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Low-flow headwater stream nutrient concentrations controlled by weathering in four forested Amazonian watersheds

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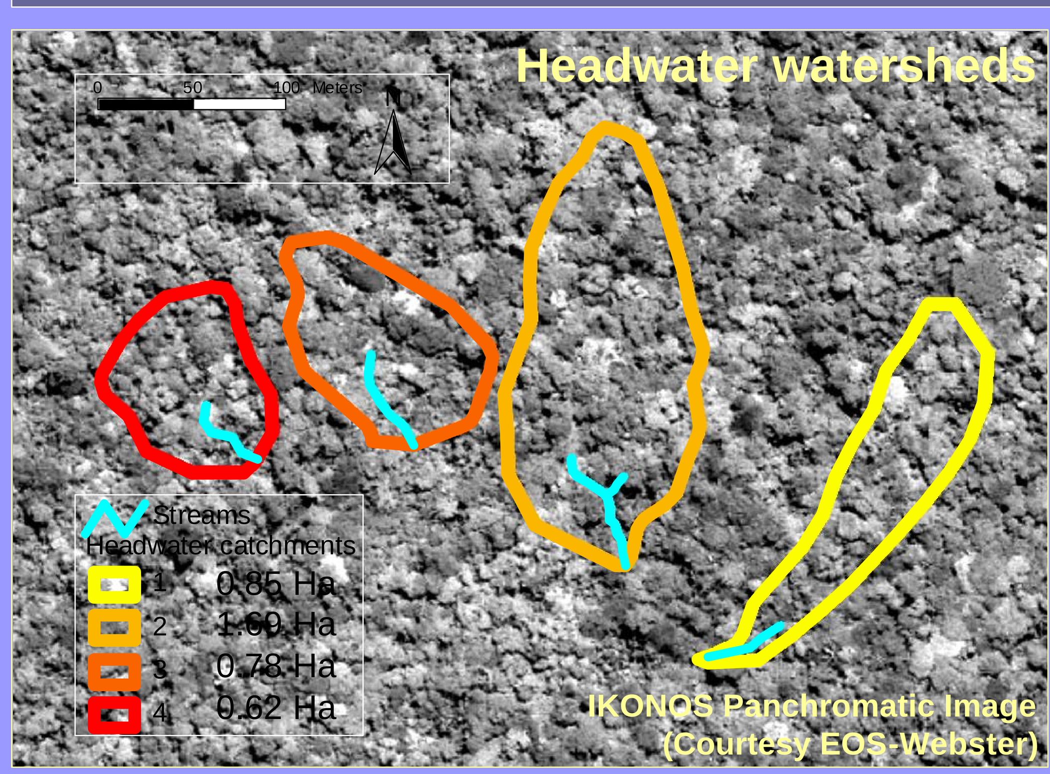
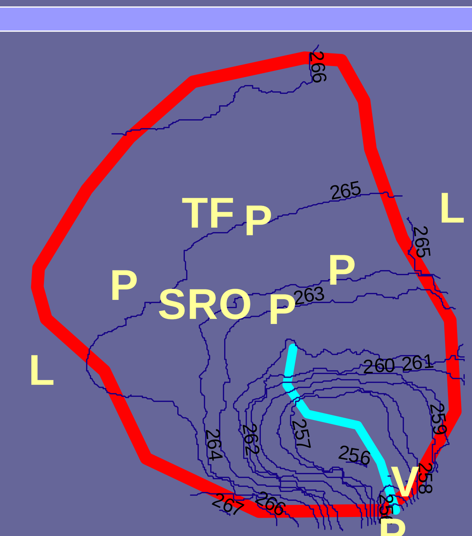
Abstract

A hydrologic study of four headwater watersheds is being conducted in an undisturbed forest near Juruena, Mato Grosso in the seasonally dry, southern Amazon. The micro-watersheds range in size from 0.6 to 1.7 ha. Soils in two of the watersheds contain a sharp increase in clay content with depth in the upper 50 cm, corresponding to a sharp decrease in hydraulic conductivity. Stream water samples were collected biweekly for the four headwater streams during the 2003 wet to dry season transition and throughout the dry season. Decreasing stream flows during this period corresponded with increases in stream water concentrations of calcium, magnesium, silica, sodium, sulfate, electrical conductivity, and alkalinity. Chloride concentrations decreased during this period, with no discernible relationship determined for pH, nitrate and potassium. While there is variation among the watersheds, the elemental concentration trends with respect to decreasing stream flow were consistent for each of the four watersheds. During the period reported here, the groundwater contribution to stream flow increased from being the predominant source during the wet to dry transition, to being the exclusive source during the dry season. Decreases in the mineral weathering index [Na/(Na + Ca)] corresponded with decreases in stream flow for each of the four watersheds throughout the 2003 low-flow period. This indicates that mineral weathering is the primary source of cations exported from these forested headwater watersheds, in contrast with results obtained in a study of a mixed-land use and larger-order Amazonian watershed (Markewitz et al., 2002).

Watershed Study Design and Methods

In each watershed, stream discharge is monitored continuously at a V-notch weir instrumented with a pressure transducer and data logger, and water table depths are monitored continuously in two 6-m deep piezometers. A suite of tipping buckets have been installed in each watershed to measure timings of throughfall, overland flow, and percolating water in each watershed. Conductivity and pH are measured in the field at the time of water sample collection. DOC is determined chromatographically after combustion following filtration with GF/F glass fiber filters (0.7 µm). Samples are preserved (HgCl for DOC; H_2SO_4 or HNO_3 for inorganics) and stored at 3°C until analysis. Cl^- was determined titrimetrically (Mohr), Ca^{2+} using atomic absorption, K^+ and Na^+ with a flame photometer, and SO_4^{2-} was analyzed colorimetrically.





TF- Throughfall
SRO- Surface runoff
Lysimeter (10 cm)
P- Piezometer nests (50 cm and 6 m)
V- V-Notch Weir

Schematic of Watershed 4 illustrating water flux measurements and collection locations common to the four basins. Tipping buckets and pressure transducers are used for measuring timings and fluxes.

V-Notch Weir and POC trap (> 2mm)

Surface-runoff collector

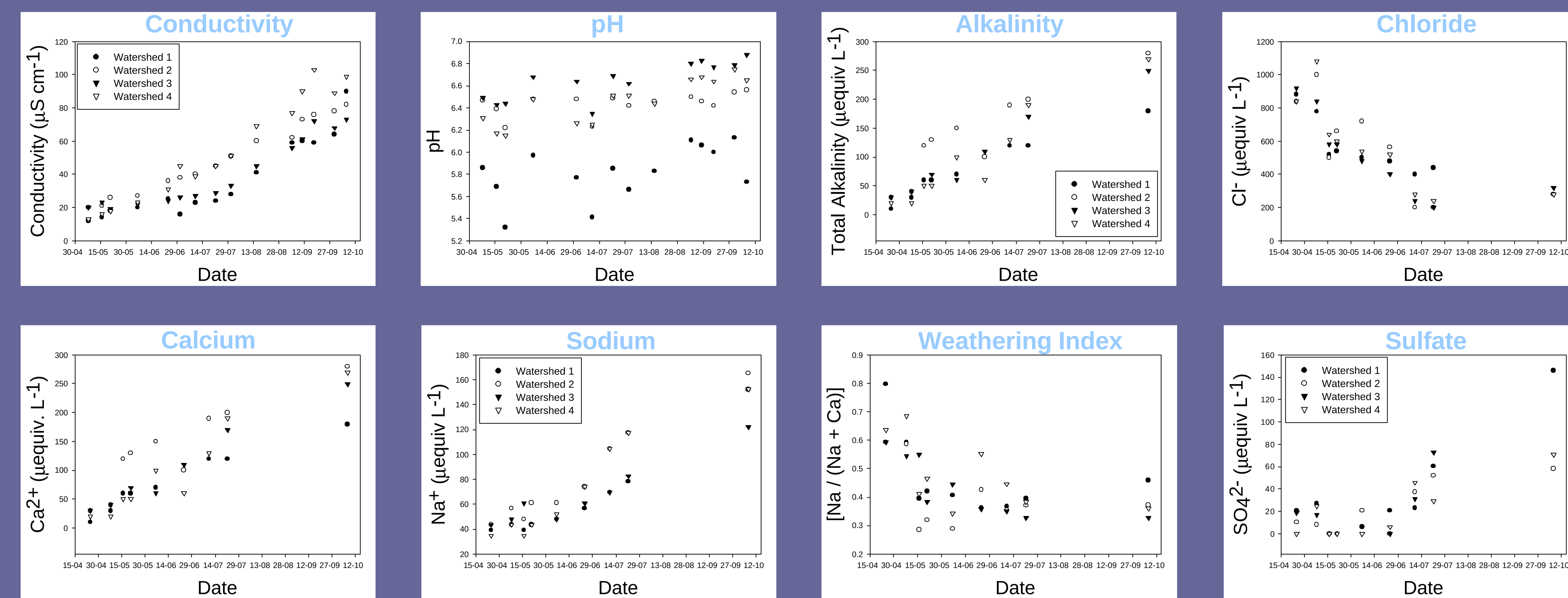
Surface-runoff tipping bucket

Zero-tension tipping bucket lysimeter

Soil pit containing lysimeters

Results

Stream water parameters during wet-to-dry season transition and dry season, 2003



Average pH, DOC and Ca^{2+}, May 2003

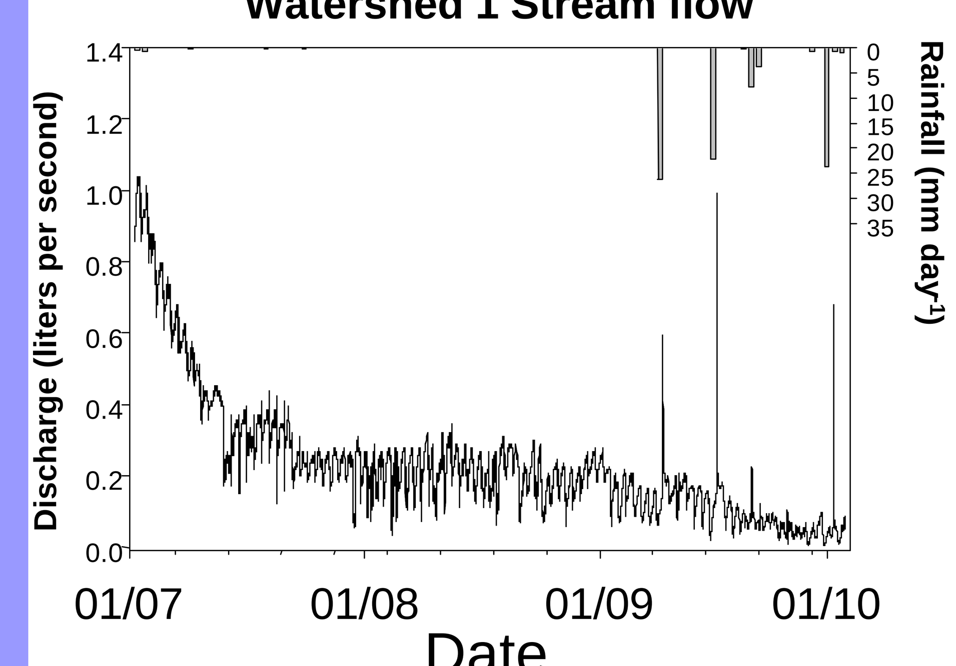
Differences between water quality of stream water and corresponding groundwater seeps (spring water) during base flow periods indicates in-stream DOC generation is likely occurring.

pH		
Watershed	Stream water	Spring water
1	5.6	5.3
2	6.4	5.0
3	6.5	5.1
4	6.2	5.0

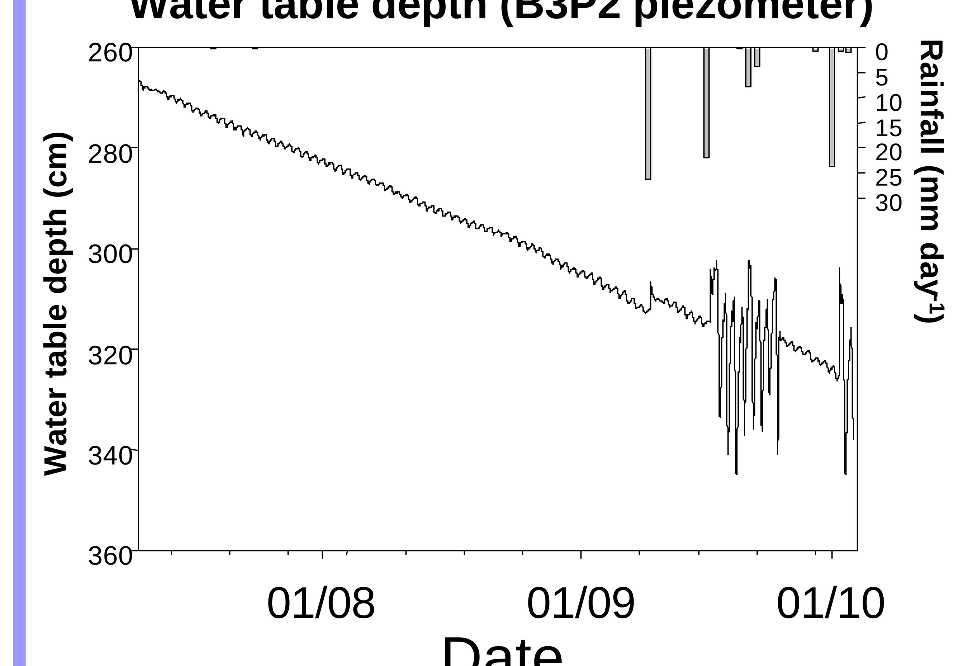
DOC (mg/L)		
Watershed	Stream water	Spring water
1	0.36	0.26
2	0.82	0.29
3	0.31	0.02
4	0.25	0.06

Ca^{2+} (µequiv. L^{-1})		
Watershed	Stream water	Spring water
1	89.82	21.61
2	149.70	34.93
3	99.80	36.43
4	94.81	59.88

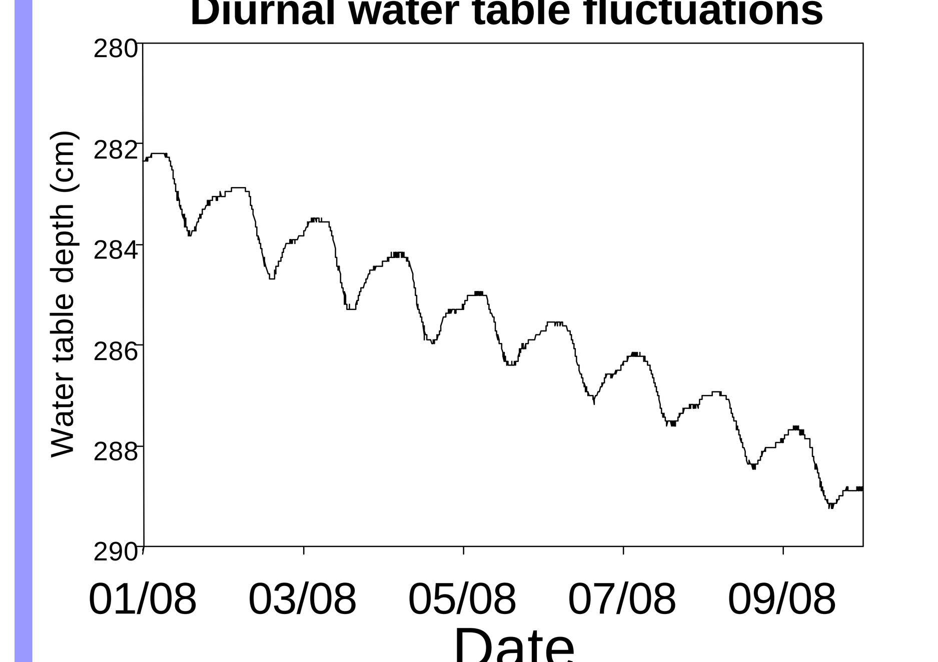
Watershed 1 Stream flow



Water table depth (B3P2 piezometer)



Diurnal water table fluctuations



References:

Markewitz, D., Davidson, E.A., Figueiredo, R.D.O., Victoria, R.L. and Krusche, A.V., 2001. Control of cation concentrations in stream waters by surface soil processes in an Amazonian watershed. Nature, 410(6830): 802-805.