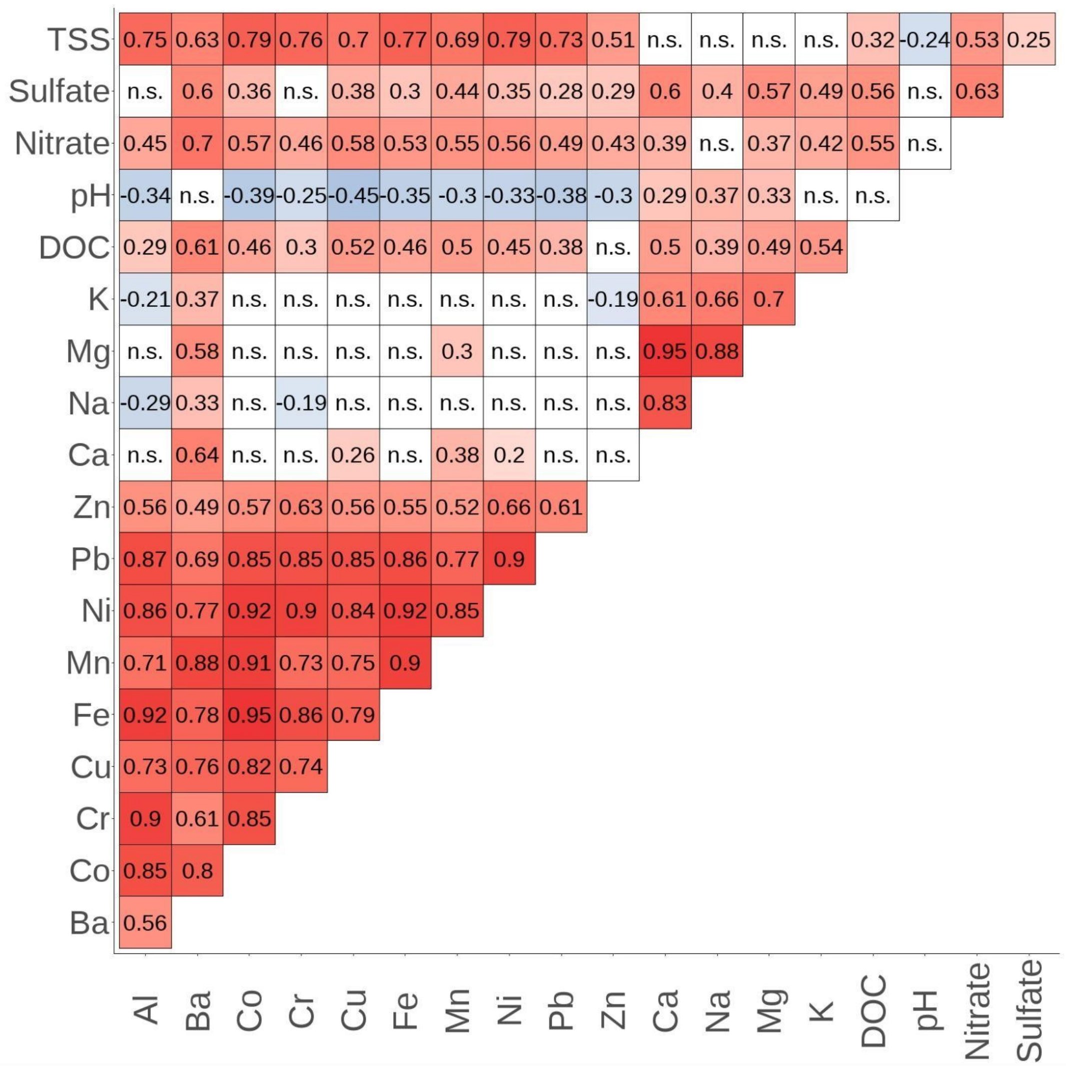


Figure S10. Heat map of Spearman correlation results for total concentrations of metals, sulfate, nitrate, DOC, pH, and TSS across all watersheds (Big Chico Creek, Butte Creek, Clear Creek, and Dry Creek). Each box contains a rho value (between -1 and 1) or is marked as not significant (n.s.). Red boxes indicate a significant positive correlation, white boxes indicate no significant correlation ($p > 0.05$), and blue boxes indicate significant negative correlation.

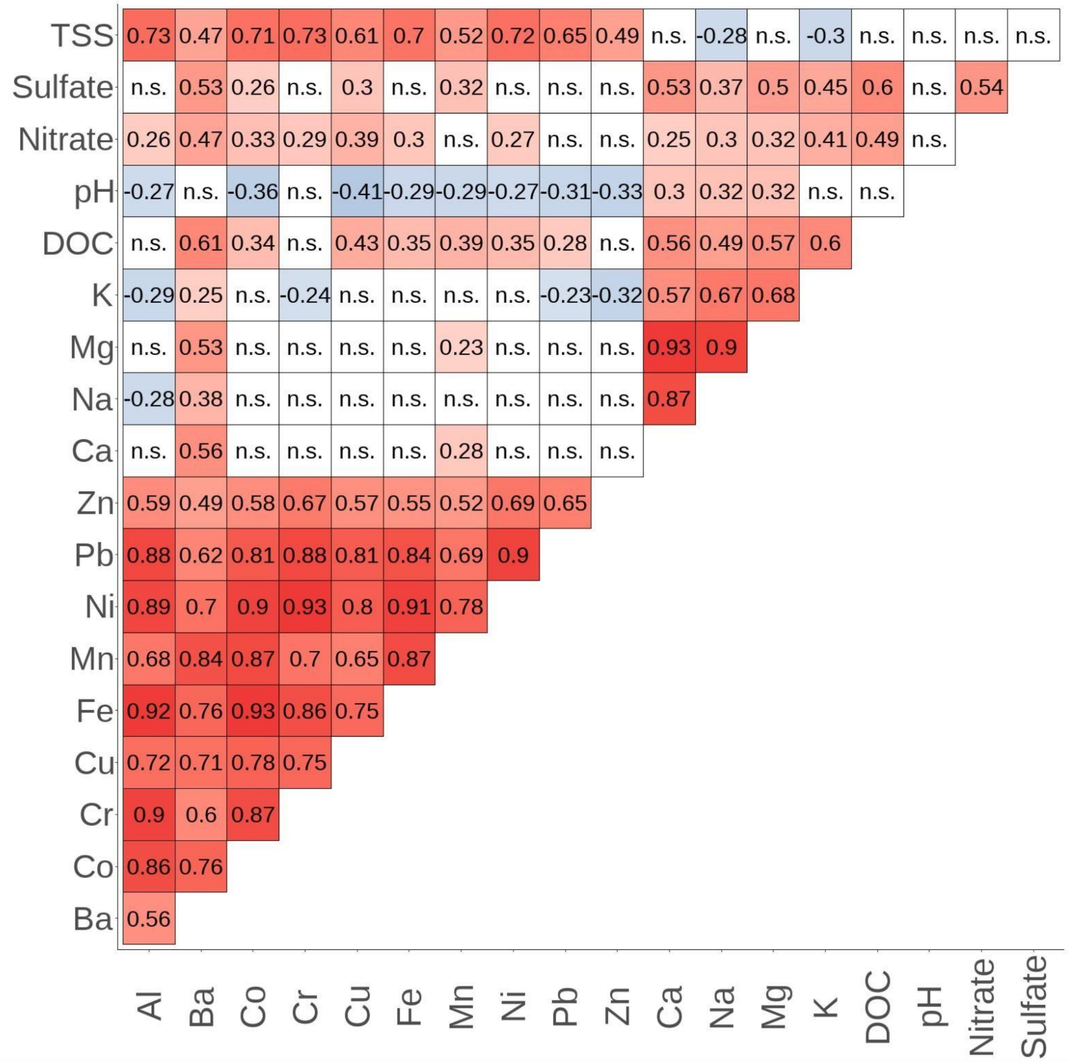


Figure S11. Heat map of Spearman correlation results for total concentrations of metals, sulfate, nitrate, DOC, pH, and TSS across burned watersheds only (Butte Creek, Clear Creek, and Dry Creek). Each box contains a rho value (between -1 and 1) or is marked as not significant (n.s.). Red boxes indicate a significant positive correlation, white boxes indicate no significant correlation ($p > 0.05$), and blue boxes indicate significant negative correlation.

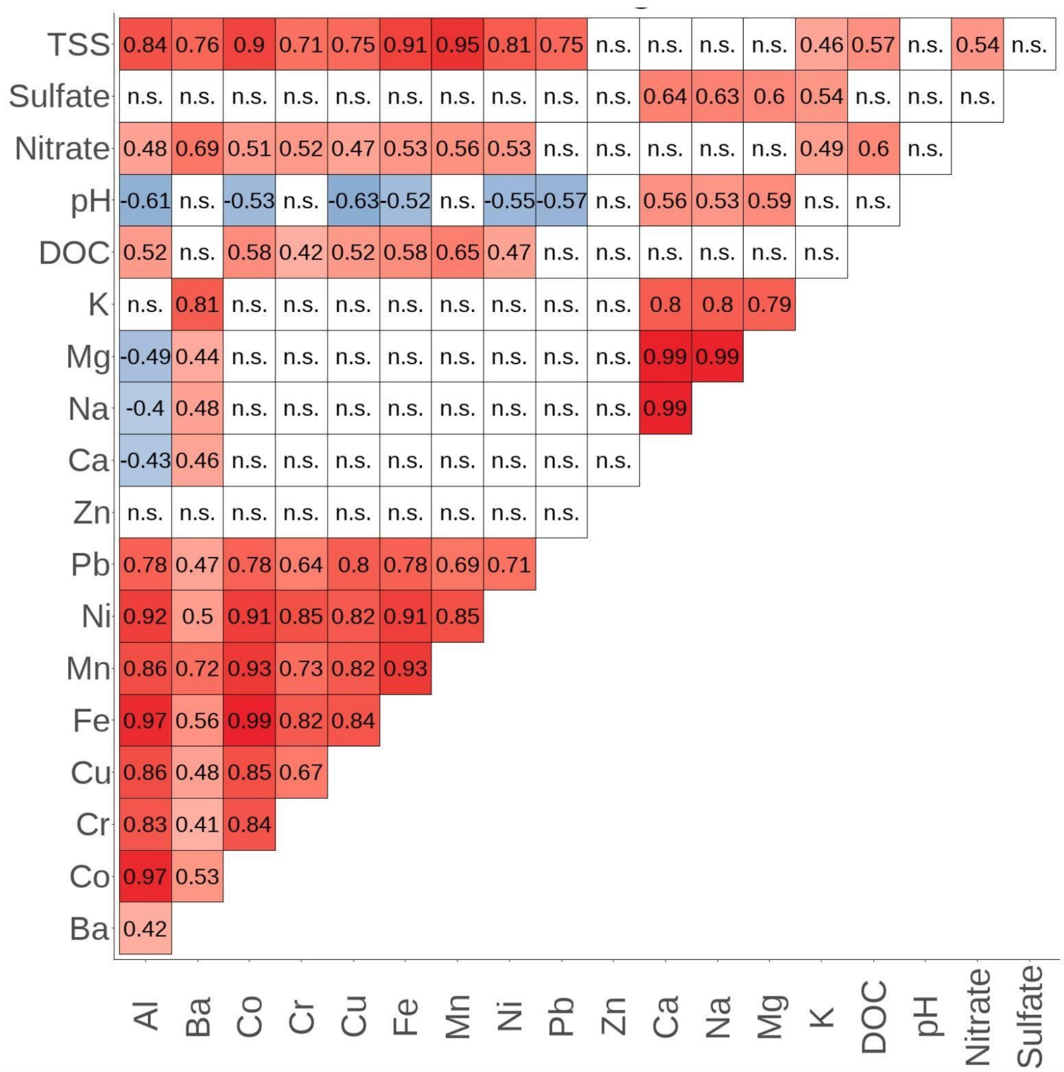


Figure S12. Heat map of Spearman correlation results for total concentrations of metals, sulfate, nitrate, DOC, pH, and TSS for unburned reference watershed Big Chico Creek. Each box contains a rho value (between -1 and 1) or is marked as not significant (n.s.). Red boxes indicate a strong positive correlation, white boxes indicate no significant correlation (p > 0.05), and blue boxes indicate significant negative correlation.

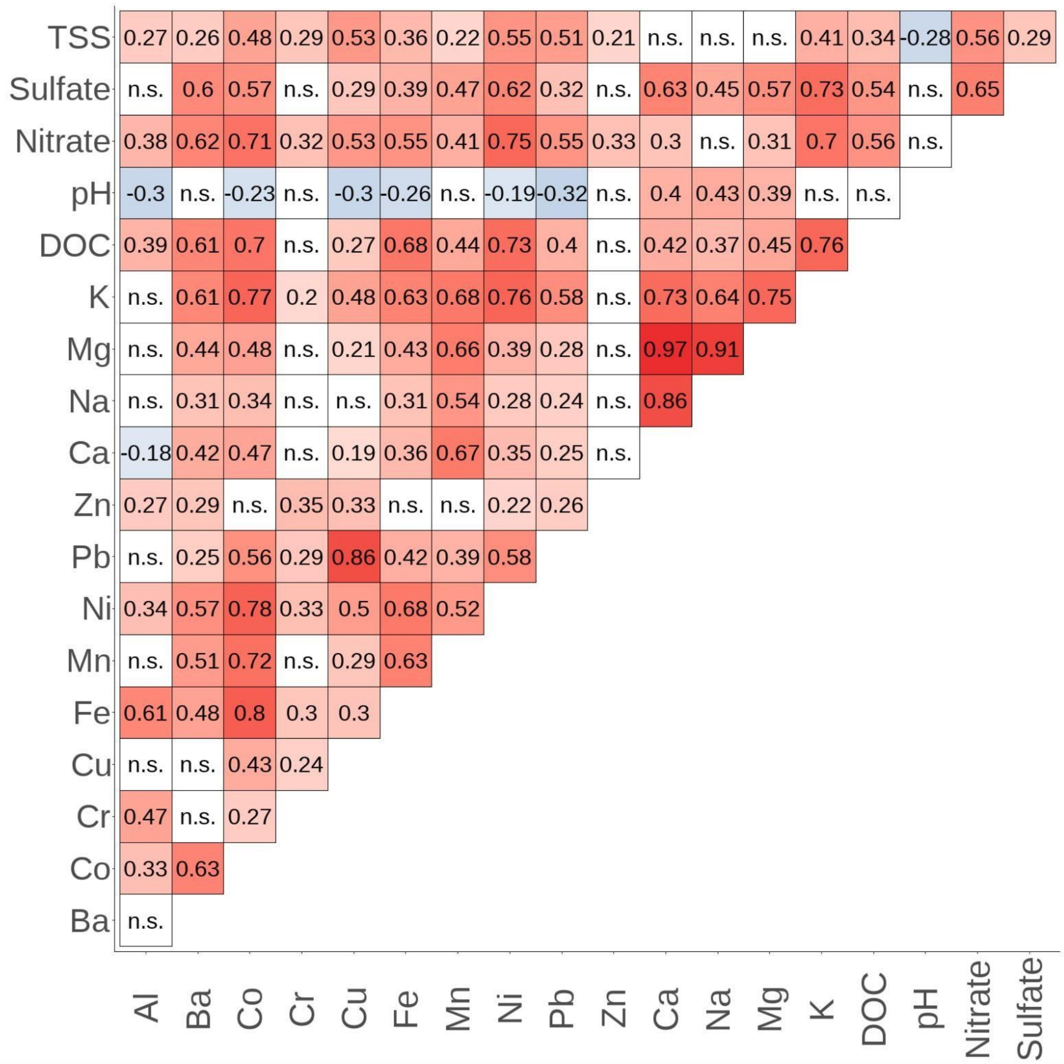


Figure S13. Heat map of Spearman correlation results for filter-passing concentrations of metals, sulfate, nitrate, DOC, pH, and TSS across all watersheds (Big Chico Creek, Butte Creek, Clear Creek, and Dry Creek). Each box contains a rho value (between -1 and 1) or is marked as not significant (n.s.). Red boxes indicate a strong positive correlation, white boxes indicate no significant correlation ($p > 0.05$), and blue boxes indicate significant negative correlation.

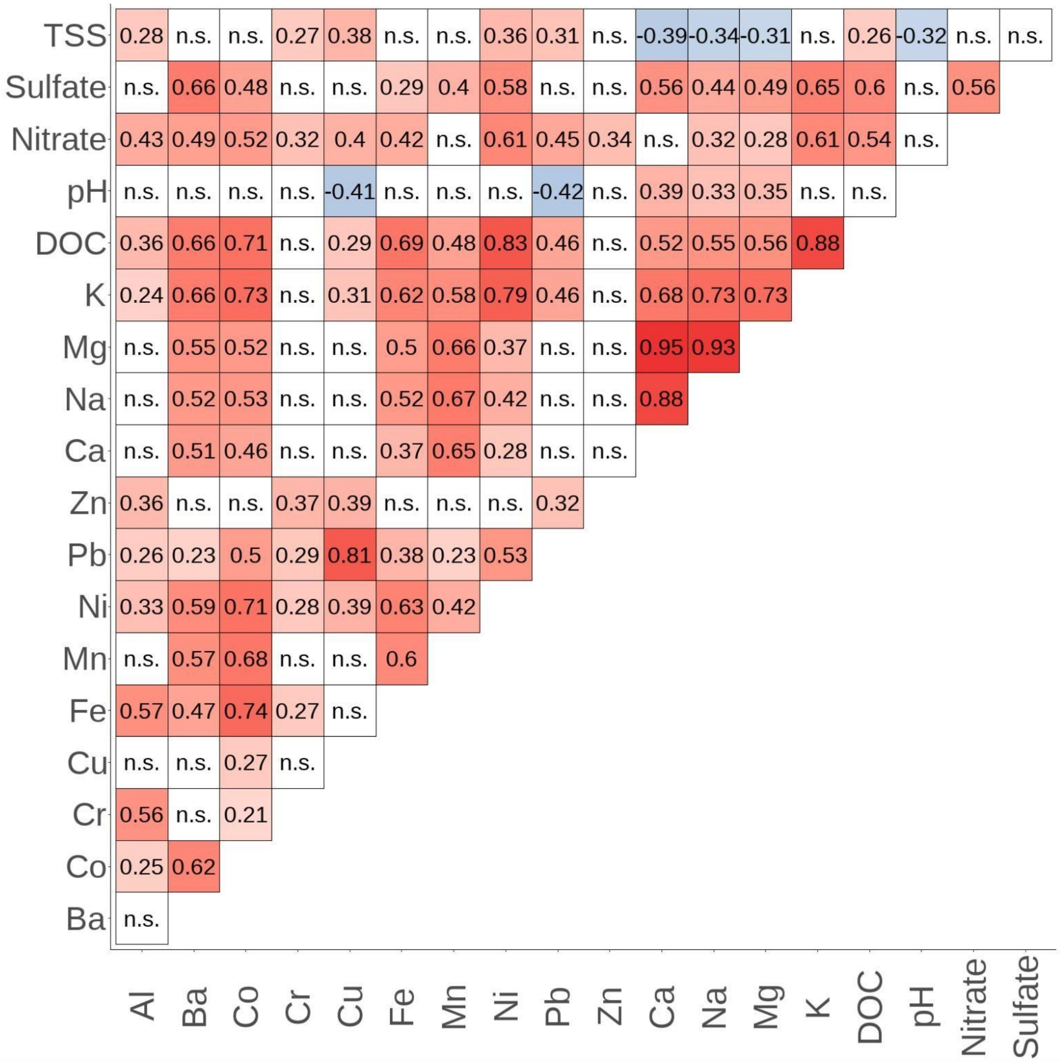


Figure S14. Heat map of Spearman correlation results for filter-passing concentrations of metals, sulfate, nitrate, DOC, pH, and TSS in burned watersheds only (Butte Creek, Clear Creek, and Dry Creek). Each box contains a rho value (between -1 and 1) or is marked as not significant (n.s.). Red boxes indicate a strong positive correlation, white boxes indicate no significant correlation ($p > 0.05$), and blue boxes indicate significant negative correlation.

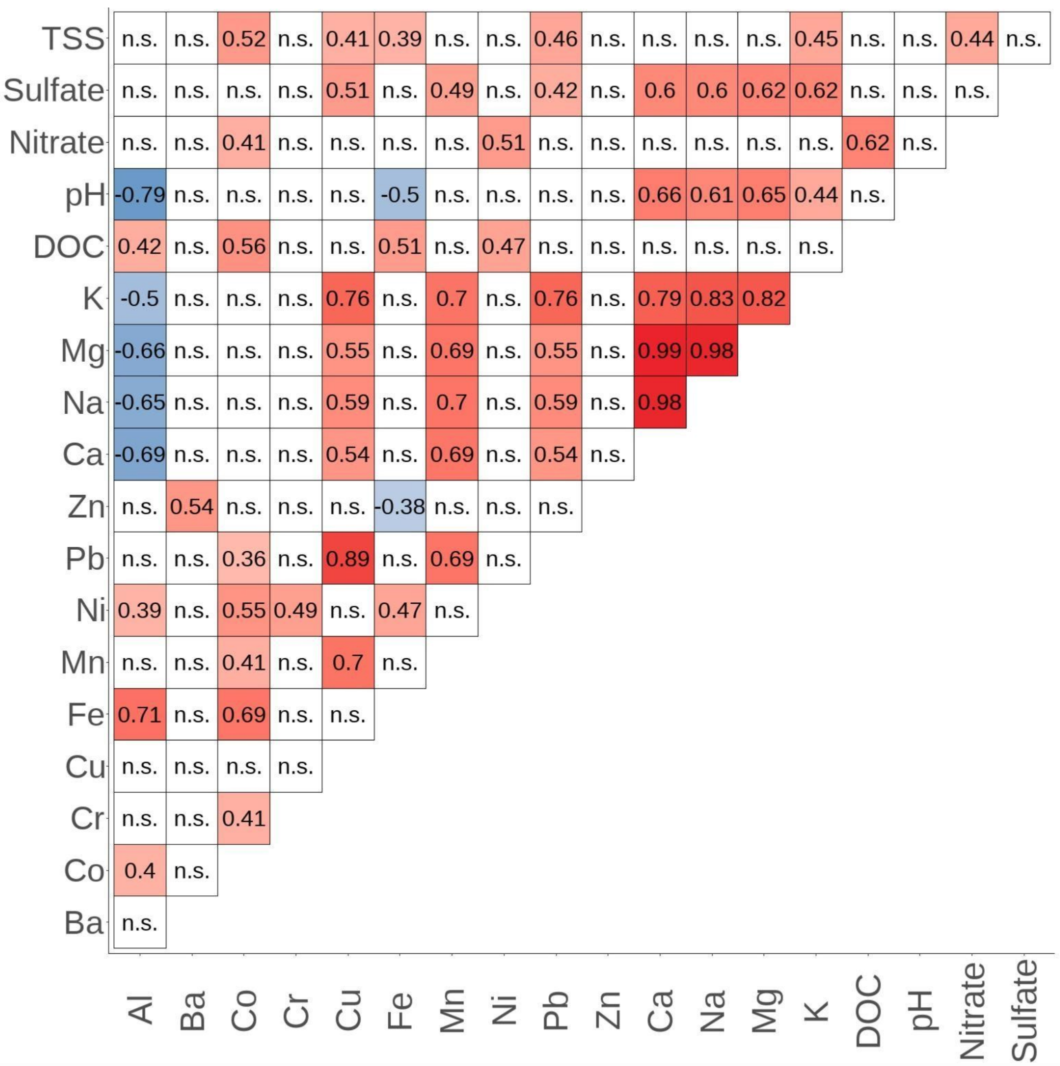


Figure S15. Heat map of Spearman correlation results for filter-passing concentrations of metals, sulfate, nitrate, DOC, pH, and TSS in unburned reference watershed Big Chico Creek. Each box contains a rho value (between -1 and 1) or is marked as not significant (n.s.). Red boxes indicate a strong positive correlation, white boxes indicate no significant correlation ($p > 0.05$), and blue boxes indicate significant negative correlation.

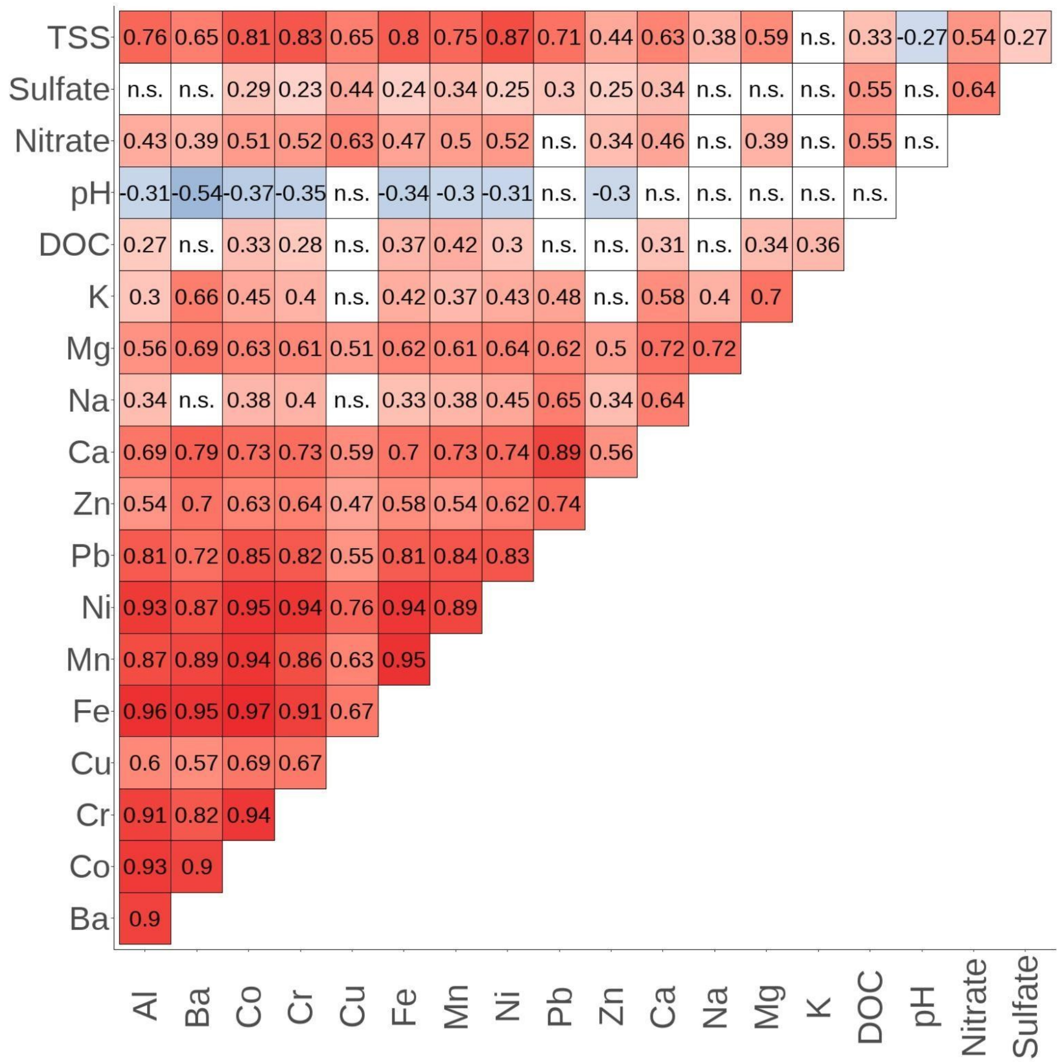


Figure S16. Heat map of Spearman correlation results for particulate concentrations of metals, with sulfate, nitrate, DOC, pH, and TSS concentrations across all watersheds (Big Chico Creek, Butte Creek, Clear Creek, and Dry Creek). Each box contains a rho value (between -1 and 1) or is marked as not significant (n.s.). Red boxes indicate a strong positive correlation, white boxes indicate no significant correlation ($p > 0.05$), and blue boxes indicate significant negative correlation.

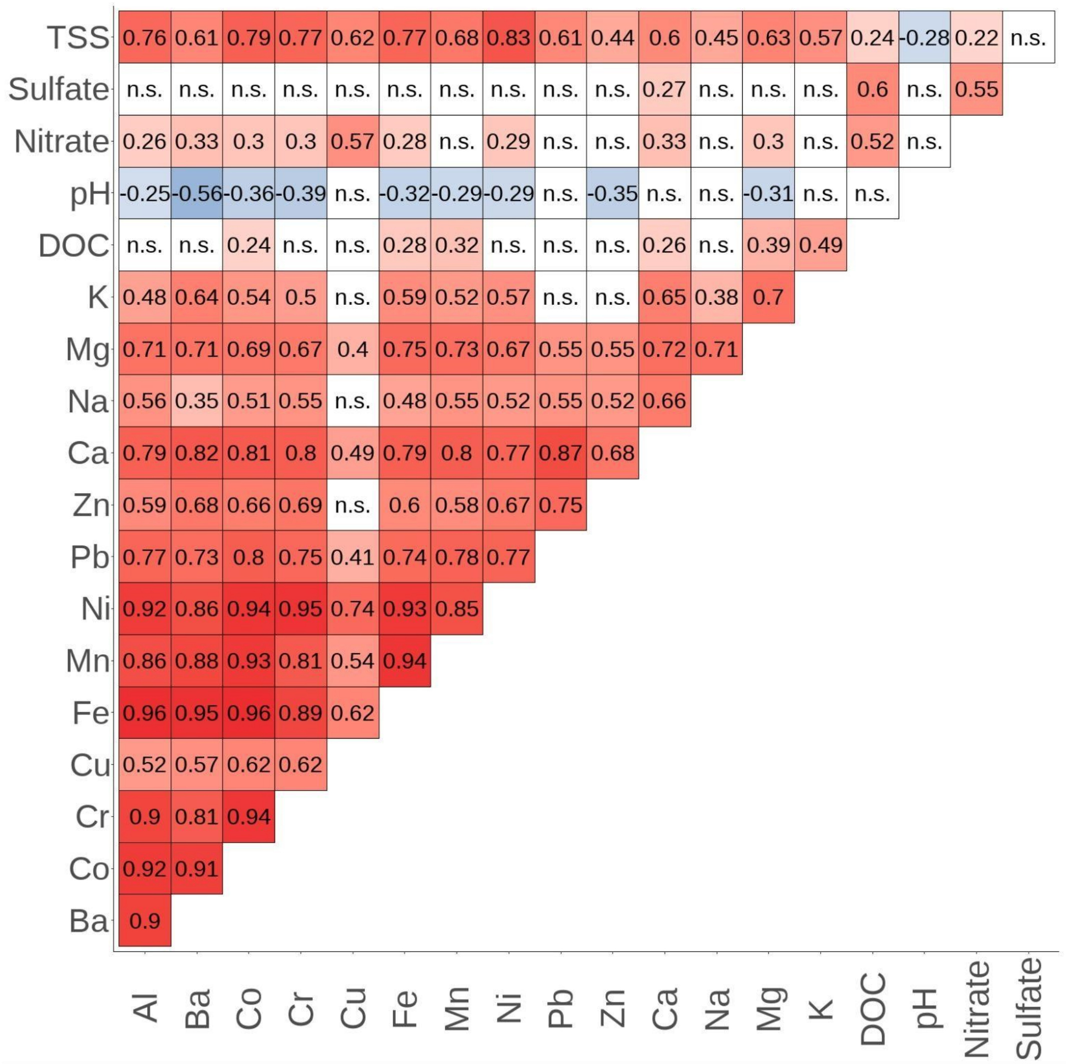


Figure S17. Heat map of Spearman correlation results for particulate concentrations of metals, with sulfate, nitrate, DOC, pH, and TSS across burned watersheds only (Butte Creek, Clear Creek, and Dry Creek). Each box contains a rho value (between -1 and 1) or is marked as not significant (n.s.). Red boxes indicate a strong positive correlation, white boxes indicate no significant correlation ($p > 0.05$), and blue boxes indicate significant negative correlation.

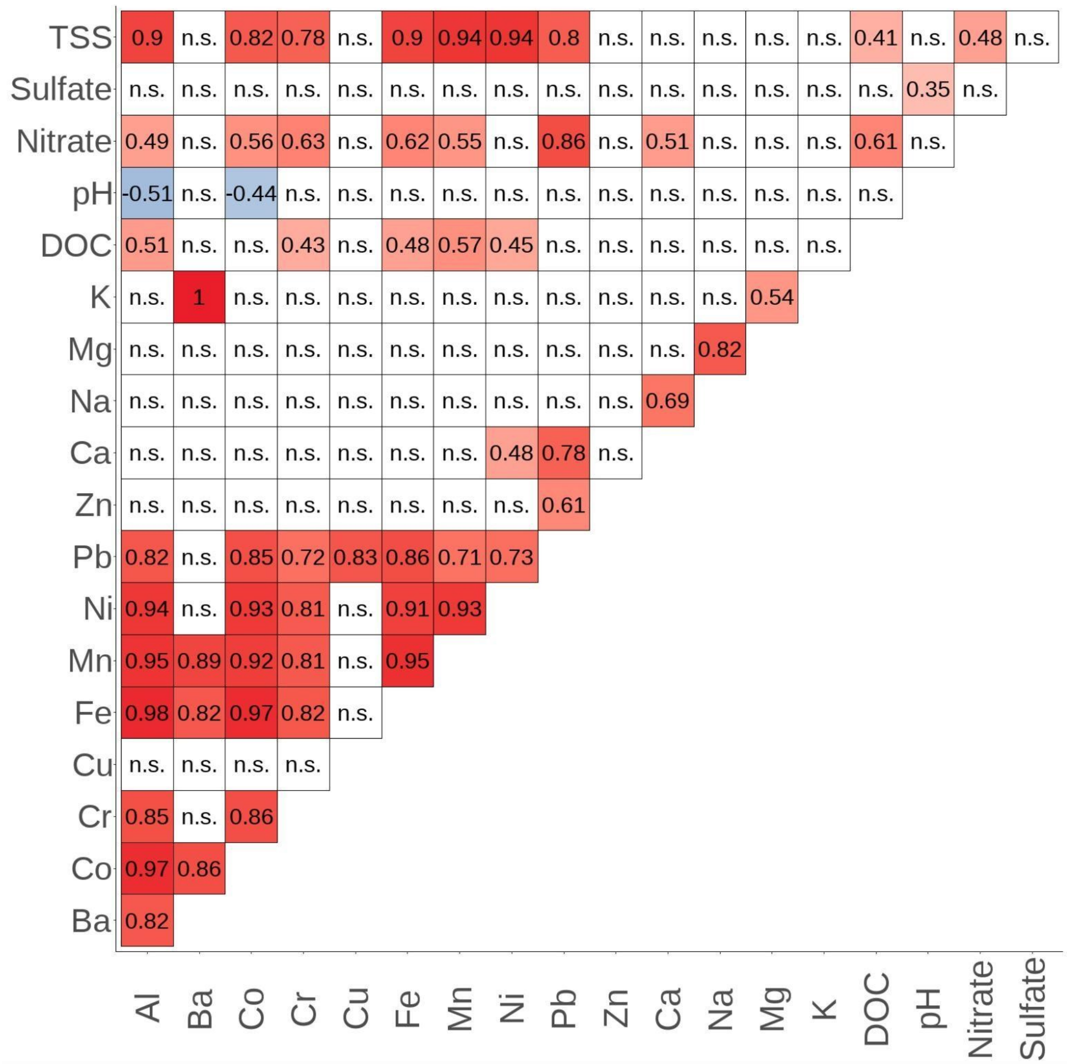


Figure S18. Heat map of Spearman correlation results for particulate concentrations of metals, with concentrations of sulfate, nitrate, DOC, pH, and TSS in unburned reference watershed Big Chico Creek. Each box contains a rho value (between -1 and 1) or is marked as not significant (n.s.). Red boxes indicate a strong positive correlation, white boxes indicate no significant correlation ($p > 0.05$), and blue boxes indicate significant negative correlation.

2.5. Exceedances (Table 2) continued.

Table S13. Summary of the number of exceedances of EPA aquatic life criteria peak recommendations (acute and chronic, EPA n.d.) for Ni and Pb in each watershed. The no. fold increase is the maximum concentration divided by the limit. A dash (-) is presented when there were no exceedances.

Metal	Sample Location	Sample Type	Aquatic Habitat Recommendation: Acute				Aquatic Habitat Recommendation: Chronic			
			No. of Exceeds.	No. Fold Increase	Max. Conc. (ppb)	Limit (ppb)	No. of Exceeds.	No. Fold Increase	Max. Conc. (ppb)	Limit (ppb)
Ni	Butte Creek	Total	–	–	–	–	4	3.0	72.0	24.0
	Clear Creek	Total	–	–	–	–	1	1.2	27.7	24.0
	Dry Creek	Total	–	–	–	–	5	2.5	43.7	17.8
Pb	Aquatic Park	Filter-passing	–	–	–	–	2	1.4	0.56	0.40
		Total	1	1.5	14.9	9.9	4	39	14.9	0.38
	Big Chico Creek	Filter-passing	–	–	–	–	1	2.6	3.44	1.29
		Total	–	–	–	–	1	1.5	1.21	0.65
	Butte Creek	Filter-passing	–	–	–	–	1	1.1	1.71	1.57
		Total	–	–	–	–	16	8.8	8.71	0.99
	Clear Creek	Total	–	–	–	–	5	4.8	6.52	1.35
		Filter-passing	–	–	–	–	4	3.7	2.80	0.76
	Dry Creek	Filter-passing	–	–	–	–	4	2.0	1.29	0.66
		Total	–	–	–	–	10	10	7.32	0.73
	Little Butte Creek Trailer Park	Total	–	–	–	–	1	2.3	6.45	2.80

2.6. Principal Component Analyses

This section documents the Principal Component Analysis results. Table S14 summarizes the rotation values and variance explained for each of the PCA models. Figure S19 and Figure S20 present additional PCA models for filter-passing and particulate concentrations, respectively.

Table S14. Rotation values (cos(θ)) for variables used in Principal Component Analyses, as well as variance explained by PC1, PC2, and total (summed PC1 + PC2).

				Variance Explained		
	Variable	**PC1 Rotation (Cos(θ))**	**PC2 Rotation (Cos(θ))**	**PC1**	**PC2**	**Total**
Total Trace Metals in Butte Creek	Al	0.358	0.071	71.08%	12.26%	83.34%
	Ba	0.360	-0.064			
	Co	0.208	0.569			
	Cr	0.317	0.320			
	Cu	0.323	-0.234			
	Fe	0.361	0.102			
	Mn	0.357	0.016			
	Ni	0.346	-0.096			
	Pb	0.324	-0.269			
	Zn	0.106	-0.646			
Total Trace Metals in Clear Creek	Al	0.337	0.310	68.74%	19.13%	87.97%
	Ba	0.334	0.115			
	Co	0.323	-0.371			
	Cr	0.362	-0.164			
	Cu	0.257	0.206			
	Fe	0.338	0.299			
	Mn	0.287	-0.459			
	Ni	0.352	0.171			
	Pb	0.320	0.239			
	Zn	0.225	-0.545			

Table S14 continued

	Variable	PC1 Rotation (Cos(θ))	PC2 Rotation (Cos(θ))	Variance Explained PC1	Variance Explained PC2	Variance Explained Total
Total Trace Metals in Dry Creek	Al	0.313	0.261	74.59%	16.47%	91.06%
	Ba	0.325	-0.338			
	Co	0.349	-0.173			
	Cr	0.324	0.315			
	Cu	0.354	-0.050			
	Fe	0.343	-0.268			
	Mn	0.213	-0.626			
	Ni	0.329	0.214			
	Pb	0.310	0.170			
	Zn	0.278	0.384			
Total Trace Metals in Big Chico Creek	Al	0.343	-0.064	82.14%	10.04%	92.18%
	Ba	0.320	-0.199			
	Co	0.305	0.362			
	Cr	0.328	0.170			
	Cu	0.325	-0.236			
	Fe	0.343	-0.077			
	Mn	0.331	-0.217			
	Ni	0.337	-0.003			
	Pb	0.321	-0.142			
	Zn	0.173	0.817			

Table S14 continued

	Variable	PC1 Rotation (Cos(θ))	PC2 Rotation (Cos(θ))	Variance Explained PC1	Variance Explained PC2	Variance Explained Total
Total Trace Metals in All Watersheds	Al	0.329	0.211	67.34%	12.00%	79.34%
	Ba	0.348	-0.285			
	Co	0.288	-0.045			
	Cr	0.336	0.260			
	Cu	0.356	-0.049			
	Fe	0.365	-0.245			
	Mn	0.246	-0.598			
	Ni	0.352	0.115			
	Pb	0.329	0.263			
	Zn	0.149	0.549			
Particulate Metals in All Watersheds	Co	0.416	-0.587	66.83%	17.60%	84.43%
	Cr	0.512	-0.238			
	Ni	0.476	-0.043			
	Pb	0.460	0.284			
	Zn	0.356	0.719			

Table S14 continued

	Variable	PC1 Rotation (Cos(θ))	PC2 Rotation (Cos(θ))	Variance Explained PC1	Variance Explained PC2	Variance Explained Total
Total Metals and All Other Parameters in All Watersheds	Al	-0.293	0.068	44.07%	21.14%	65.21%
	Ba	-0.328	-0.119			
	Ca	-0.057	-0.434			
	Co	-0.332	0.012			
	Cr	-0.322	0.085			
	Cu	-0.343	0.007			
	DOC	-0.096	-0.263			
	Fe	-0.333	-0.015			
	K	0.097	-0.320			
	Mg	-0.005	-0.464			
	Mn	-0.229	-0.092			
	Na	0.068	-0.377			
	Ni	-0.333	0.056			
	Nitrate	-0.108	-0.218			
	Pb	-0.305	0.025			
	pH	0.117	-0.268			
	Sulfate	-0.127	-0.344			
	Zn	-0.202	0.081			
Filtered Metals and All Other Parameters in All Watersheds	Al	0.206	0.278	32.85%	19.74%	52.59%
	Ba	0.293	-0.041			
	Ca	0.221	-0.418			
	Co	0.069	0.075			
	Cr	0.070	0.169			
	Cu	0.153	0.296			
	DOC	0.334	-0.013			
	Fe	0.279	0.151			
	K	0.385	-0.056			
	Mg	0.230	-0.402			
	Mn	0.084	0.016			
	Na	0.147	-0.374			
	Ni	0.349	0.169			
	Nitrate	0.313	0.087			
	Pb	0.225	0.237			
	pH	0.007	-0.356			
	Sulfate	0.293	-0.169			
	Zn	0.120	0.222			

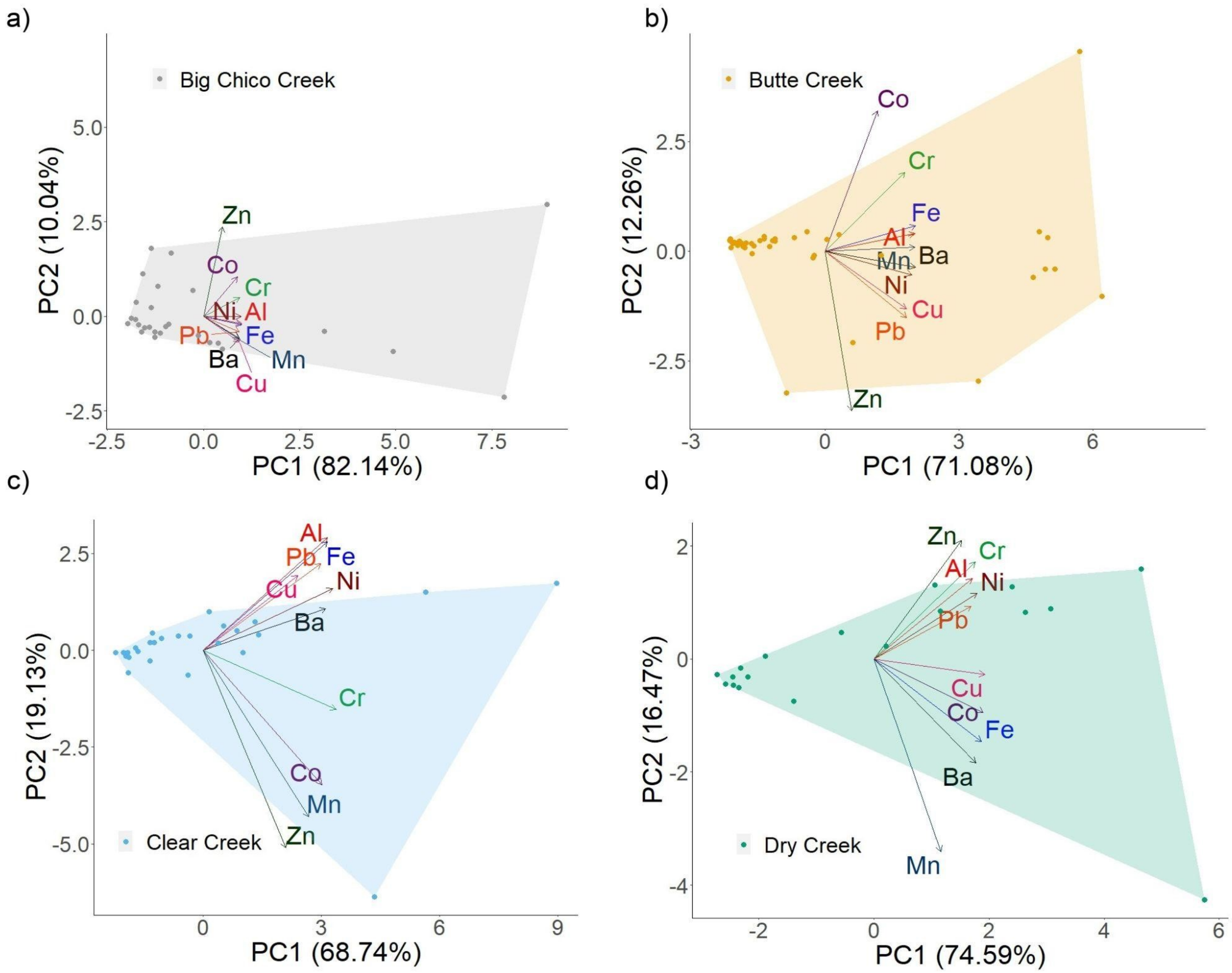


Figure S19. Principal component analysis (PCA) of total trace metal concentrations in each watershed: a) Big Chico Creek, b) Butte Creek, c) Clear Creek, and d) Dry Creek. Each point represents a discrete sampling event, and shaded areas represent the dataset for each watershed.

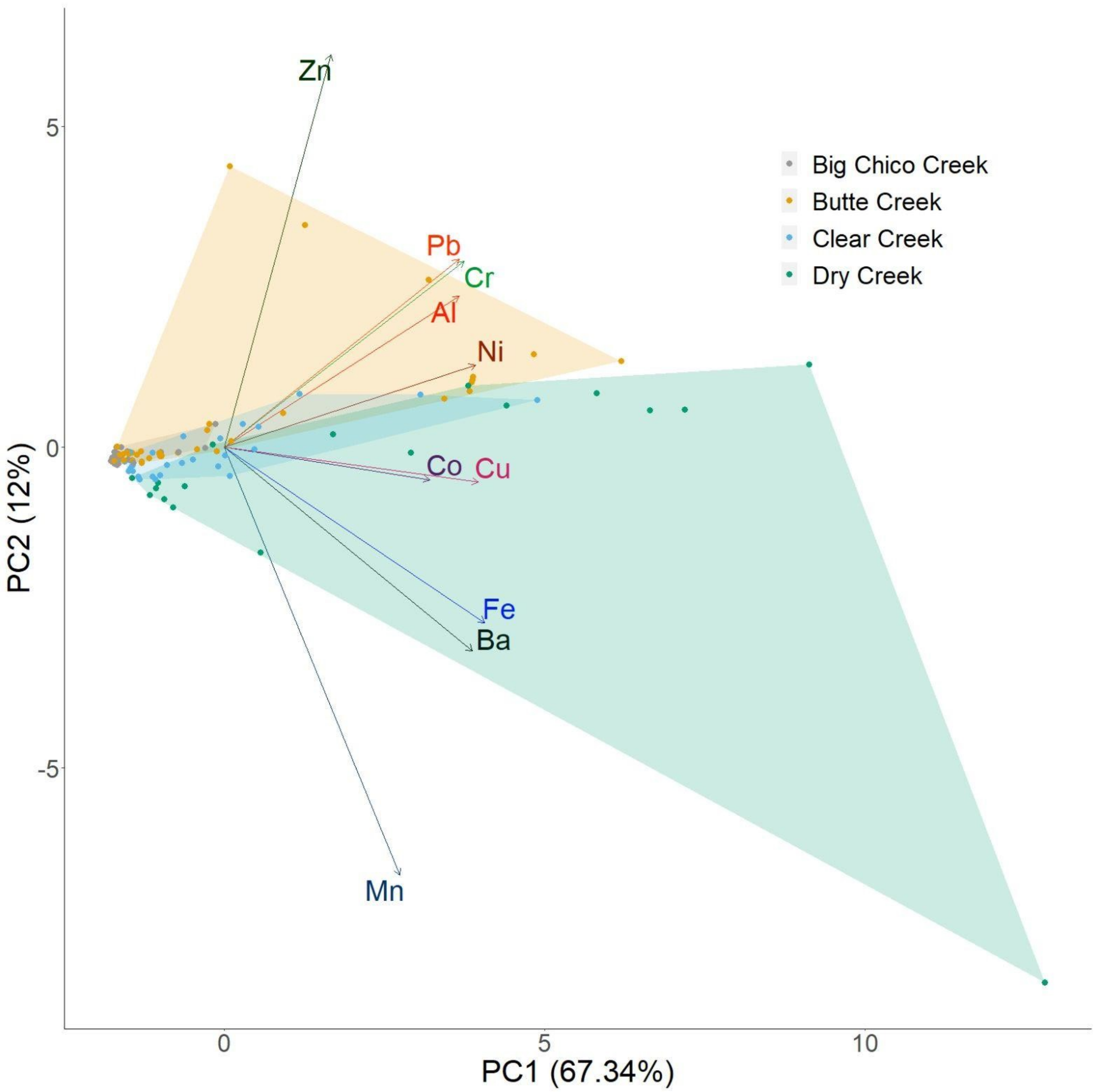


Figure S20. Principal component analysis (PCA) of total trace metal concentrations in all watersheds (Big Chico Creek, Butte Creek, Clear Creek, and Dry Creek). Each point represents a discrete sampling event, and shaded areas confine discrete samples within each watershed.

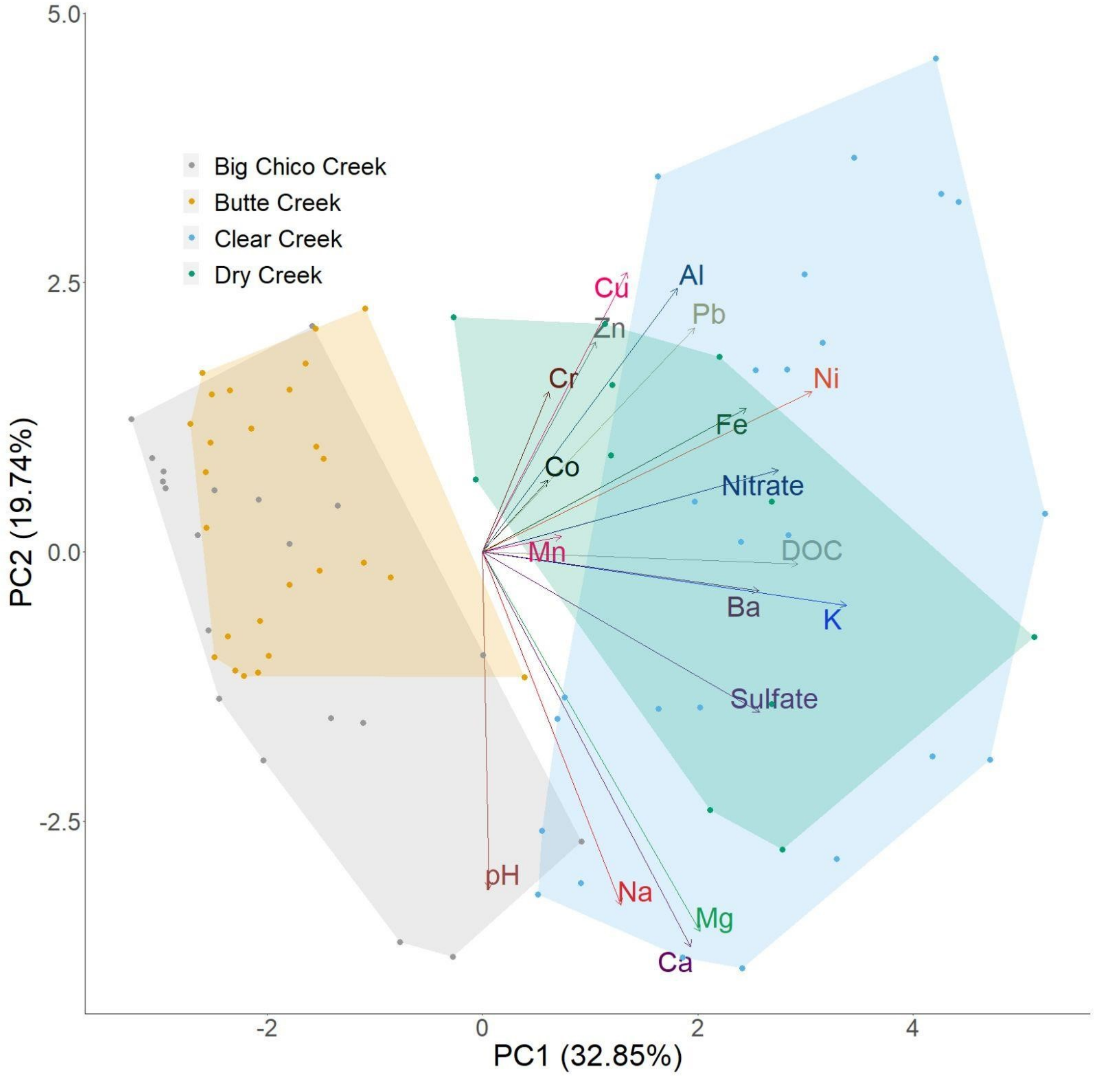


Figure S21. Principal component analysis (PCA) of filter-passing trace metal concentrations, major cations, DOC, sulfate, nitrate, and pH in Big Chico Creek, Butte Creek, Clear Creek, and Cry Creek. Each point represents a discrete sampling event, and shaded areas confine discrete samples within each watershed.

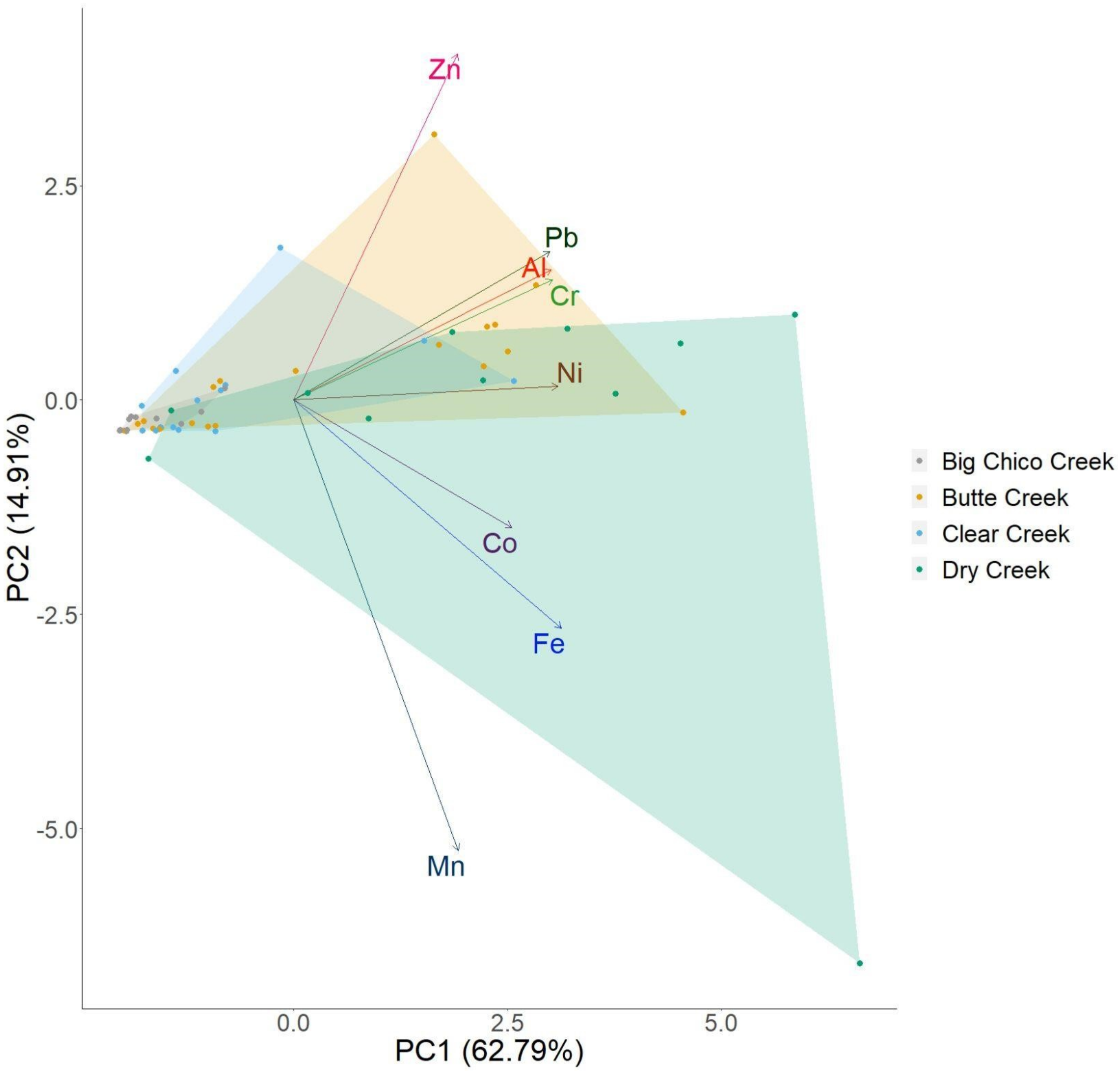


Figure S22. Principal component analysis (PCA) of particulate concentrations for Al, Cr, Co, Fe, Ni, and Pb in Big Chico Creek, Butte Creek, Clear Creek, and Cry Creek. Each point represents a discrete sampling event, and shaded areas confine discrete samples within each watershed.

2.7. Redundancy Analysis

This section presents two additional RDAs. Filter-passing elemental concentrations are analyzed in Figure S23 with the axes defined by Equations S2 and S3.

$$RDA1 = (0.6546 \times \text{Percent Urban}) + (-0.3078 \times \text{Destroyed Structures}) + (-0.7554 \times \text{Flow}) \quad \textbf{Eqn. S2}$$

$$RDA2 = (-0.4051 \times \text{Percent Urban}) + (-0.8592 \times \text{Destroyed Structures}) + (0.0794 \times \text{Flow}) \quad \textbf{Eqn. S3}$$

Figure S24 presents an RDA for particulate elemental concentrations with axes defined by Equations S4 and S5.

$$RDA1 = (0.3471 \times \text{Urban area (\%)}) + (0.2871 \times \text{Destroyed Structures}) + (0.9859 \times \text{TSS}) + (0.5554 \times \text{Flow}) \quad \textbf{Eqn. S4}$$

$$RDA2 = (0.332 \times \text{Urban area (\%)}) + (0.9254 \times \text{Destroyed Structures}) + (0.06169 \times \text{TSS}) + (-0.3695 \times \text{Flow}) \quad \textbf{Eqn. S5}$$

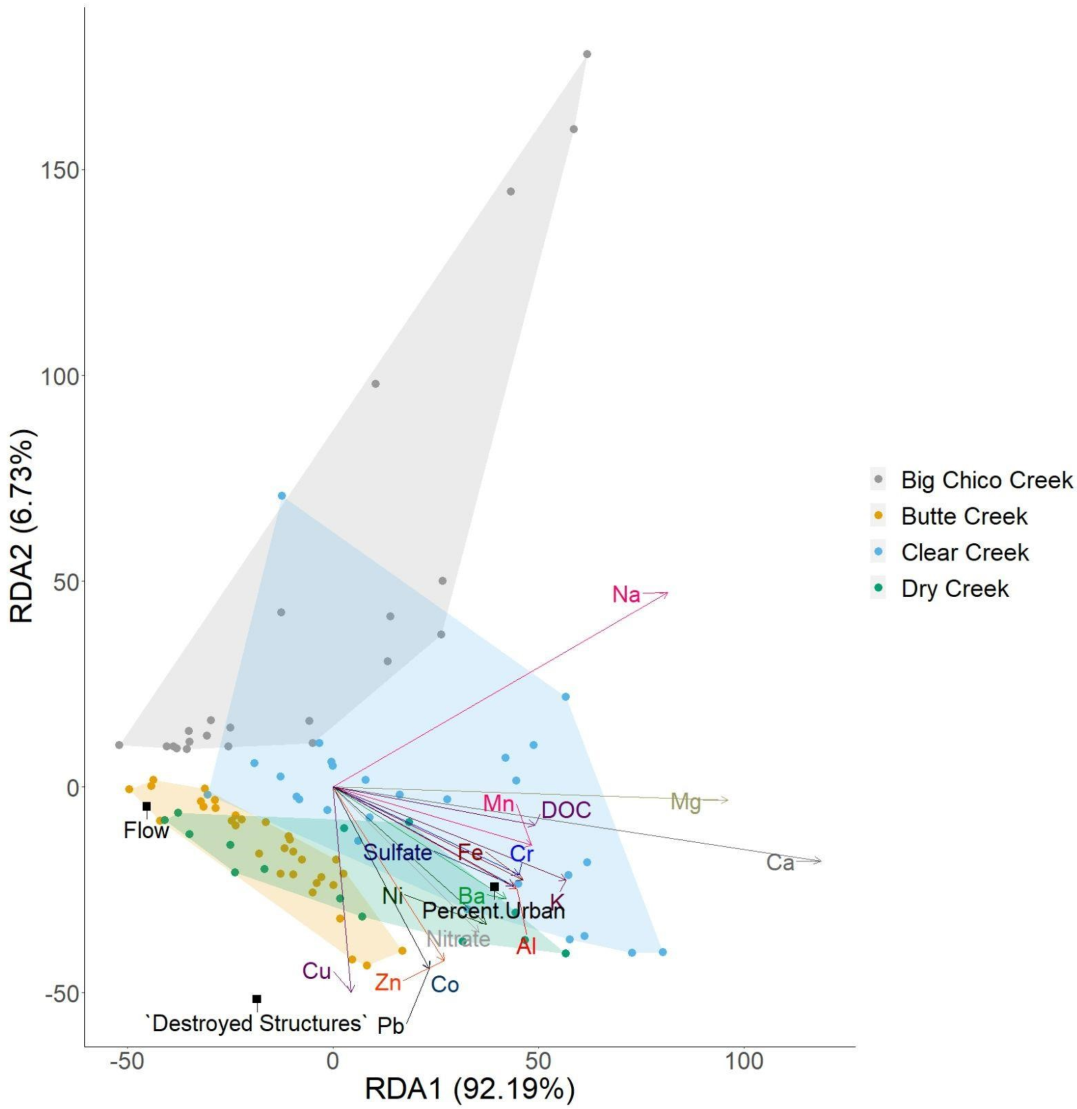


Figure S23. Redundancy analysis (RDA) of all watersheds (Big Chico Creek, Butte Creek, Clear Creek, and Dry Creek) including dependent variables of filter-passing metal concentrations, total major cation concentrations, sulfate, nitrate, and DOC, and independent variables including percent urban land use in watershed, number of burned structures per watershed, and flow as measured in Butte Creek. Each point represents a discrete sampling event, and shaded areas confine discrete samples within each watershed. RDA was plotted using the scaling I method (correlation biplot).

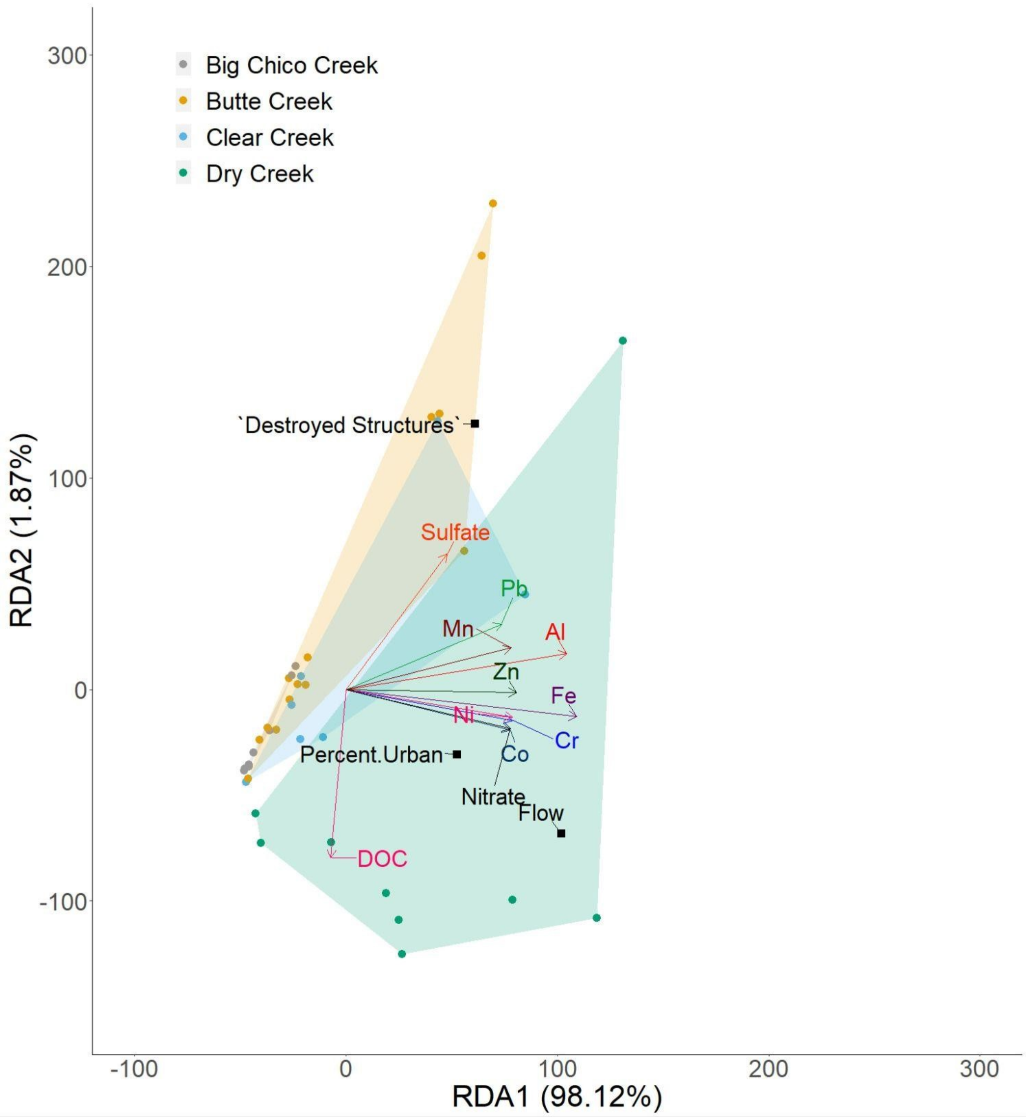
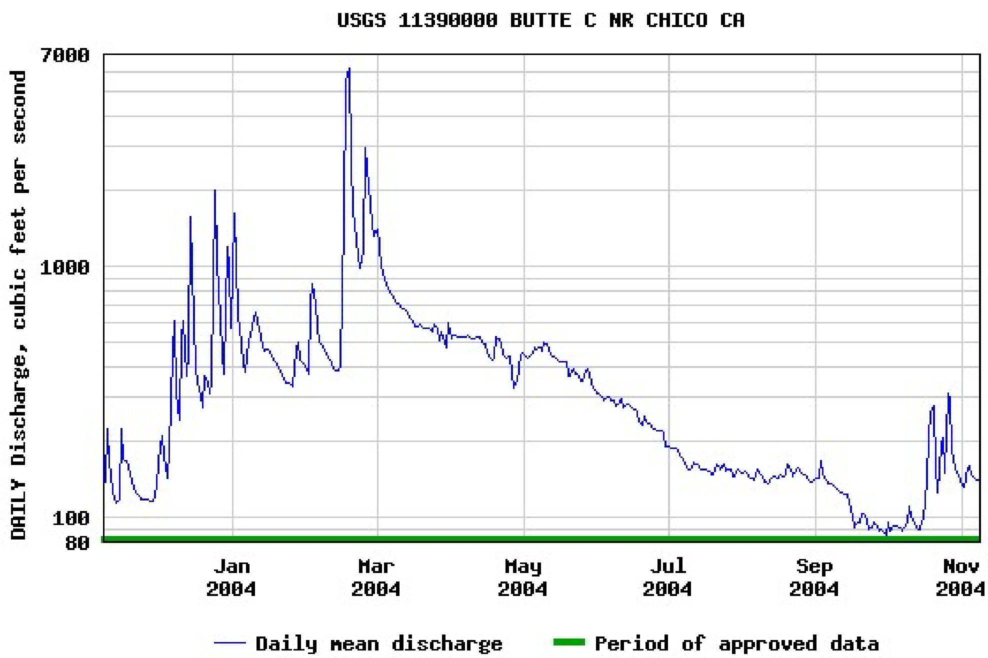


Figure S24. Redundancy analysis (RDA) of all watersheds (Big Chico Creek, Butte Creek, Clear Creek, and Dry Creek) including dependent variables of particulate metal concentrations, total major cation concentrations, sulfate, nitrate, and DOC, and independent variables including percent urban land use in watershed, number of burned structures per watershed, TSS, and flow as measured in Butte Creek. Each point represents a discrete sampling event, and shaded areas confine discrete samples within each watershed. RDA was plotted using the scaling I method (correlation biplot). RDA1 and RDA2 are defined by equations S4 and S5.

2.8. Butte Creek Hydrographs



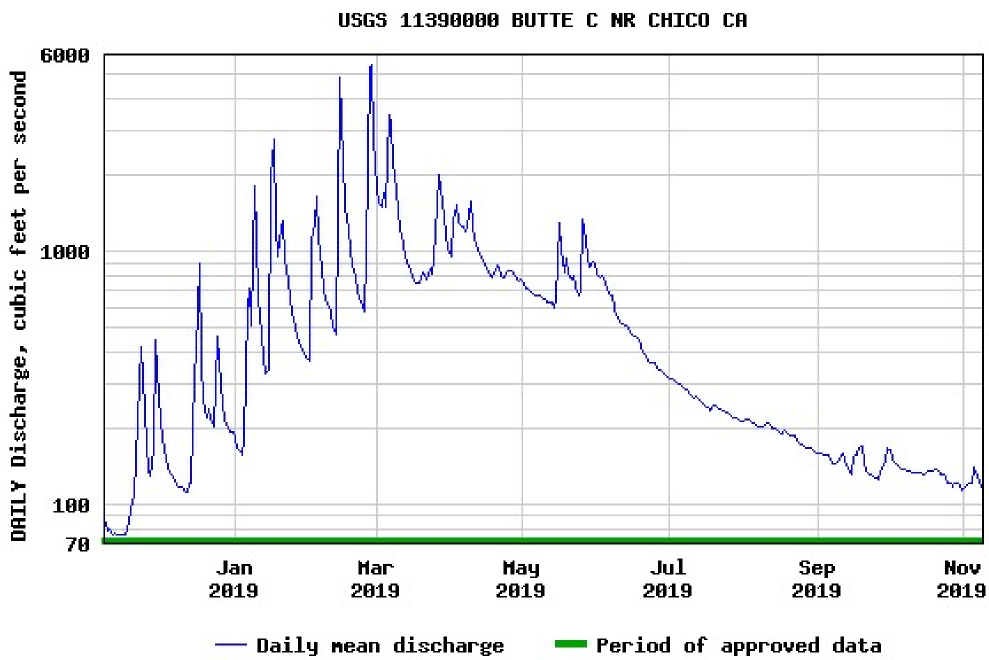


Figure S25: comparison of 2003/2004 and 2018/2019 hydrographs at Butte Creek streamgage station 11390000 (USGS, 2016).

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