Water chemistry varied by water type and elevation in a montane ecosystem

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Introduction

Surface and subsurface flow of water from seasonally snow-covered mountain regions is the major water source in California and the western United States. Thus, water quality in catchment runoff is important for downstream activities including agriculture irrigation and reservoir storage. Studies have shown carbon and nutrient cycling are still active in winter[1,2], and the cycling processes are strongly influential on nutrient export via runoff before, during, and after the growing season[3,4].

In high elevated montane ecosystems, precipitation usually exists in the form of snow for large part of the year. However, studies have rarely reported how water chemistry changes as it moves through the soil system and is exported via streams, which is important for understanding nutrient retention in forested areas.

We collected snowmelt, soil water and stream water samples in water year 2009 to answer the following four questions

Materials and Methods

Study sites were located in the Kings River Experimental Watersheds in the southern Sierra Nevada in California (Fig. 1). Eight watersheds were included in this study namely B201, B203, B204, T003 in the Bull location, ranging from 2050-2480 m in elevation; and P301, P303, P304, D102 in the Providence location, ranging from 1500-2120 m in elevation (Fig 1).

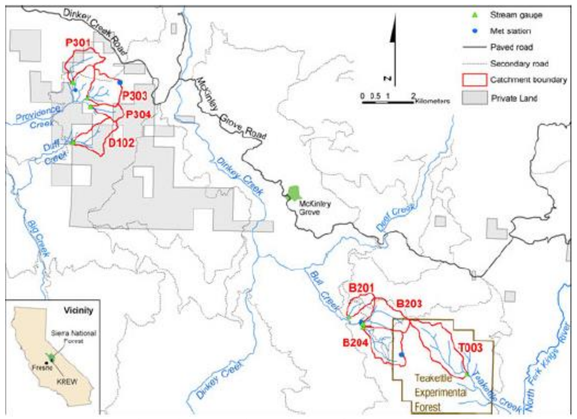


Fig. 1. Kings River Experimental Watersheds (KREW) Catchments

Snow depth and mass

- Measured with sonic depth sensors and snow pillows (Fig. 2a).
- Collected in four Providence watersheds from December 2008 to May 2009, using passive samplers with above and belowground components

Soil solutions

- Used installed Prenart vacuum lysimeters (Fig. 2b).
- Collected at 13 and 26 cm soil depth in four Providence watersheds from January 2009 to May 2009

Stream water

- Used ISCO 6712 automated samplers in winter and grab bottles in summer (Fig. 2c).
- Collected in all eight watersheds (Providence and Bull) from August 2008 to August 2009

Fig. 2. Sampling for snowmelt (left), soil solution (middle) and stream water (right)

All water samples were analyzed for total organic carbon, aromatic carbon ($SUVA_{254}$, $SUVA_{280}$), total nitrogen, NO_3-N, NH_4-N, and pH.

Two-way ANOVA was conducted to explore the effects of water type and collection date on water chemistry. Data was log-transformed to meet the normality of residuals.

Q1. Does water chemistry vary by water source?

YES!

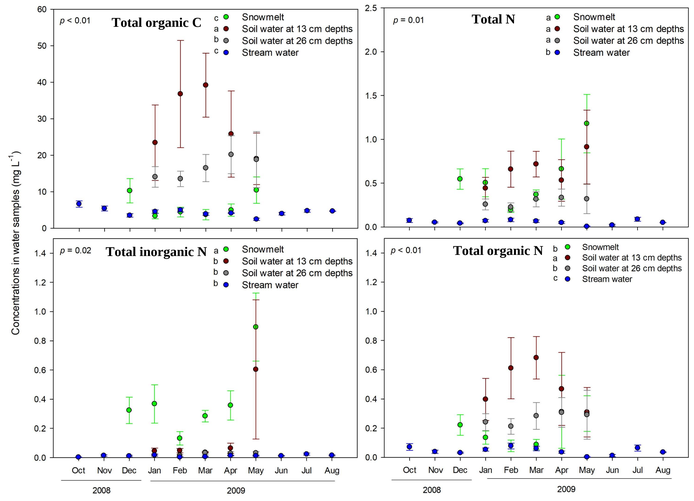


Fig 3. Chemical concentrations varied by water types

Total organic C: Snowmelt and stream water < soil water at two depths
Total N: Stream water had the lowest concentrations
Total inorganic N: Snowmelt had the highest concentrations
Total organic N: Stream water < Soil water at 26 cm depth, Snowmelt < Soil water at 13 cm depth

Q2. Does stream water chemistry vary by elevation?

YES!

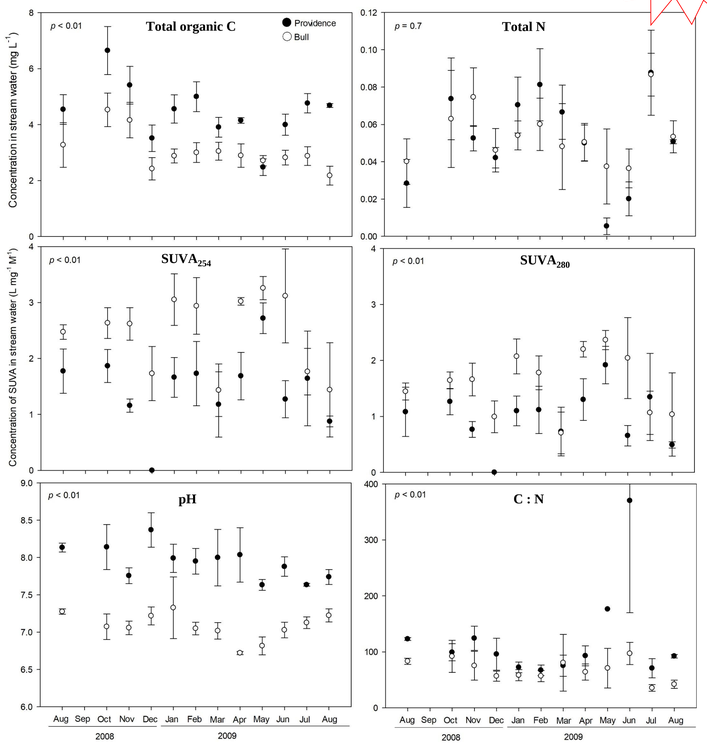
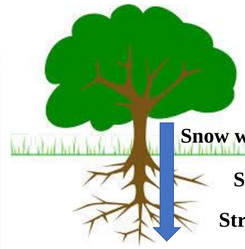


Fig 4. Stream water chemistry varied by elevation

Higher in lower elevations	Higher in higher elevations	No effects
Total organic C	$SUVA_{254}$, $SUVA_{280}$	Total N
pH	NO_3-N	NH_4-N
C : N		Total organic N

Q3. Do monthly fluxes vary by water type in the winter?

YES!



	Amount per month	TOC (g ha^{-1} mo^{-1})	TN (g ha^{-1} mo^{-1})
Snow water equivalence	509 cm	9.04	2.14
Soil water	7.5 cm	1.7	0.04
Stream export	22010 cm^3	812	9.90

Q4. Do monthly stream fluxes vary by elevation?

YES!

Bull (mean elevation of 2,351 m)

Providence (mean elevation of 1,928 m)

Discharge (L s^{-1} mo^{-1})	786.2 ±219.3	172.5 ±24.9
Total organic C (Kg ha^{-1} mo^{-1})	1.35 ±0.2	0.69 ±0.1
Total N (Kg ha^{-1} mo^{-1})	0.021 ±0.010	0.009 ±0.001
Total inorganic N (Kg ha^{-1} mo^{-1})	0.01 ±0.003	0.002 ±0.0004
Total organic N (Kg ha^{-1} mo^{-1})	0.011 ±0.004	0.007 ±0.001

Stream export

Discussion and Conclusions

1. Soil water usually had higher concentrations of organic carbon and organic nitrogen than snowmelt and stream water presumably because is was closer to source of organic matter.
2. Total fluxes of organic carbon and nitrogen were increased from snowmelt to soil water, with the highest in stream water.
3. Watersheds in higher elevations (Bull) export ~2 times higher total organic carbon and total nitrogen than watersheds in lower elevations (Providence) because of the larger water discharge (4.5 times) even with lower concentration in water chemistry (0.7 times).

Fig 5. Installed eddy covariance flux tower (left) and stream gauging station (right)

Future Work

This project is an effort of a synthesis project in Southern Sierra Critical Zone Observatory. We will incorporate data including upland biomass, soil chemistry and erosion to conduct a full profile of biogeochemical cycles. Any suggestions on further analysis are welcome!

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