Water Quality Contaminant Transport from Soils to Surface Water in Annual Rangelands

Toby O'Geen*, Alex Swarowsky*, Randy Dahlgren* & Ken Tate

***Department of Land, Air and Water Resources
University of California, Davis**

- Oak woodlands occupy ~3 million hectares in California






- Two-thirds of all drinking water reservoirs are located within oak woodland ecosystems

Objectives

Exp. 1. Identify the sources of dissolved organic matter from litter and duff of representative plant materials.

Exp. 2. Identify the dominant hydrologic flowpaths that deliver contaminants from soils to streams.

Exp. 3. Document the fate of DOC from source to the Yuba River.

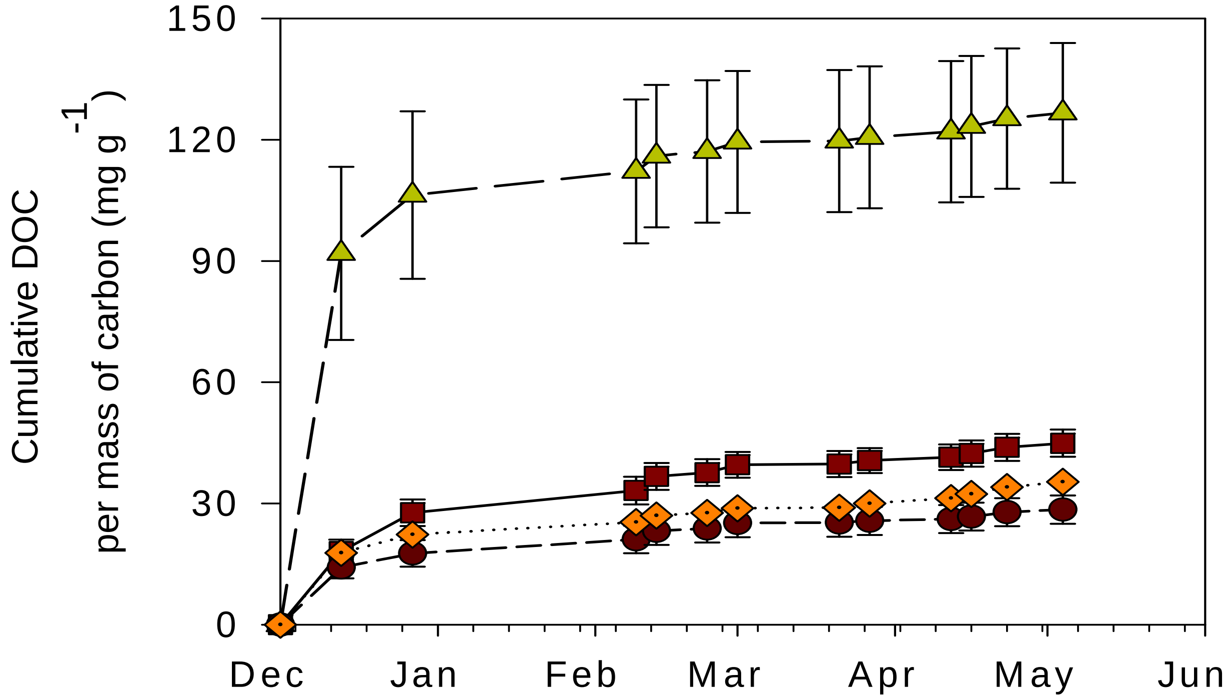
Exp. 4. Evaluate grazing management practices that minimize pollution.

Experiment 1-Sources of DOC

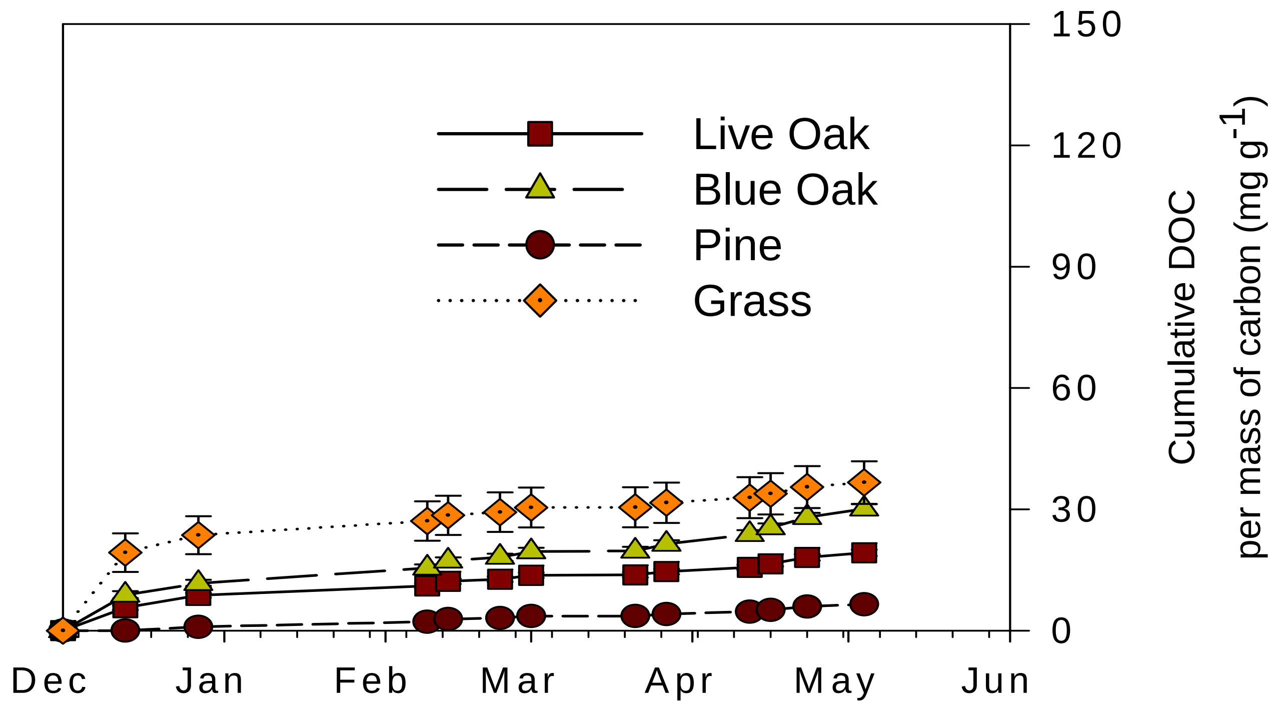
- **Litter and duff from dominant vegetation were exposed to rain events during 2006-07 water year to collect leachate**
  - Live oak (*Quercus wislizenii* A. DC.)
  - Blue oak (*Quercus douglassii* (H.&A.)
  - Foothill pine (*Pinus sabiniana*)
  - Annual grasses

Exp. 1. Source of DOC

Cumulative DOC (Litter)

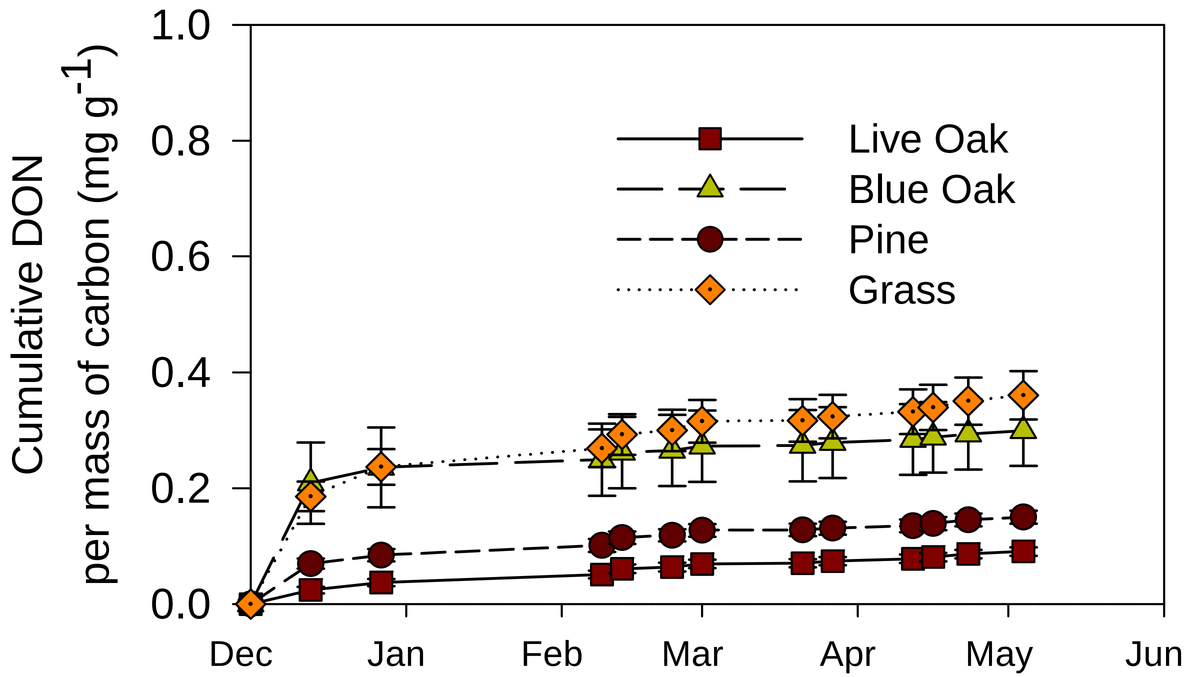


Cumulative DOC (Duff)

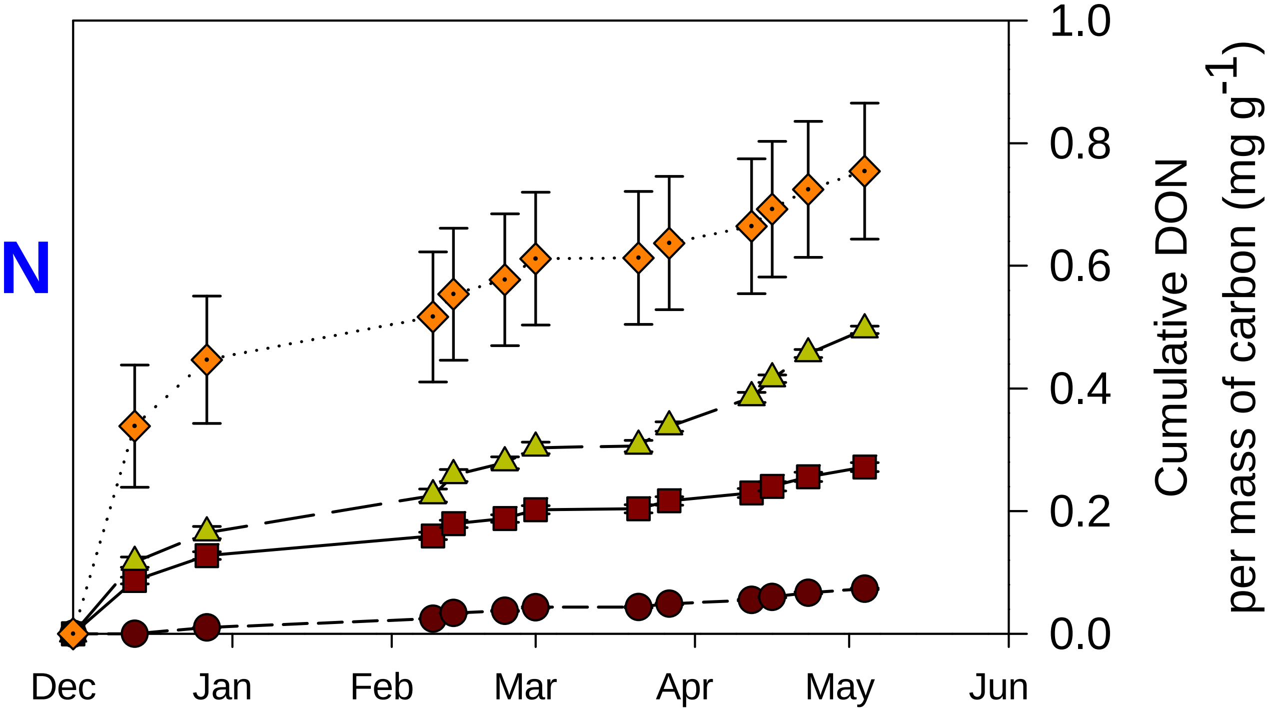


Exp. 1. Source of DON

Cumulative DON (Litter)



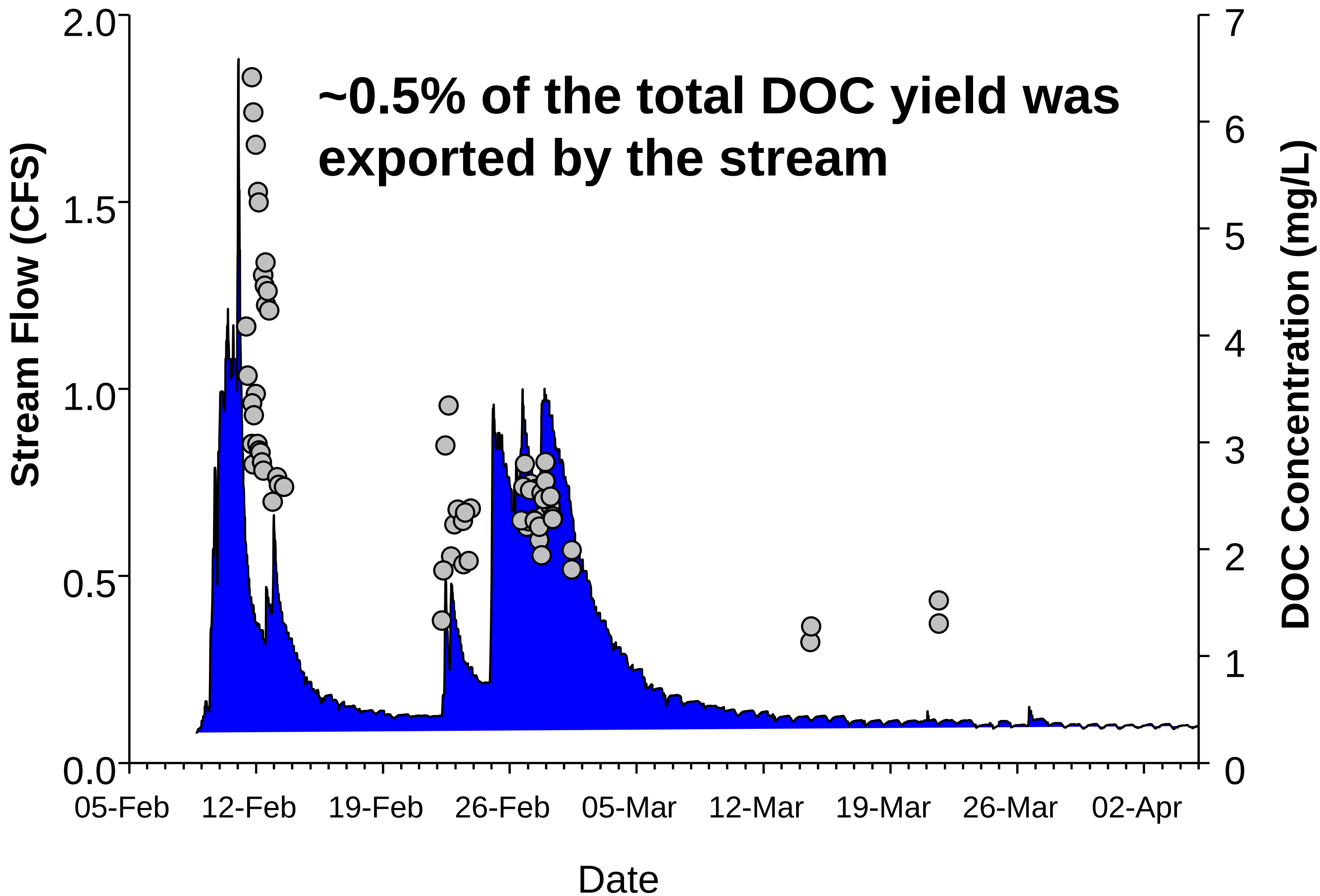
Cumulative DON (Duff)



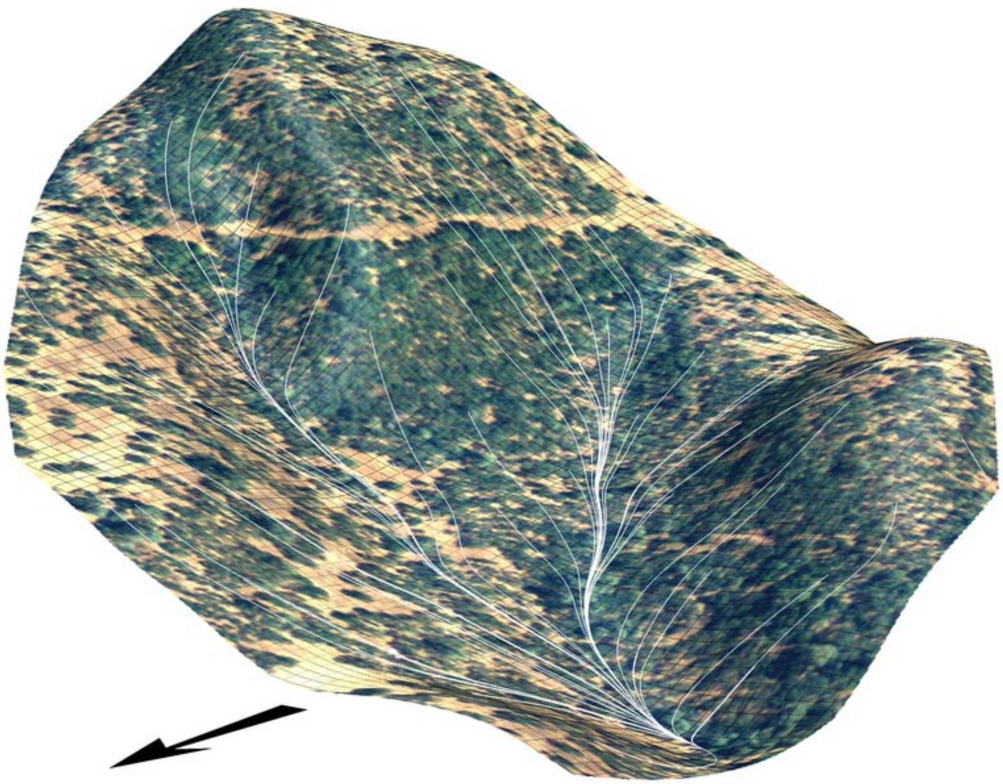
Maximum potential production of DOC, DON, THMs, and HANs from litter and duff

Sample	DOC (kg ha^{-1})	DON (kg ha^{-1})	THMs (kg ha^{-1})	HANs (kg ha^{-1})
Litter				
Live Oak	2.8	0.01	0.08	0.01
Blue Oak	74	0.28	2.1	0.38
Pine	2.7	0.02	0.06	0.01
Grass	31	0.32	0.93	0.09
Duff				
Live Oak	3.5	0.05	0.11	0.01
Blue Oak	300	4.9	9.9	1.2
Pine	6.0	0.07	0.16	0.02
Grass	24	0.38	0.45	0.06
Total*	445	6.0	14	1.8

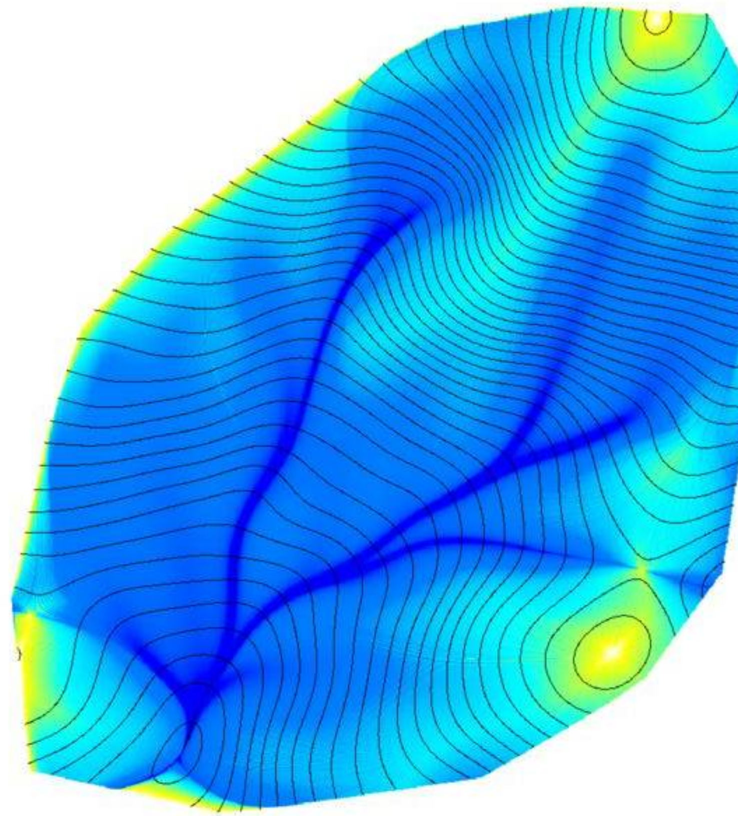
Exp. 1. DOC export from the watershed



Experiment 2-Hydrologic flowpaths in an experimental watershed



Sierra Foothill Research and Extension Center's Experimental Watershed

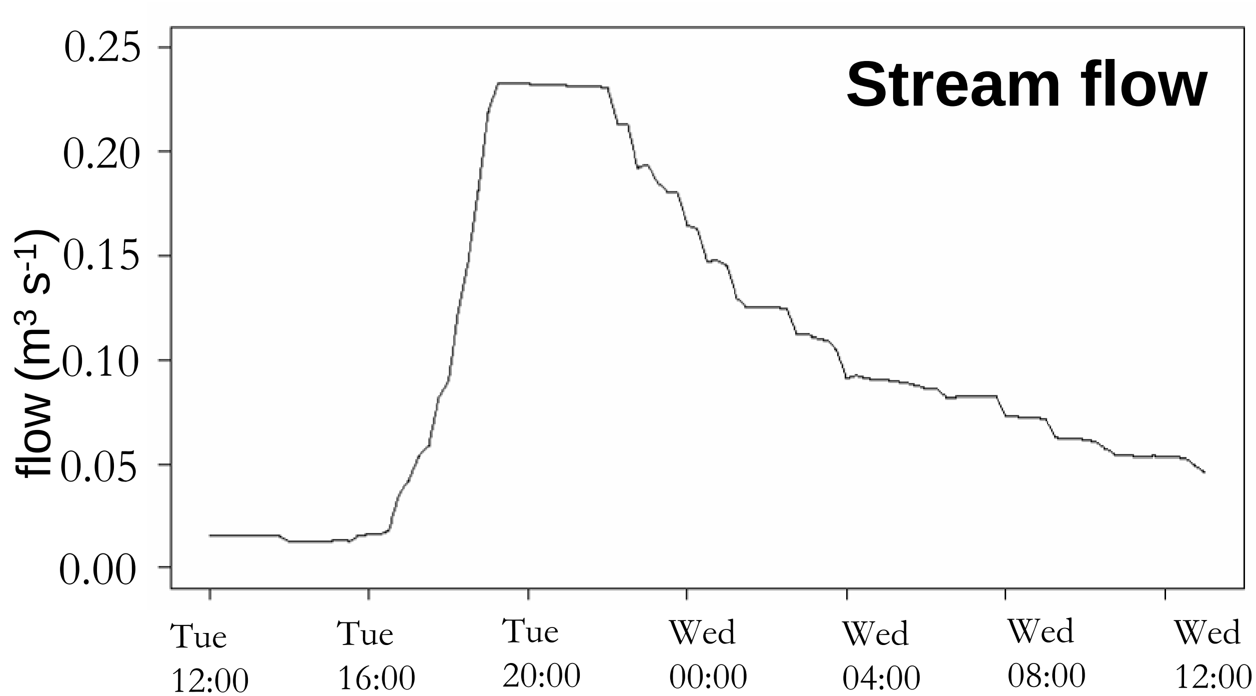


Hydrologic flowpath determined by surface topography

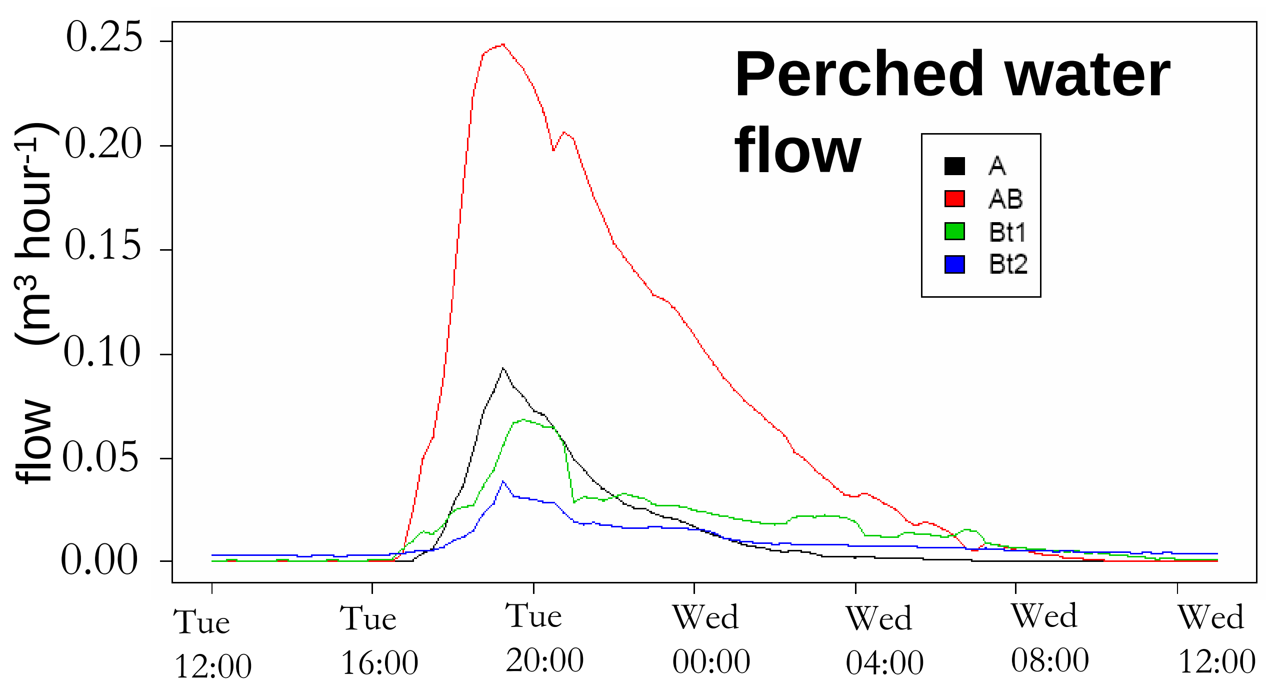
Monitoring infrastructure

Stream flow, perched water, soil water content, groundwater, bypass flow, and surface runoff

Exp. 2. Flowpaths

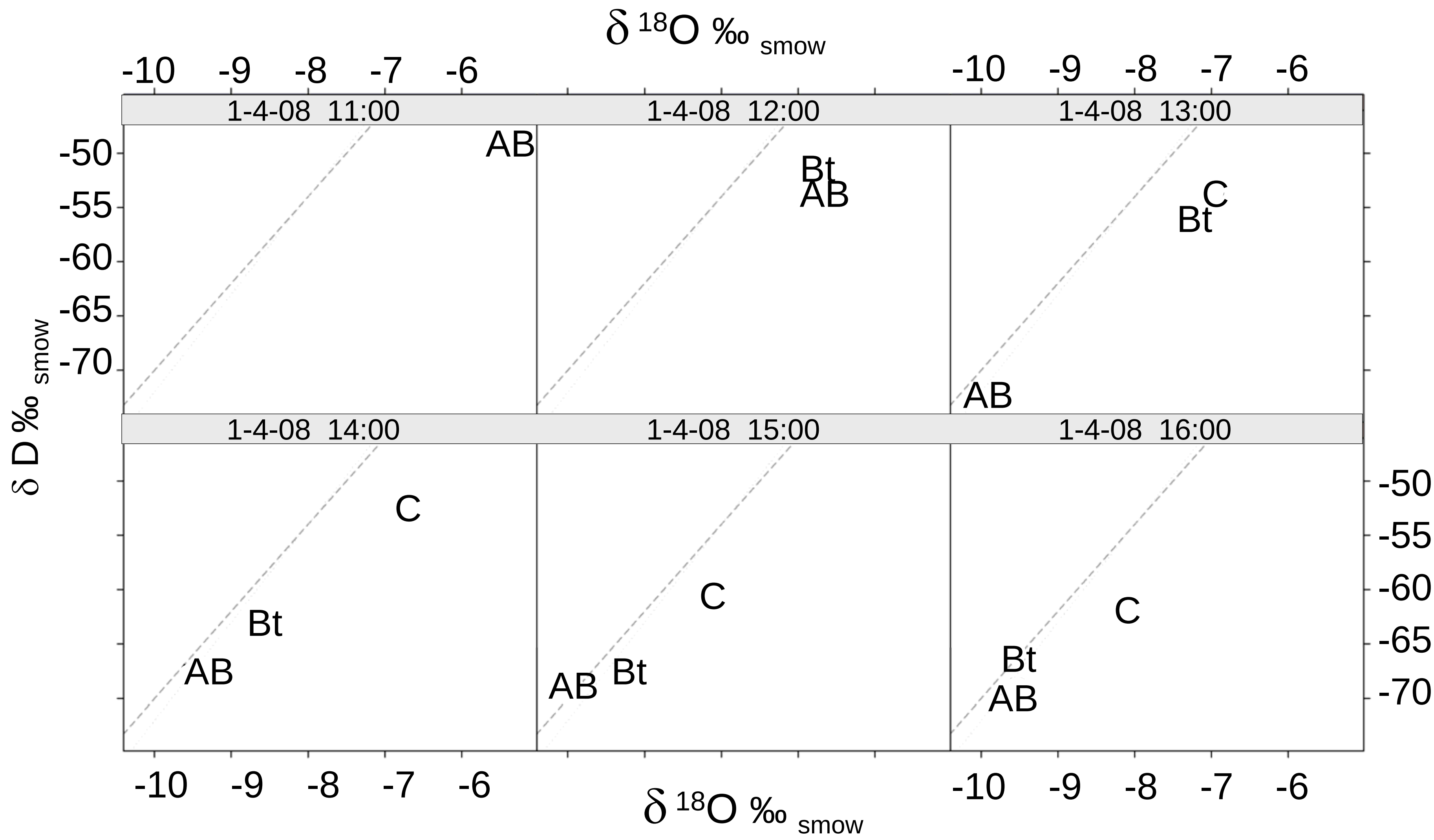


Stream flow corresponds with perched water flow above Bt1.

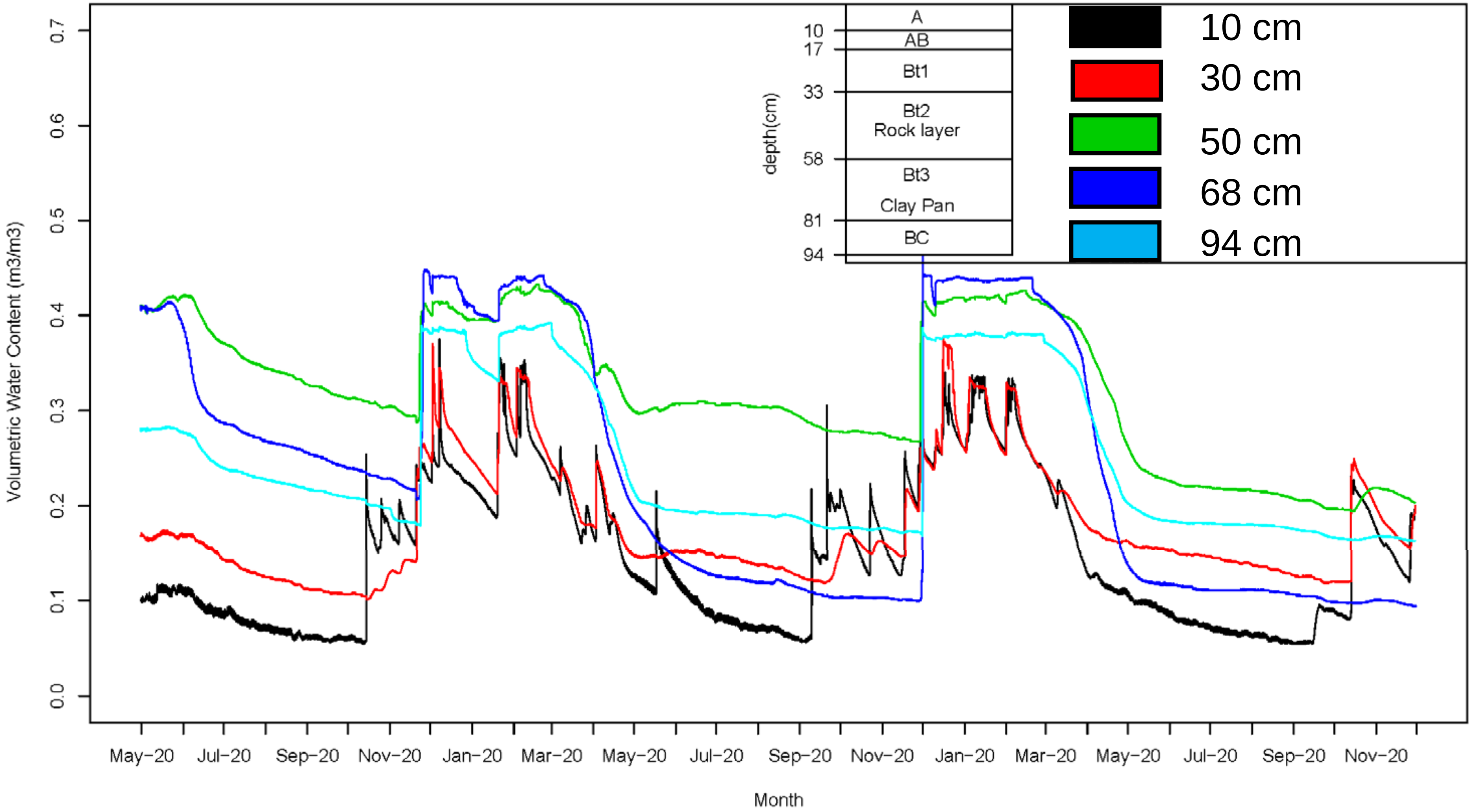


AB horizon supplies largest water volume

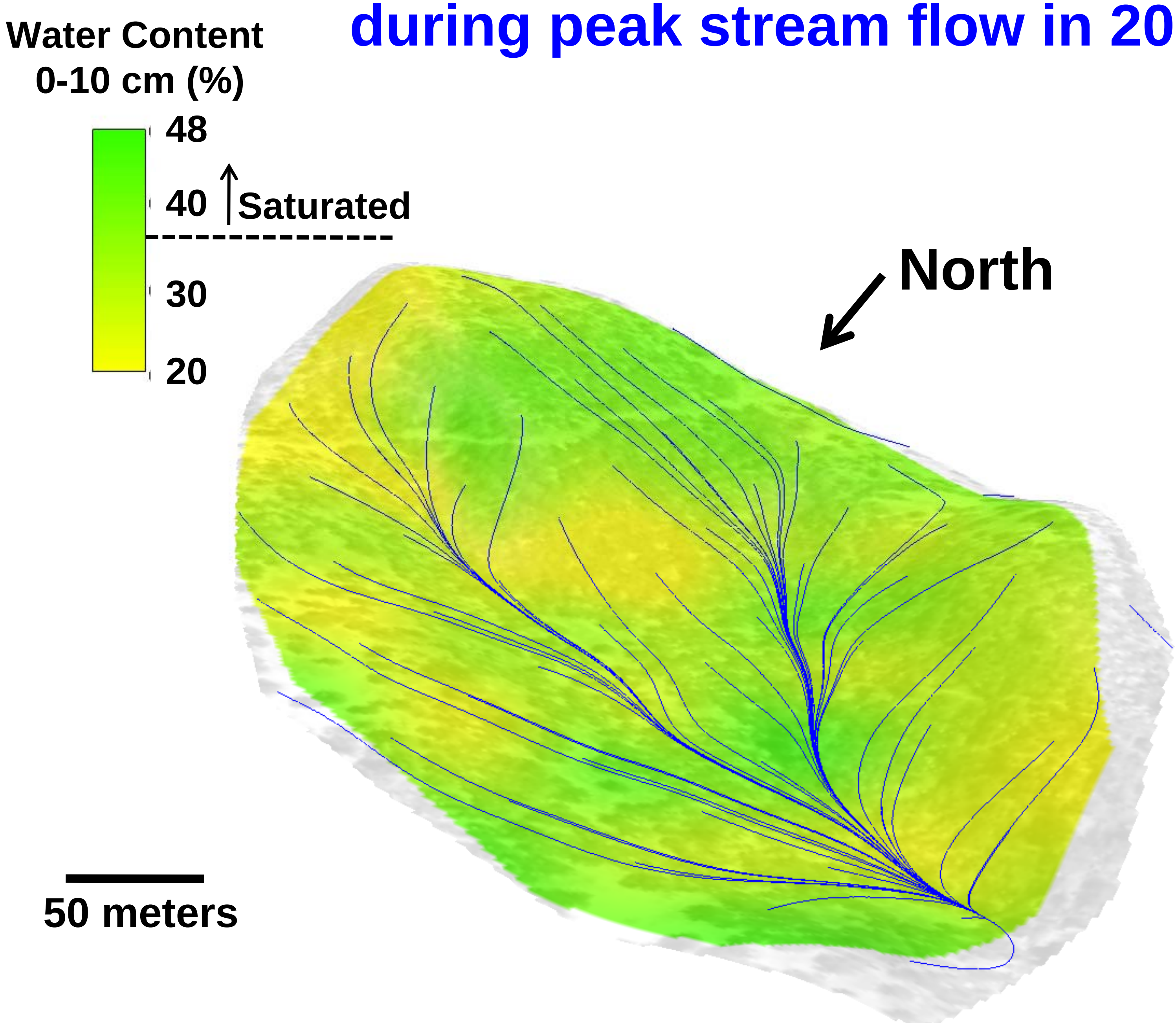
Exp. 2. Isotopic signature of perched water is similar to stream water.



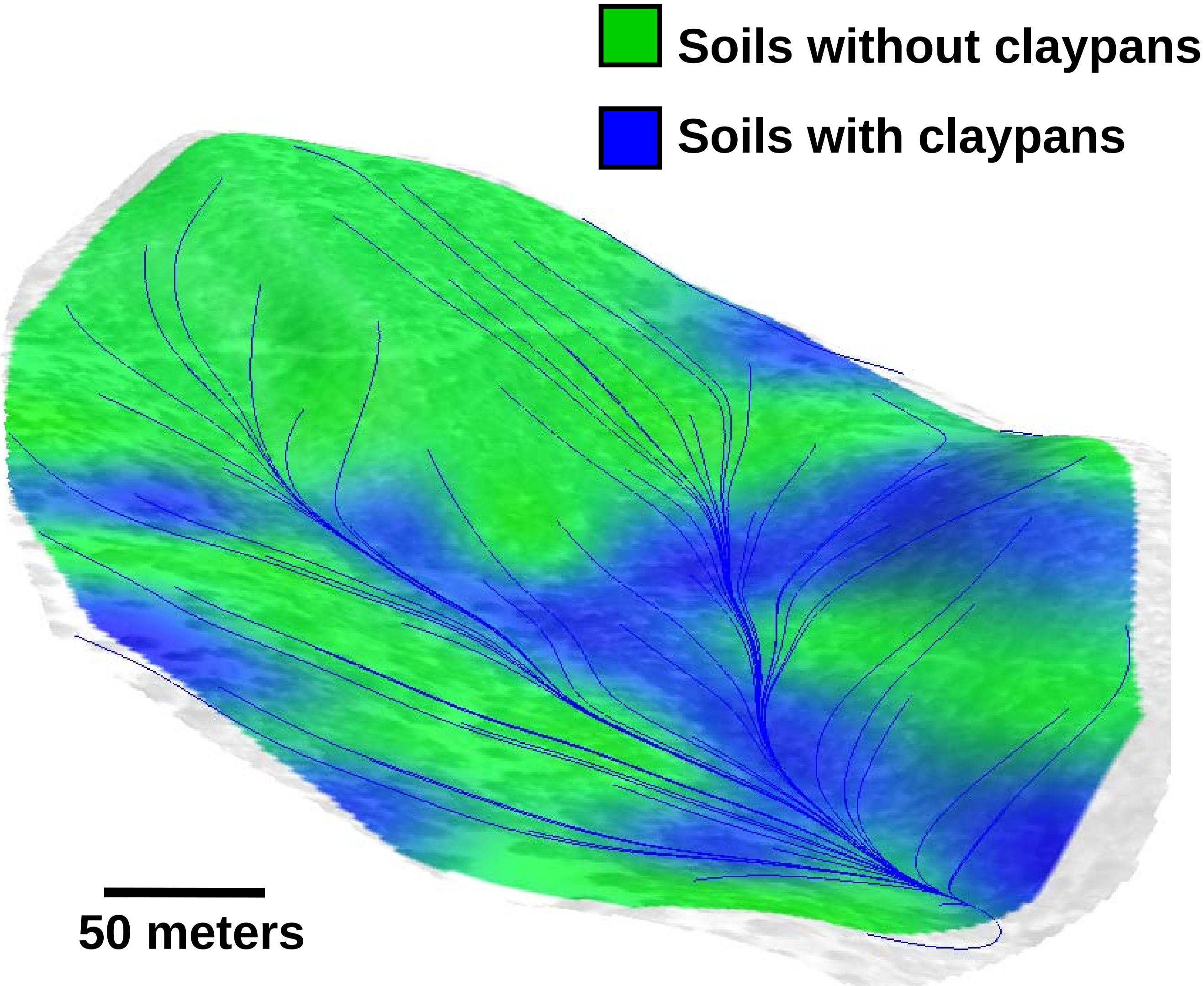
Exp. 2. Temporal changes in soil water content 2006-2008



Exp. 2. Distribution of soil moisture during peak stream flow in 2008

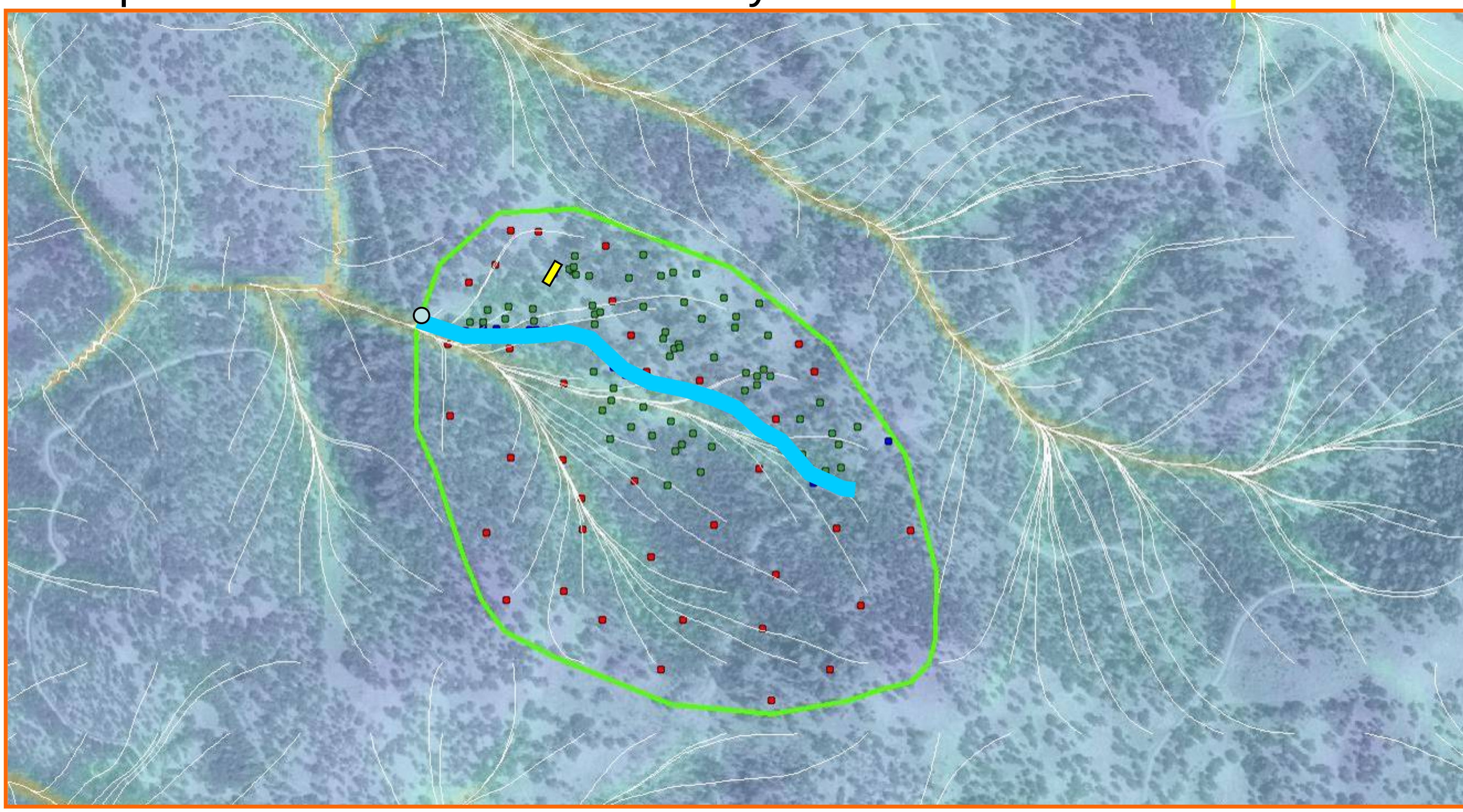


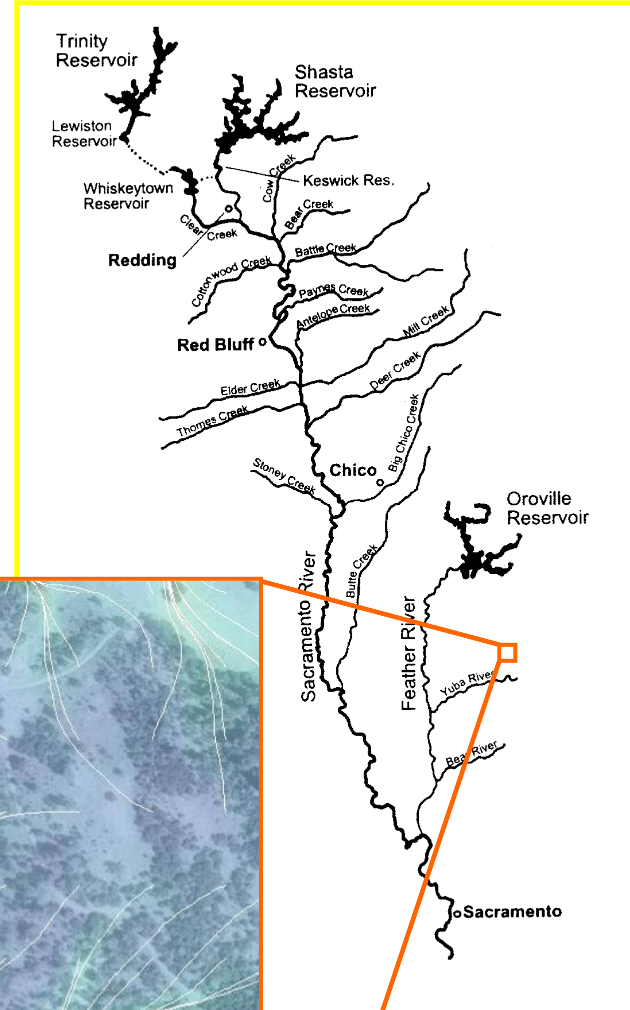
Exp. 2. Spatial extent of soils with claypans



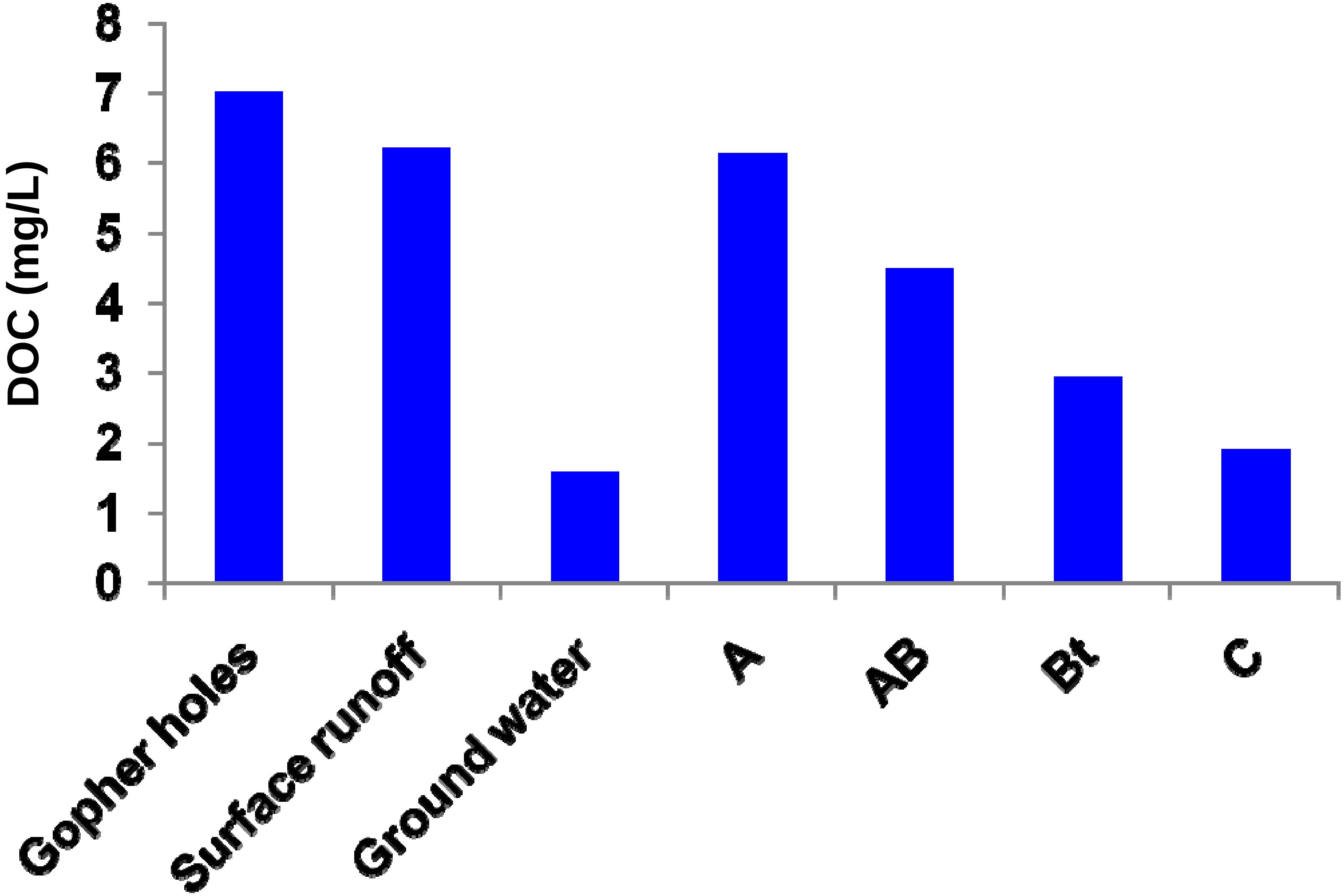
Experiment 3-Fate of DOC in Yuba R. Watershed: From soils to surface water

- Perched water monitoring station
- Stream flow monitoring station
- Ephemeral stream
- Experimental watershed boundary

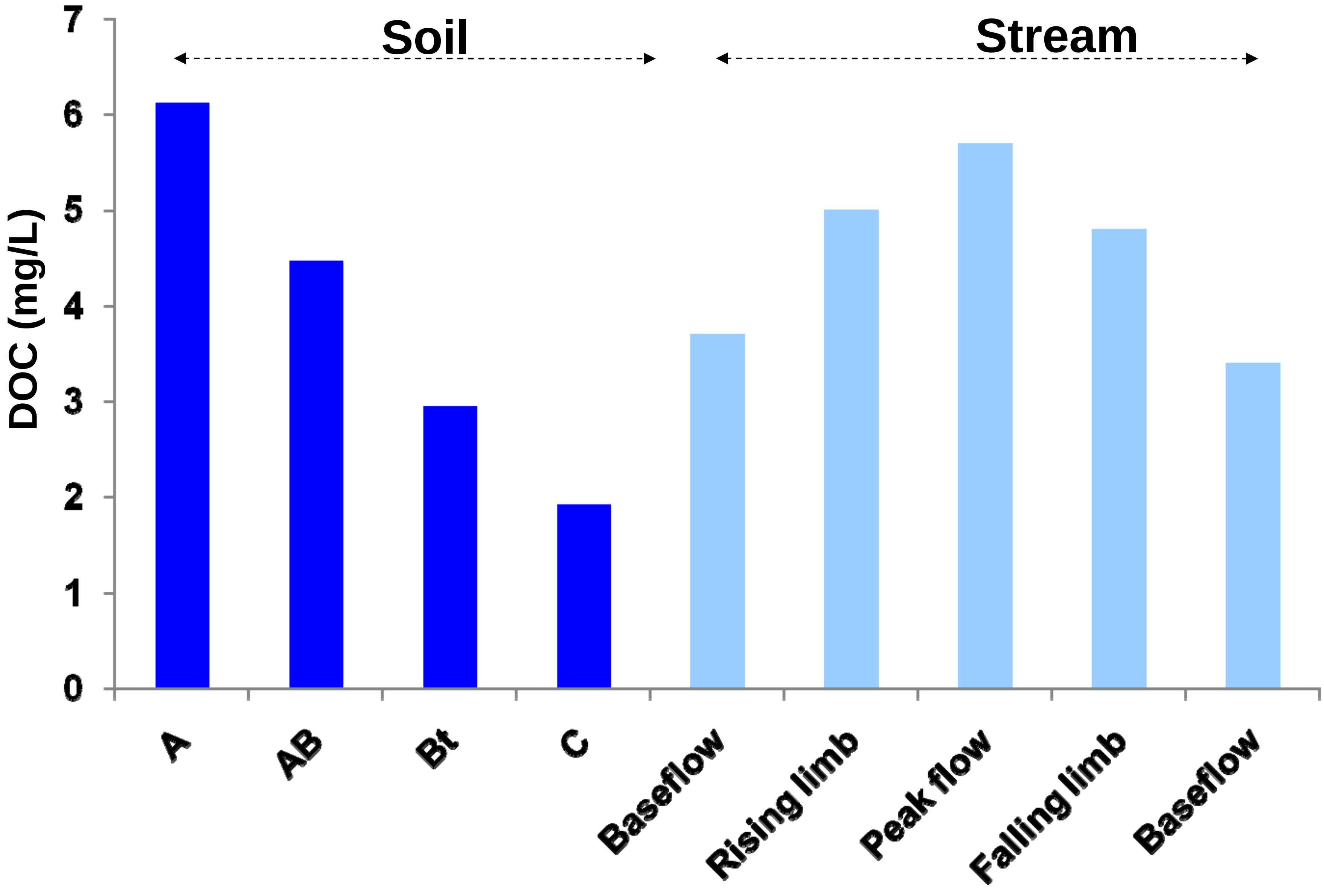




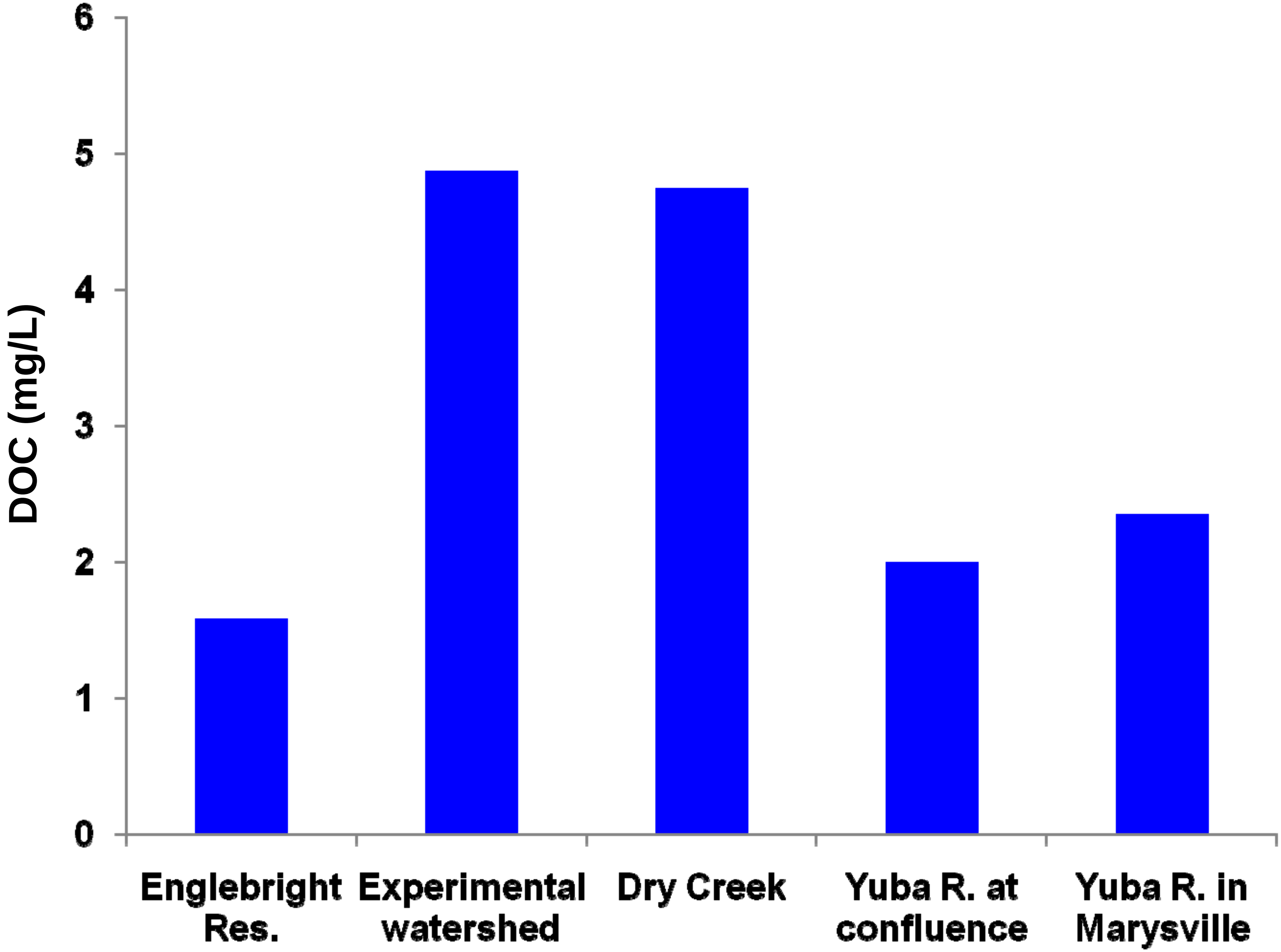
Exp. 3. Average [DOC] in hydrologic flowpaths



Exp. 3. [DOC] in soils vs. stream



Exp. 3. Fate of DOC in the Yuba River watershed

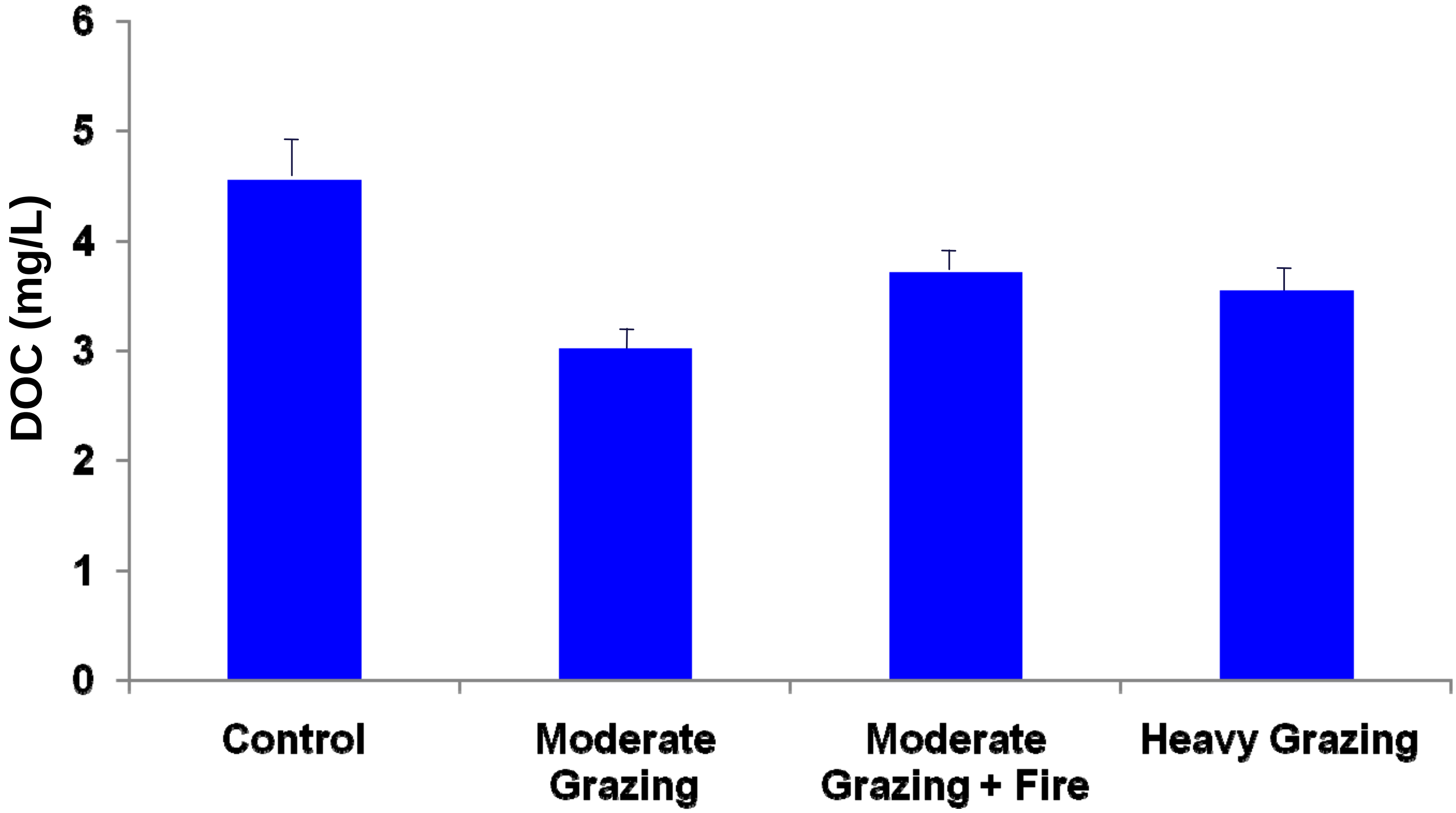


Experiment 4-Evaluating rangeland BMPs

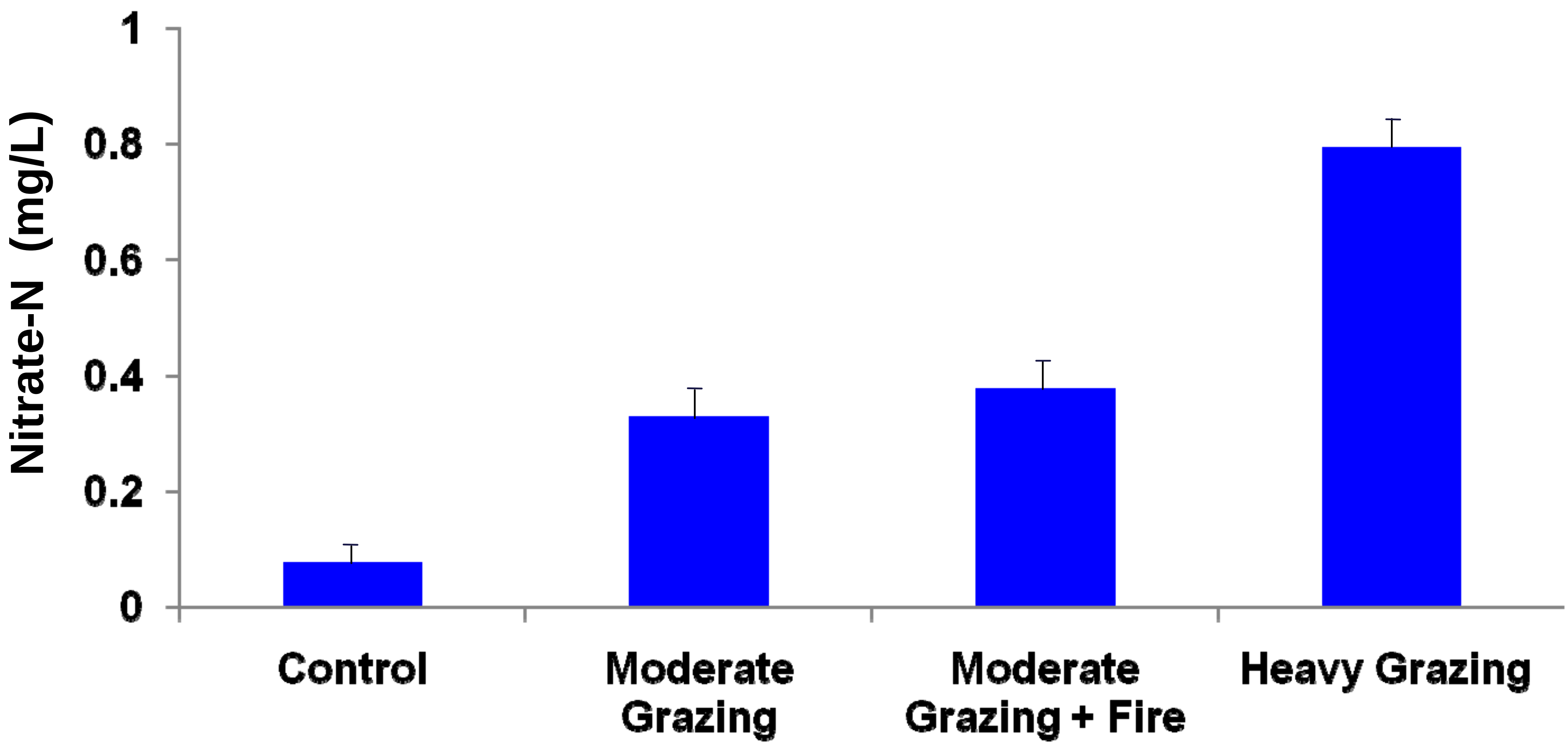
Paired Watersheds

- **Control - no grazing for 10 yrs**
- **Moderate grazing – 10 yrs at 1000 lbs/acre residual dry matter (RDM)**
- **Moderate grazing – 10 yrs at 1000 lbs/acre RDM + prescribed fire in 2004**
- **Heavy grazing – 10 yrs at 500 lbs/acre RDM**

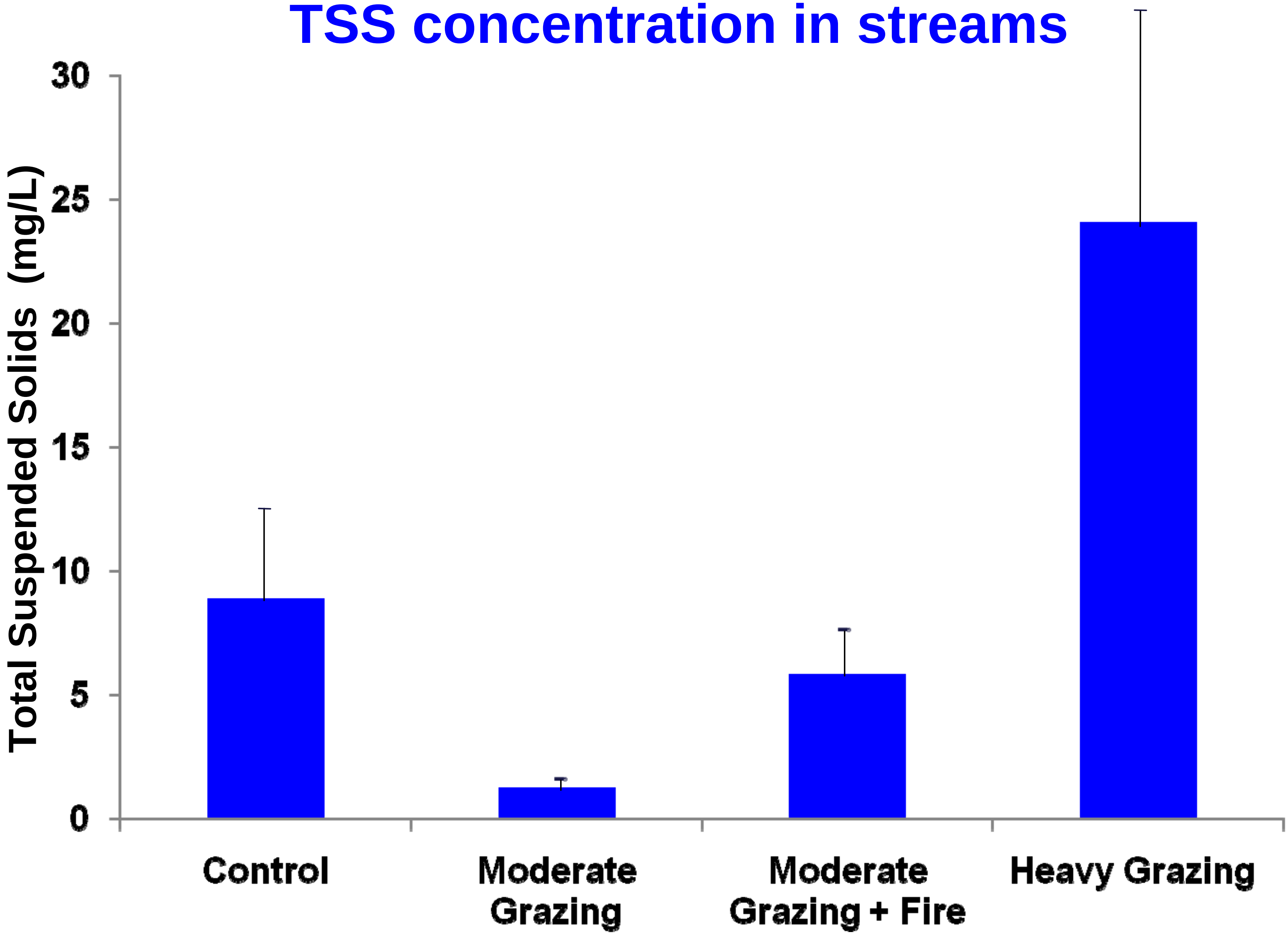
Exp. 4. Effects of rangeland management on dissolved organic carbon concentration in streams



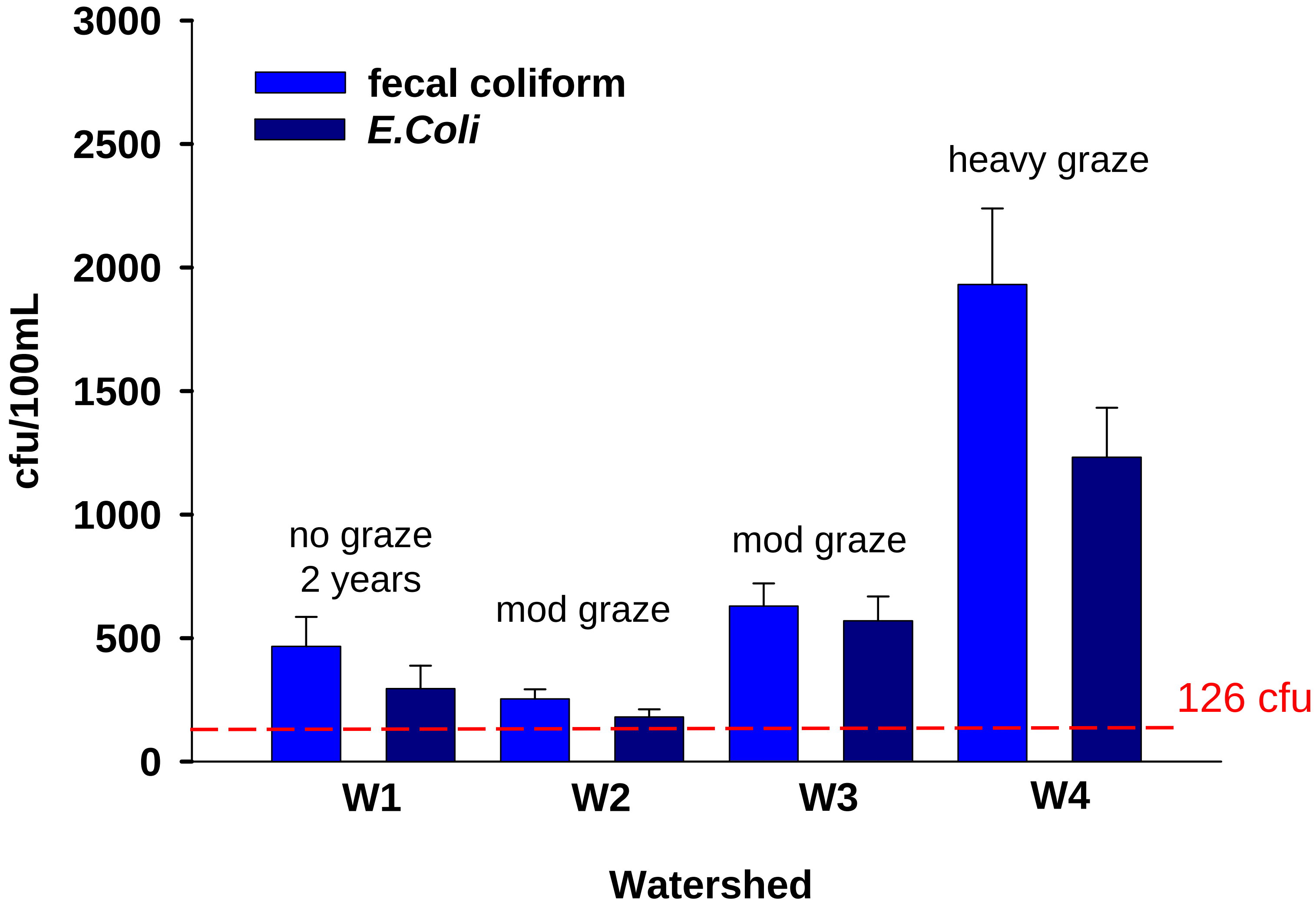
Exp. 4. Effects of rangeland management on nitrate-N concentration in streams



Exp. 4. Effects of rangeland management on TSS concentration in streams



SFREC – observe variable difference among non-grazed and moderately grazed watersheds, background not = 0.



Summary Exp. 1.

- **Most DOC and DON is leached during the first storm events of the season.**
- **Blue oak and annual grass litter and duff had the highest potential production of THMs and HAAs due to their spatial extent and biomass production.**
- **0.5% of the total DOC yield was exported by the stream and the major source of stream flow is the AB horizon.**

Summary Exp. 2. & 3.

- **Lateral flow of perched water is the main flowpath dictating steam water quality.**

- **The connectivity of lateral flow to streams is governed by the spatial extent of the claypan.**

- **In the dry years studied, the claypan also influences surface runoff by affecting the spatial extent of surface saturation.**

- **DOC was highest in perched water, gopher holes and surface runoff matching stream levels during stormflow.**

- **DOC is high in 1st and 2nd order streams, but attenuated in the Yuba River to low levels.**

Summary Exp. 4.

- **DOC export was higher in the ungrazed watershed due to the amount of biomass.**

- **Nitrate-N was significantly higher in the heavily grazed watershed, but low relative to other land uses,**

- **TSS & pathogen indicators were significantly higher in the heavily grazed watershed.**

- **Moderate grazing reduces biomass (decreasing DOC production), and limits TSS, pathogen, and nitrate runoff.**

- **The effects of prescribed fire were not detectable after four years.**

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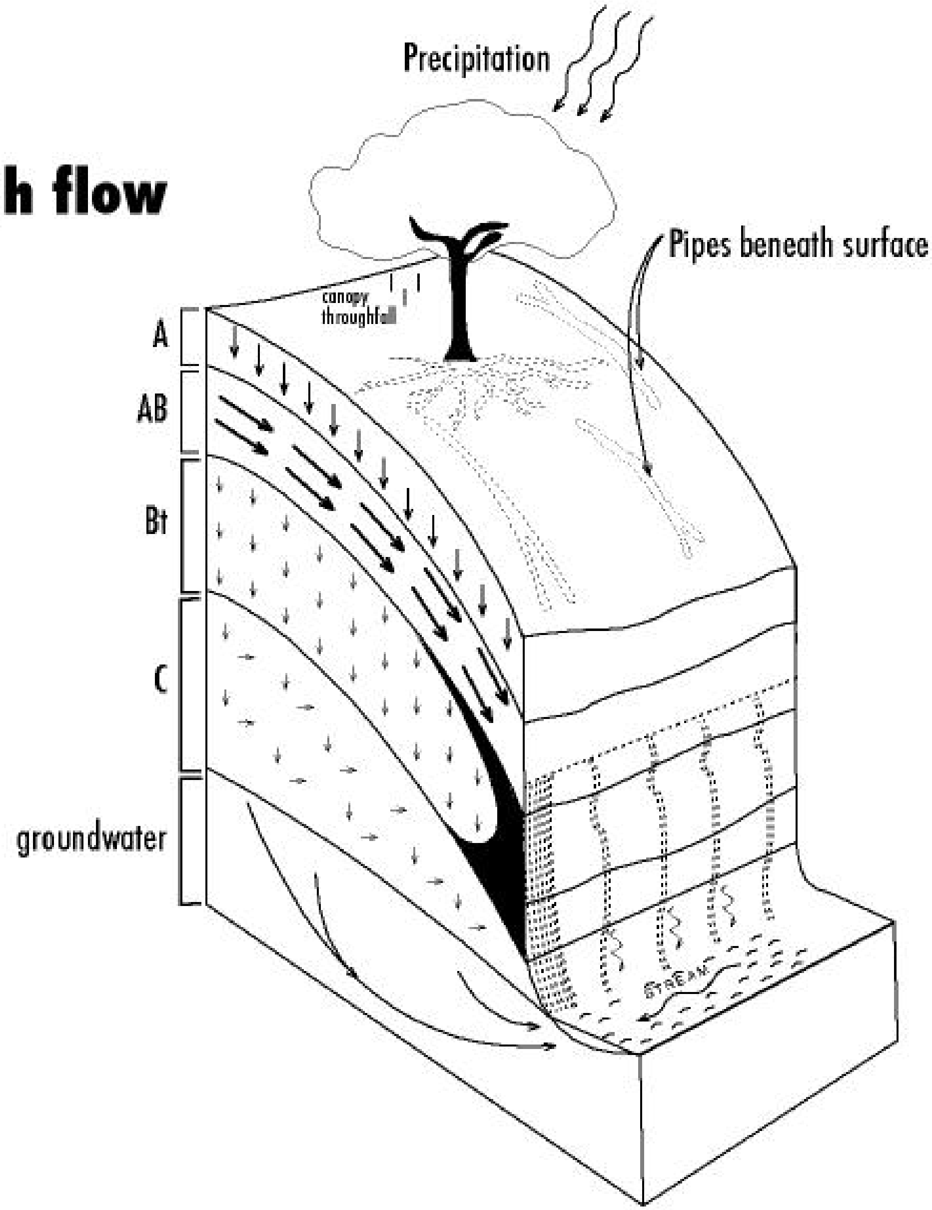
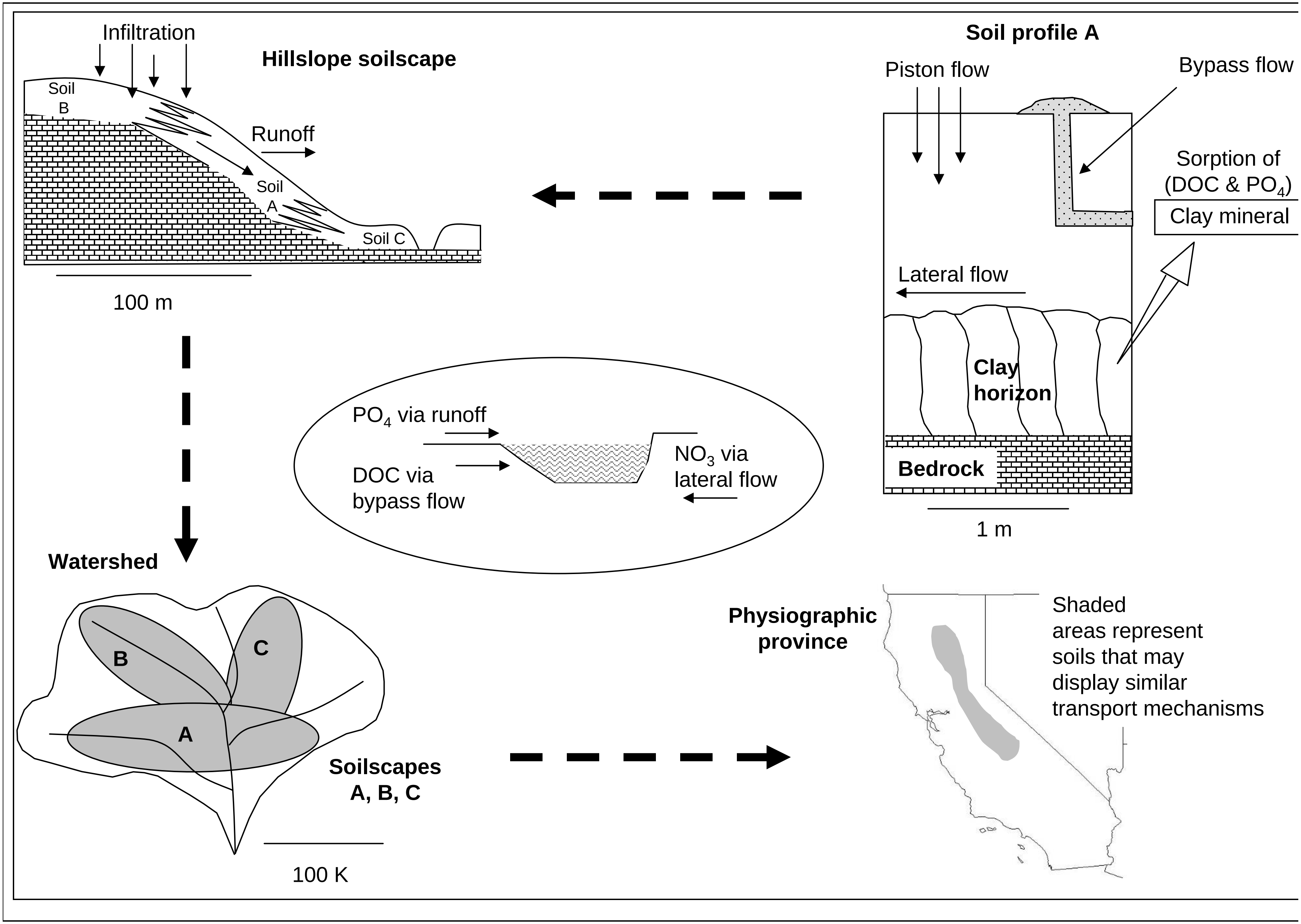
Exp. 1. Reactivity of disinfection byproduct formation

	THM-FP	HAA-FP	HAN-FP	CHD-FP
	------------------------ mmol mol-C^{-1} ------------------------			
	------------------ Litter ------------------			
Live Oak	3.36	2.69	0.15	0.18
Blue Oak	3.36	2.65	0.12	0.16
Foothill Pine	2.09	1.78	0.15	0.17
Annual Grass	3.41	2.76	0.20	0.22
	------------------ Duff ------------------			
Live Oak	3.49	2.72	0.28	0.25
Blue Oak	3.39	2.61	0.34	0.28
Foothill Pine	3.07	2.49	0.37	0.28
Annual Grass	1.80	1.62	0.31	0.16

THM trihalomethanes; HAA haloacetic acid; HAN haloacetonitriles, CHD chloral hydrates

High flow


Precipitation
Pipes beneath surface
canopy
throughfall
A
AB
Bt
C
groundwater
STREAM



Infiltration
Hillslope soilscape
Soil B
Runoff
Soil A
Soil C
100 m
Soil profile A
Piston flow
Bypass flow
Sorption of (DOC & PO_4)
Clay mineral
Lateral flow
Clay horizon
Bedrock
1 m
PO_4 via runoff
DOC via bypass flow
NO_3 via lateral flow
Watershed
B
C
A
Soilscapes A, B, C
100 K
Physiographic province
Shaded areas represent soils that may display similar transport mechanisms