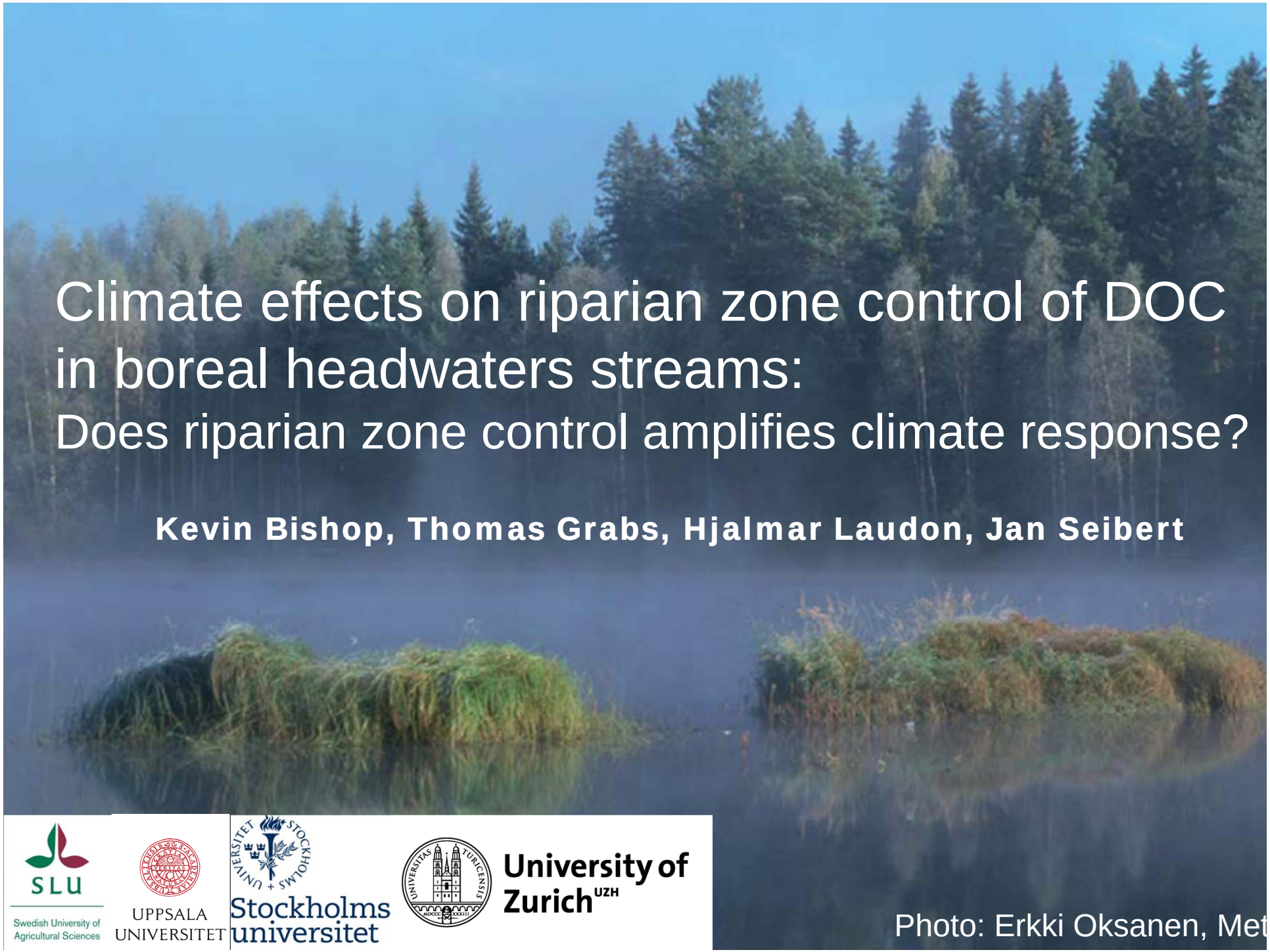


Climate effects on riparian zone control of DOC in boreal headwaters streams:
Does riparian zone control amplifies climate response?

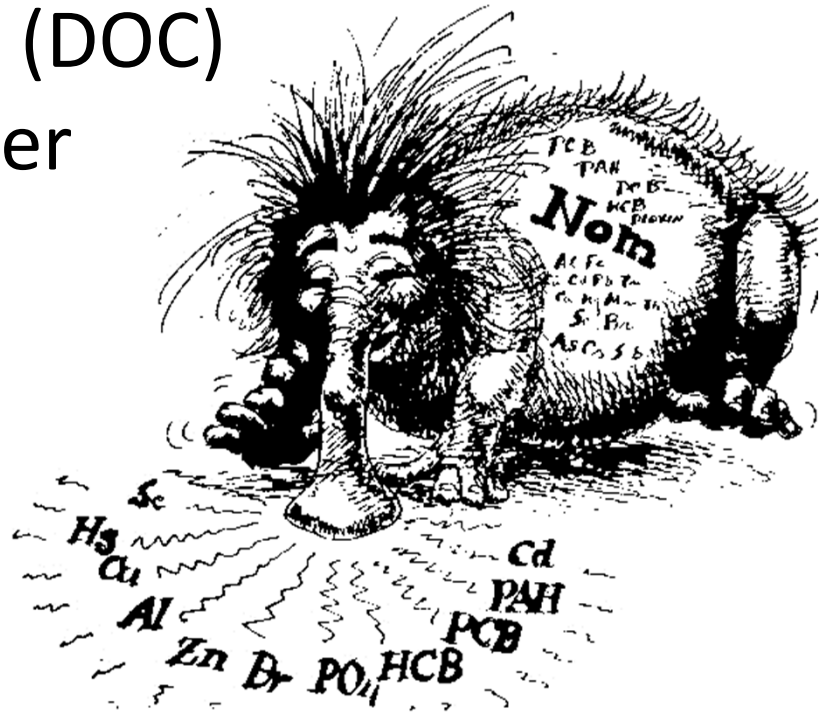
Kevin Bishop, Thomas Grabs, Hjalmar Laudon, Jan Seibert

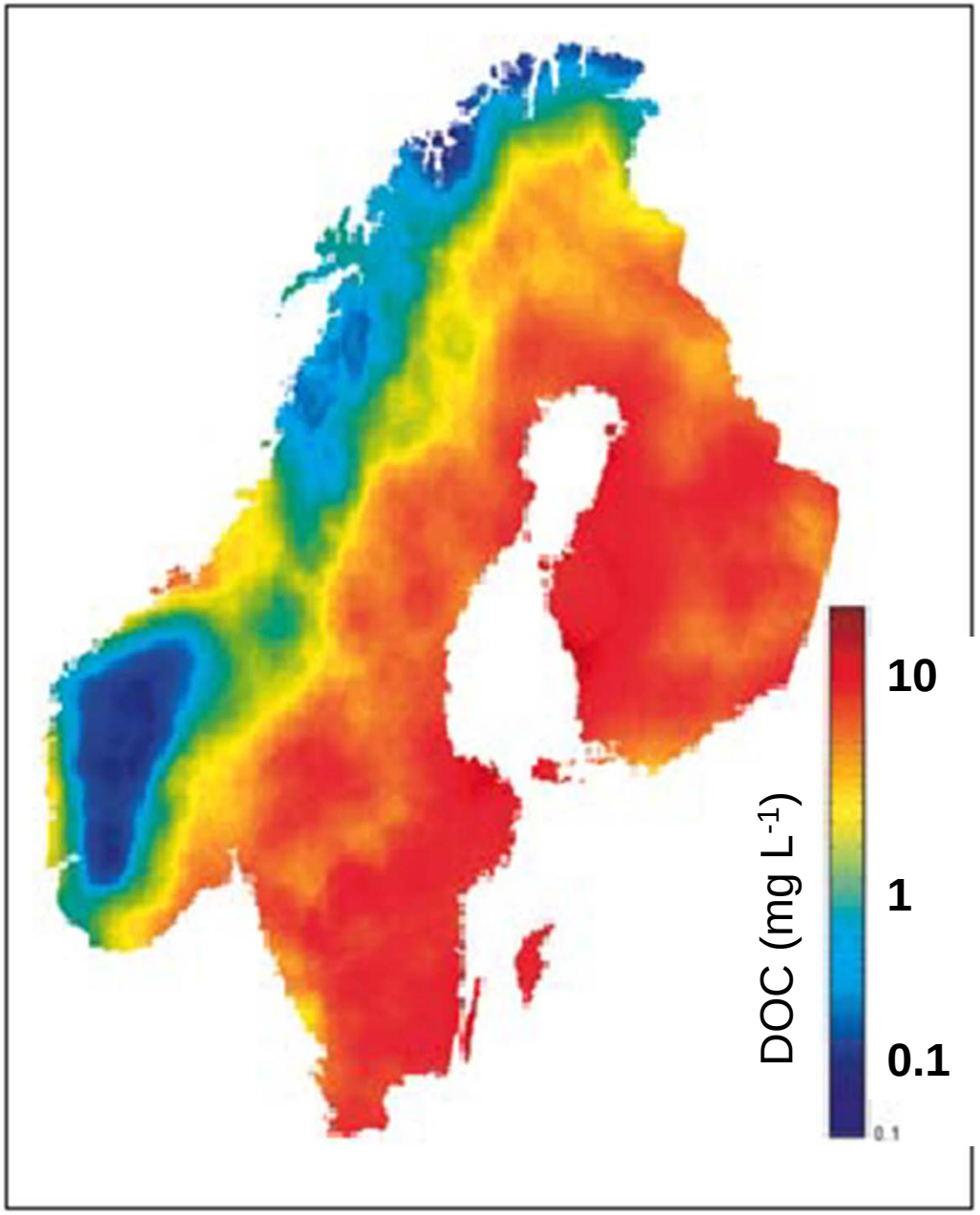
SLU Swedish University of Agricultural Sciences
UPPSALA UNIVERSITET
Stockholms universitet
University of Zurich[UZH]

Photo: Erkki Oksanen, Met

Dissolved Organic Carbon (DOC)
Natural Organic Matter

– A nasty beast





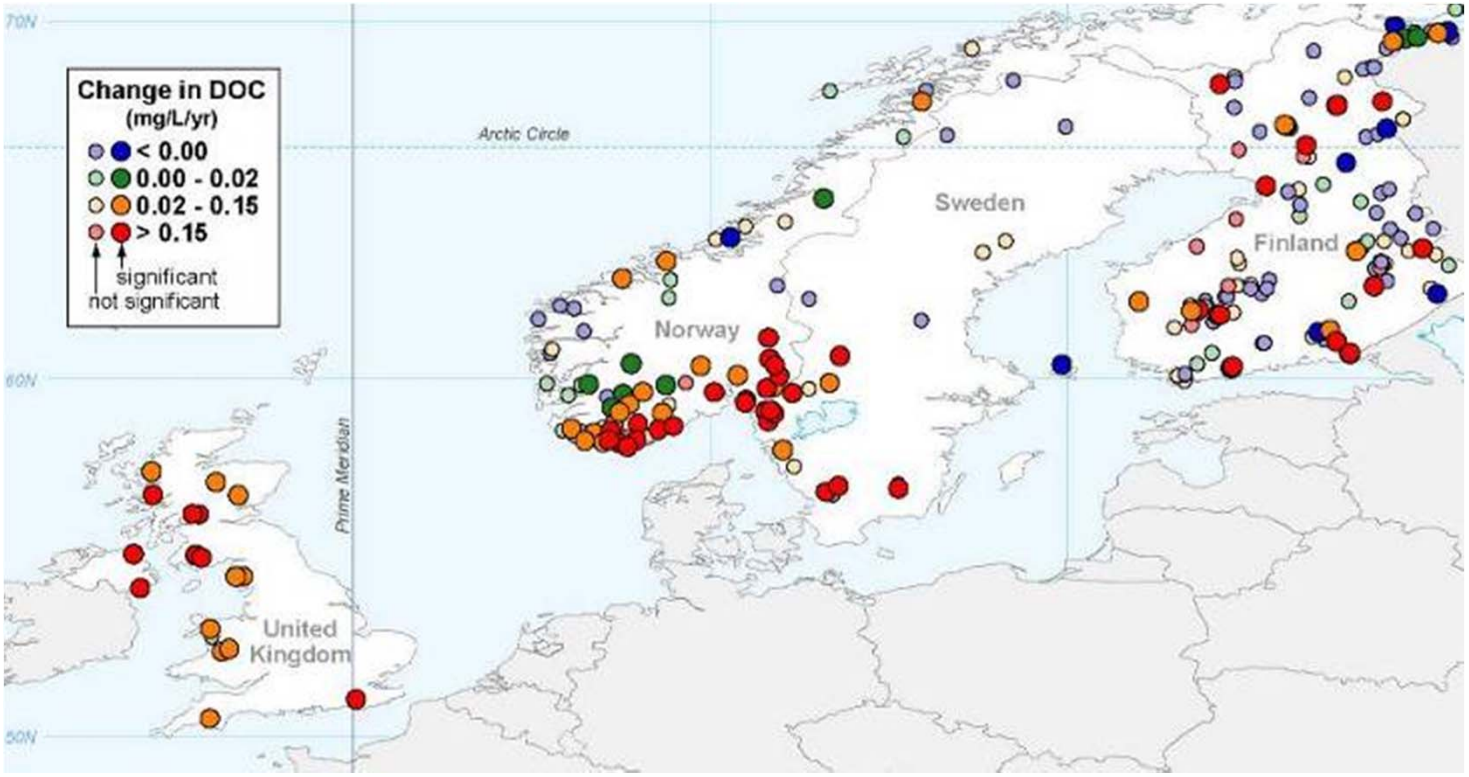
DOC in Fenno-Scandian Surface Water

There is lots – defines aquatic life,

impacts drinking water

DOC is increasing!

- 50%-100% increase 1990-2005

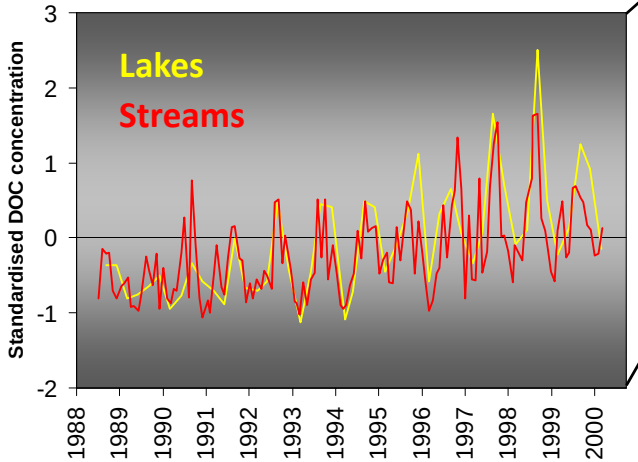


Monteith,et al. 2007 Nature

Why is DOC is Rising!

- Temperature originally linked via “enzymatic latch”.
- Other Suggestions:
  Rainfall, Acidification Recovery
  Ionic strength, N-dep, CO_2

  Still looking for mechanism(s)…




brief communications

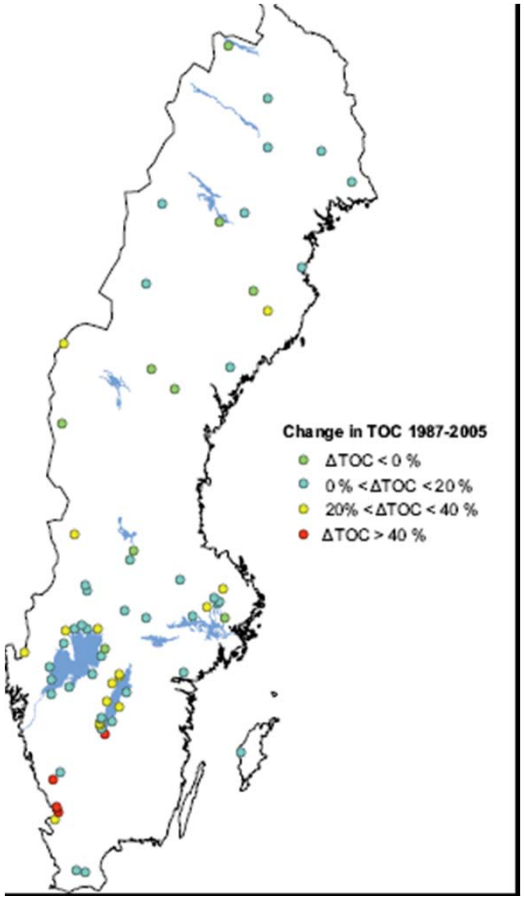
Export of organic carbon from peat soils

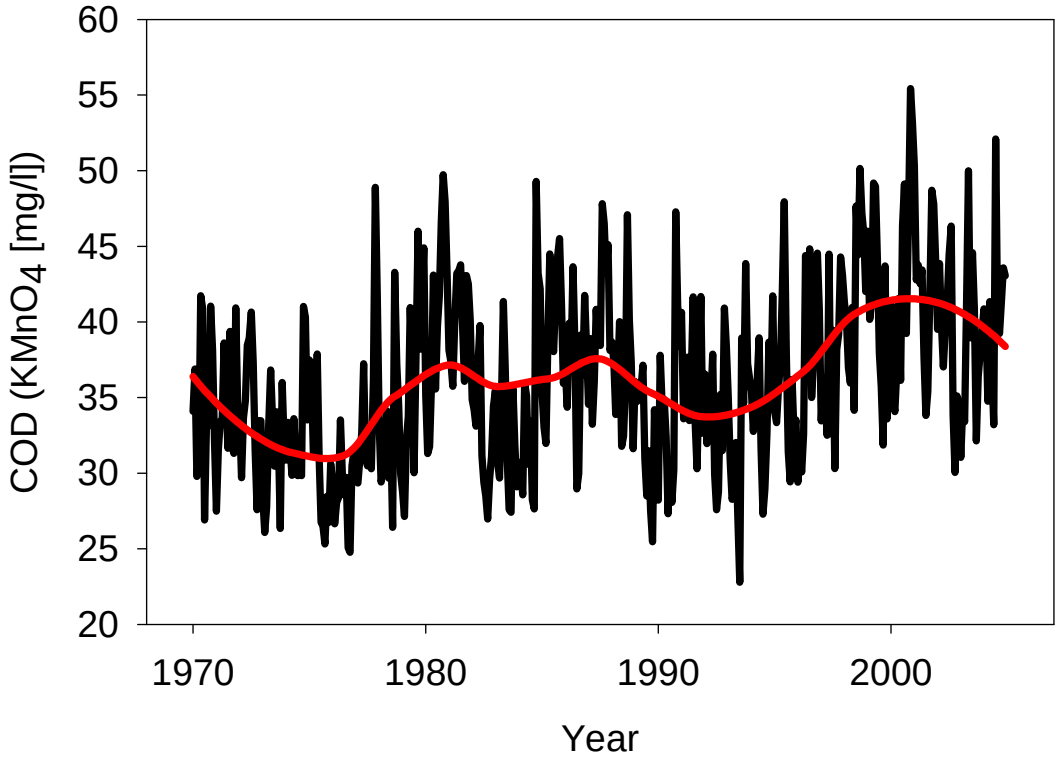
Warmer conditions may be to blame for the exodus of peatland carbon to the oceans.

Ancient homes for hard-up hermit crabs

C. Freeman, C.D. Evans, D.T. Monteith, B. Reynolds and N. Fenner. Nature (2001)

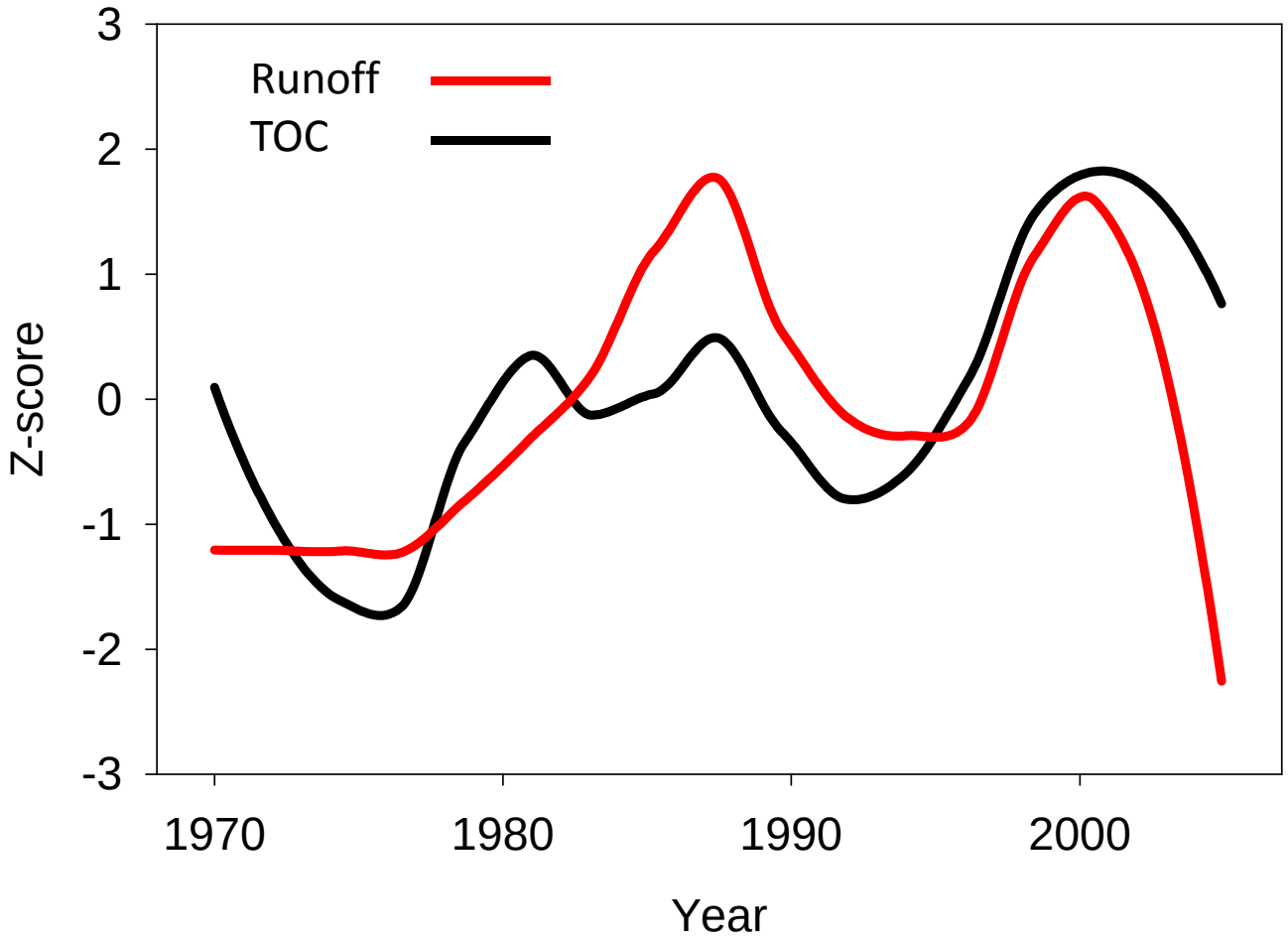
But the time-series for 35 years show both increasing and decreasing trends



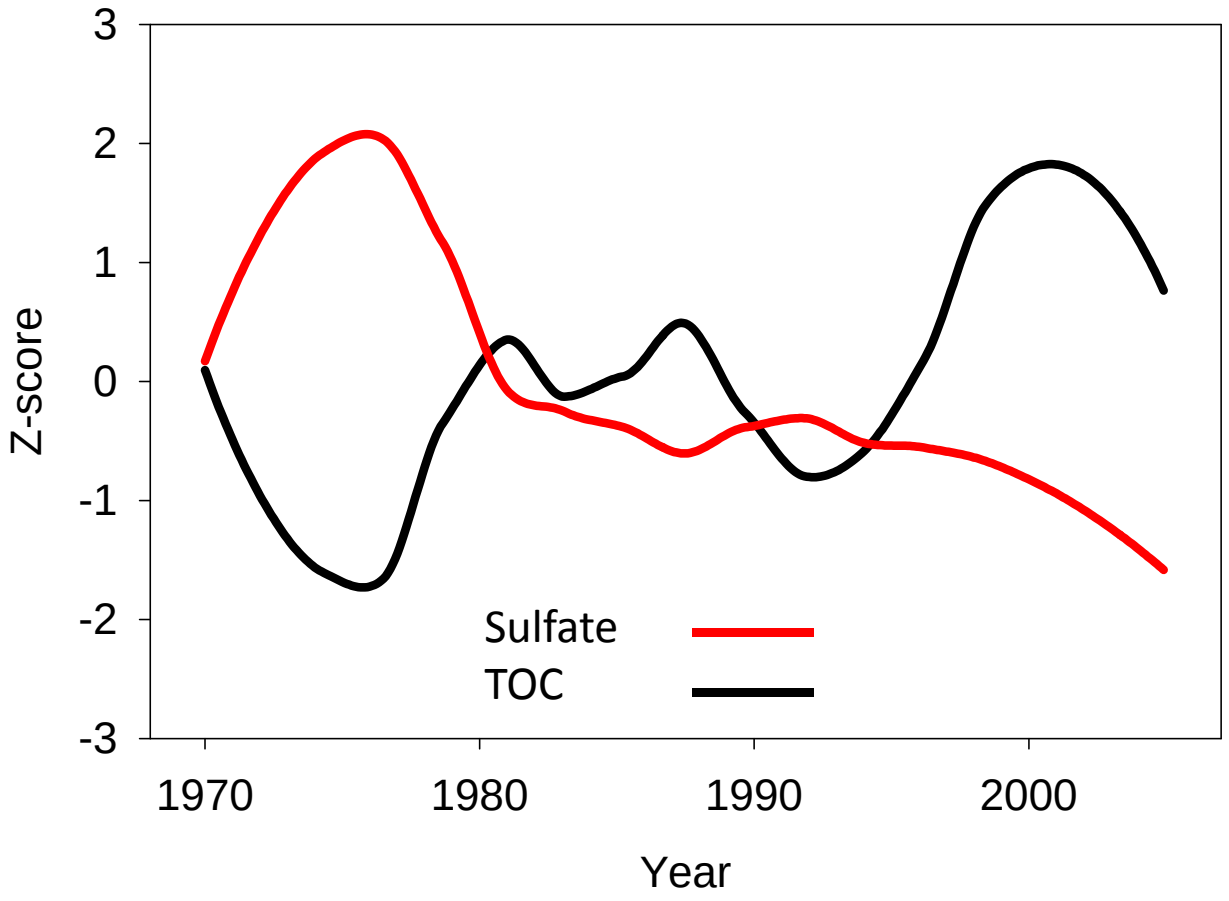


COD – mean value for
28 Swedish rivers

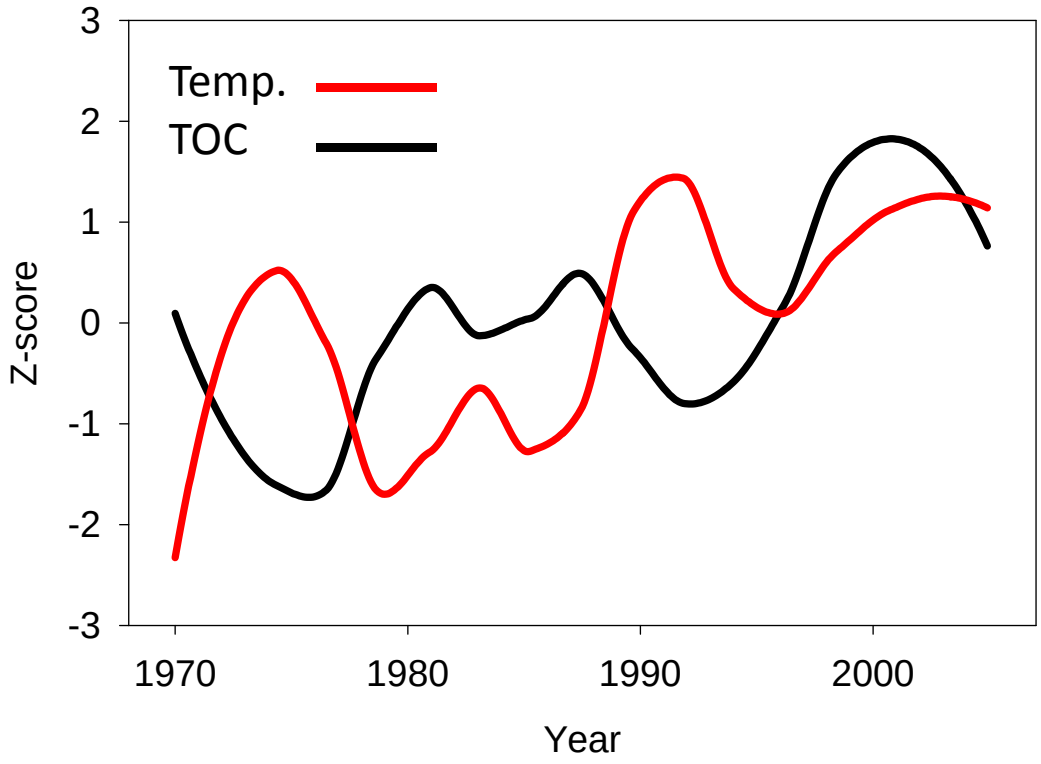
Is Runoff the driver?



Is dissovled Sulphate the driver?



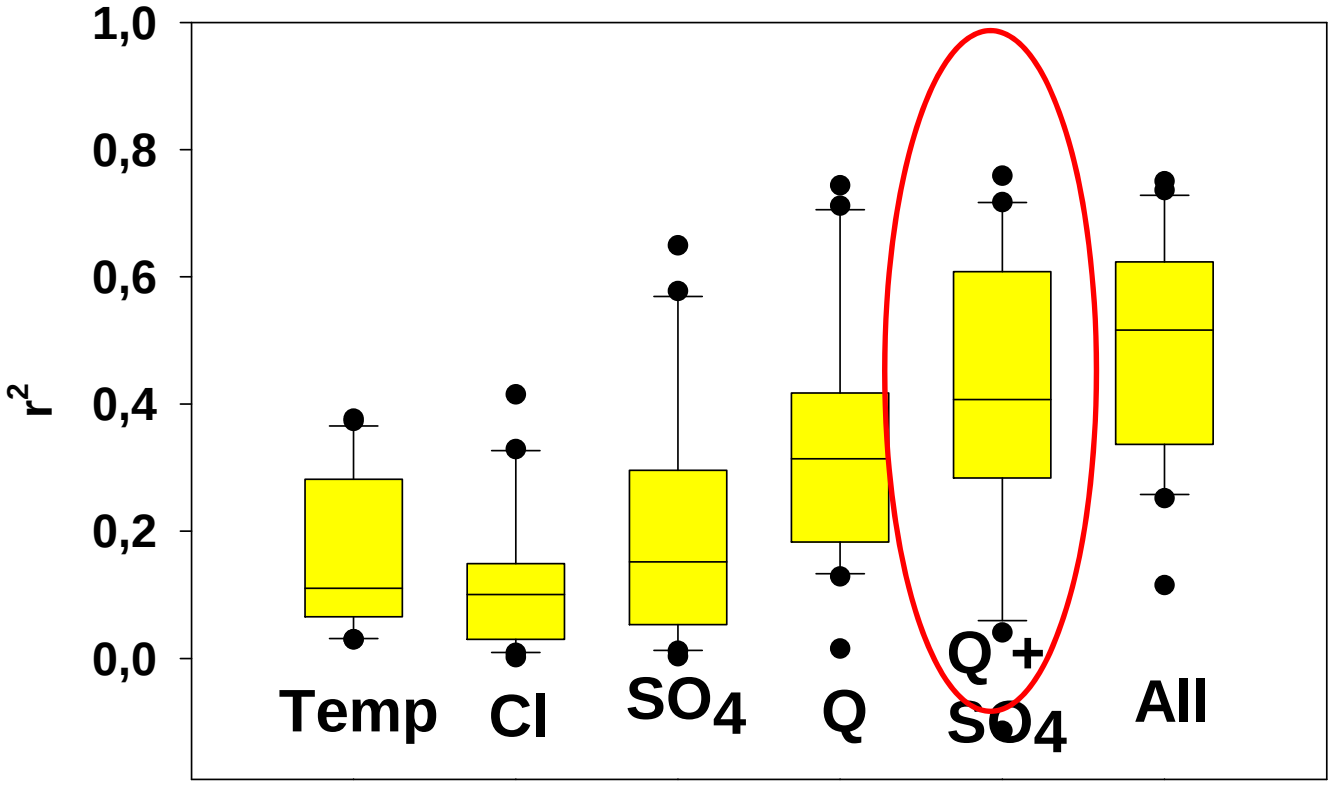
Air Temperature?

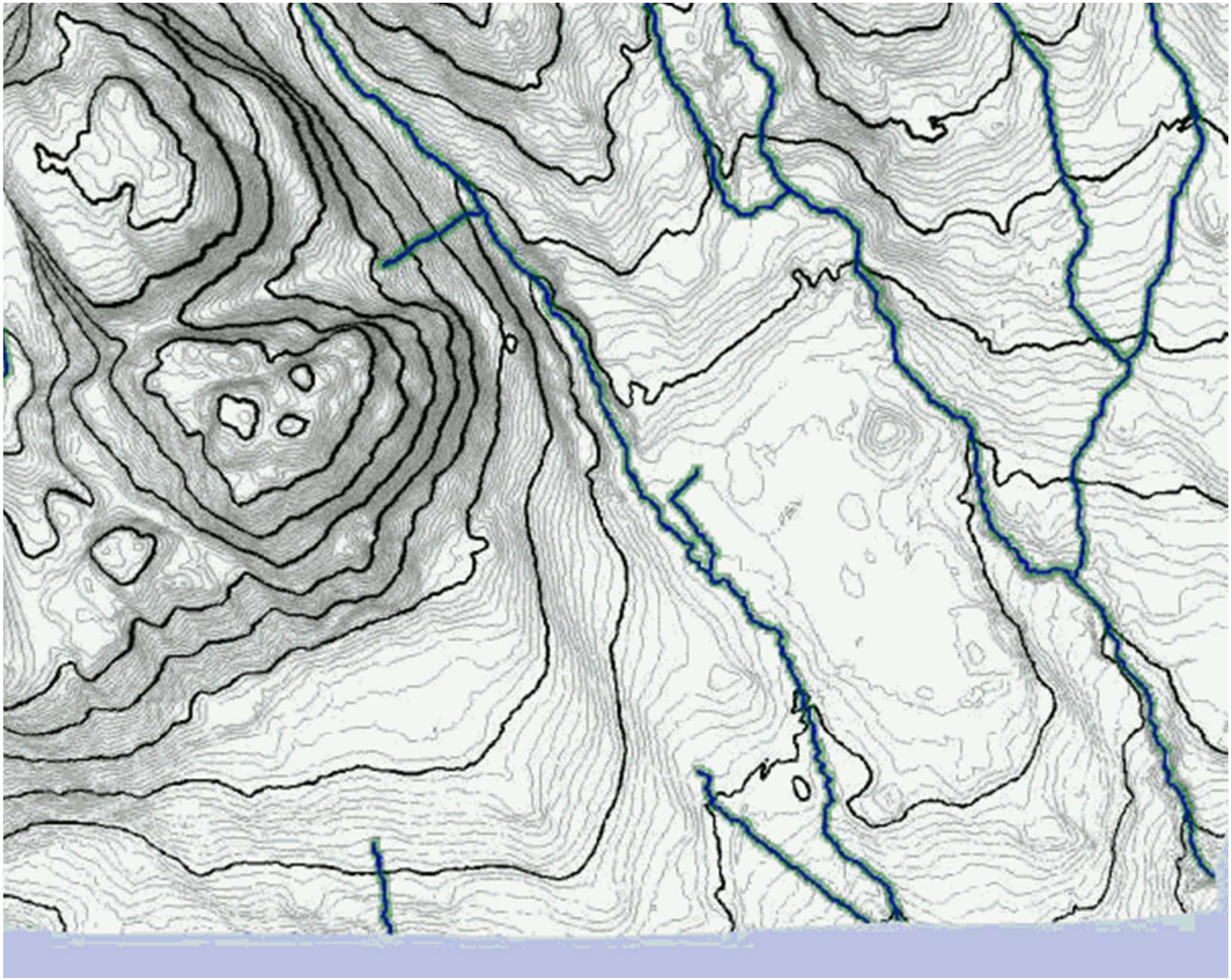


Flow and SO_4 drive annual TOC over 35 yrs

Future climate (2 C warmer, 25% more flow) gives 6% TOC increase. (Erlandsson et al. GBC, 2008)

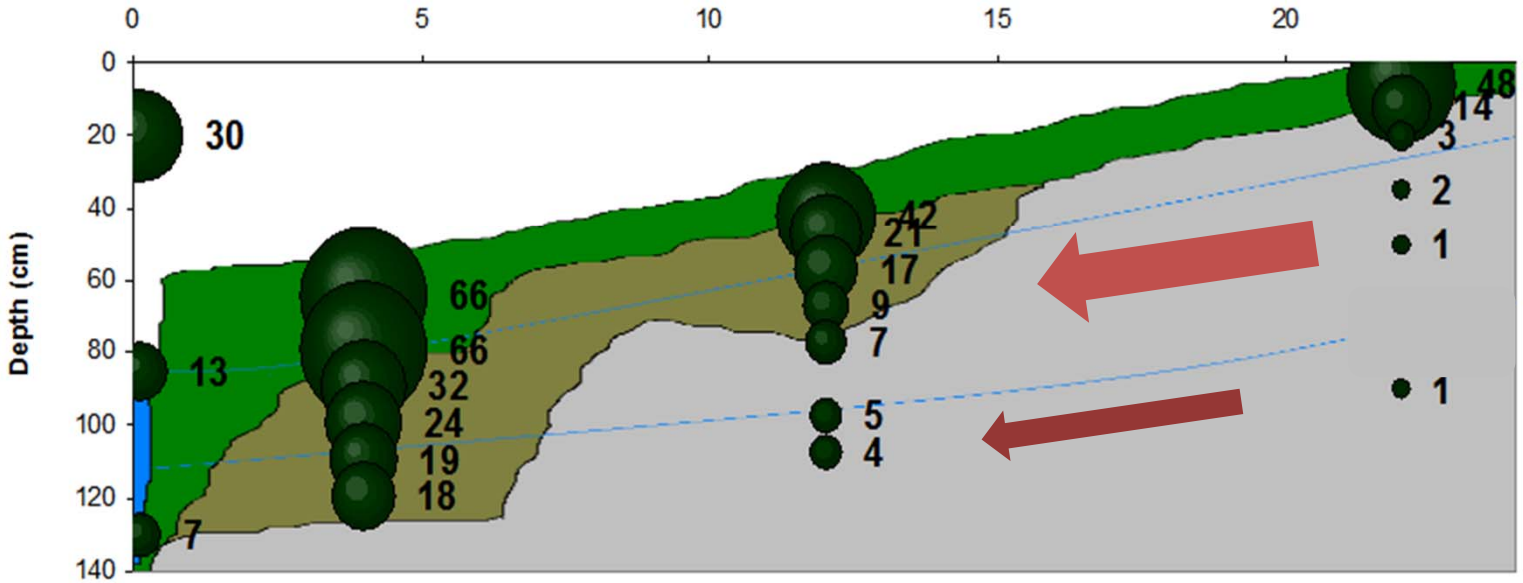
Is that it?





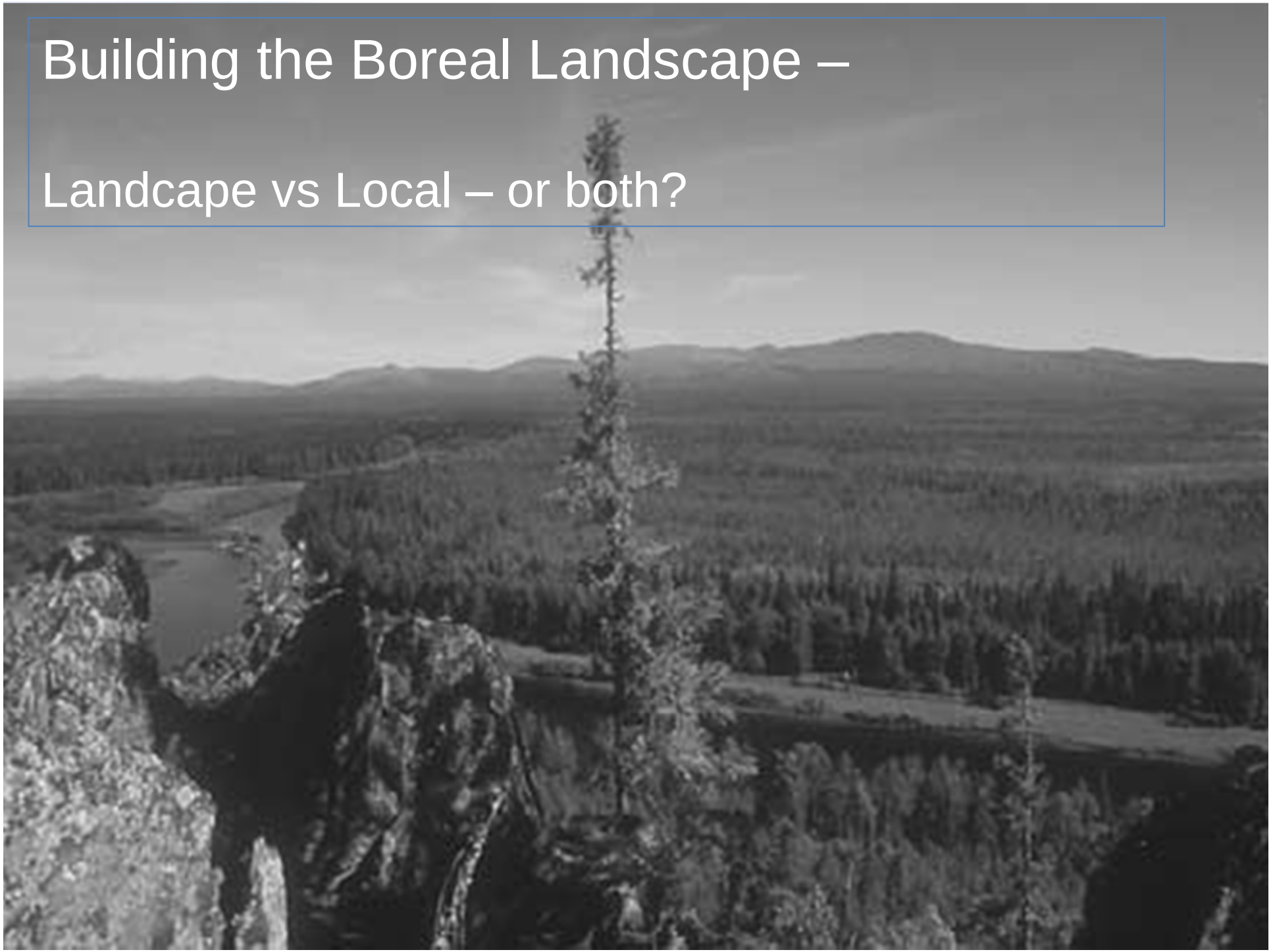
Shallow Groundwater has low DOC (< 2 mg/L), Streams are 10, 20, 30 mg/L

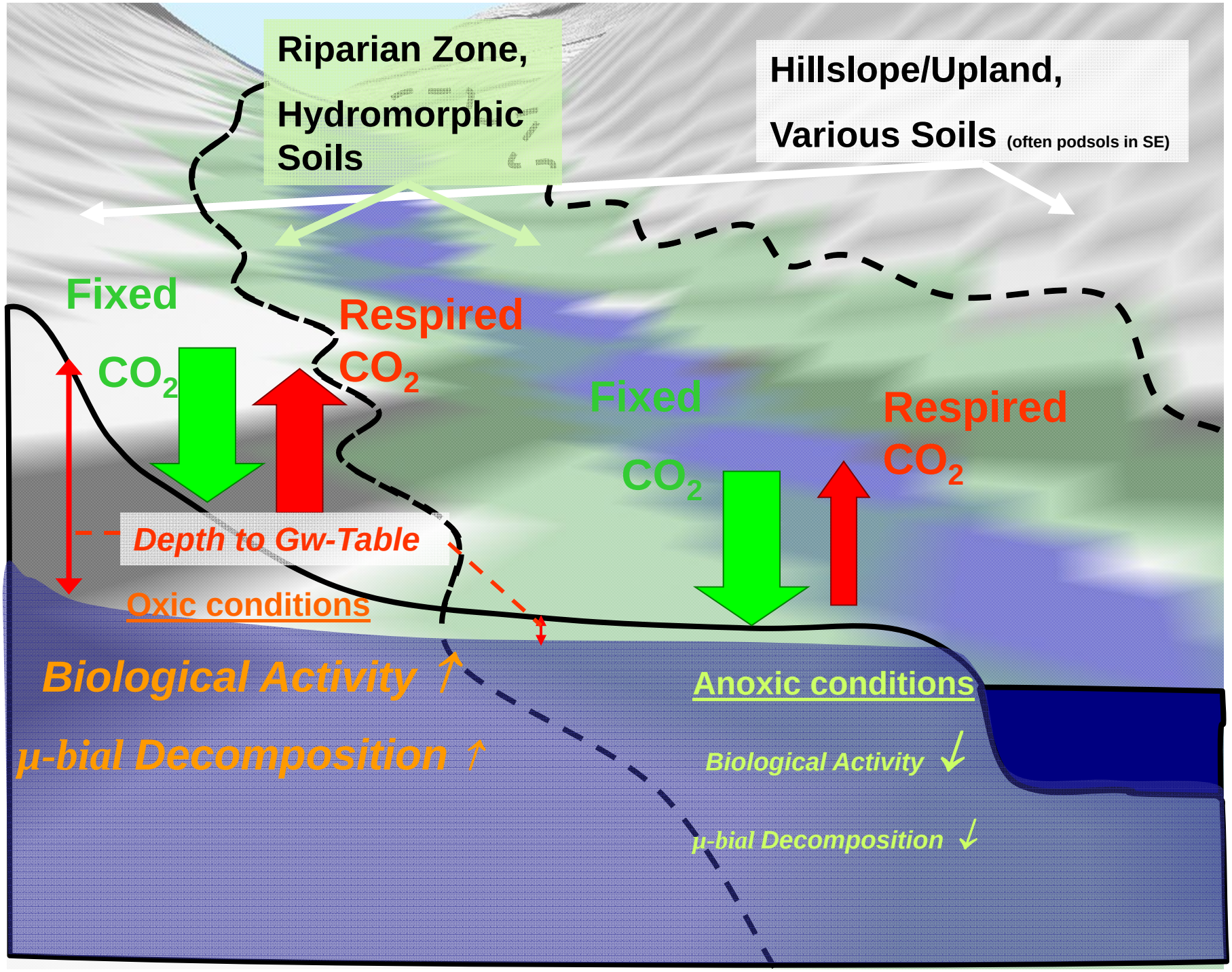
Runoff DOC comes from ”Connected” Organic Soils in the Near-Stream/Rpiarian Zone and Wetlands

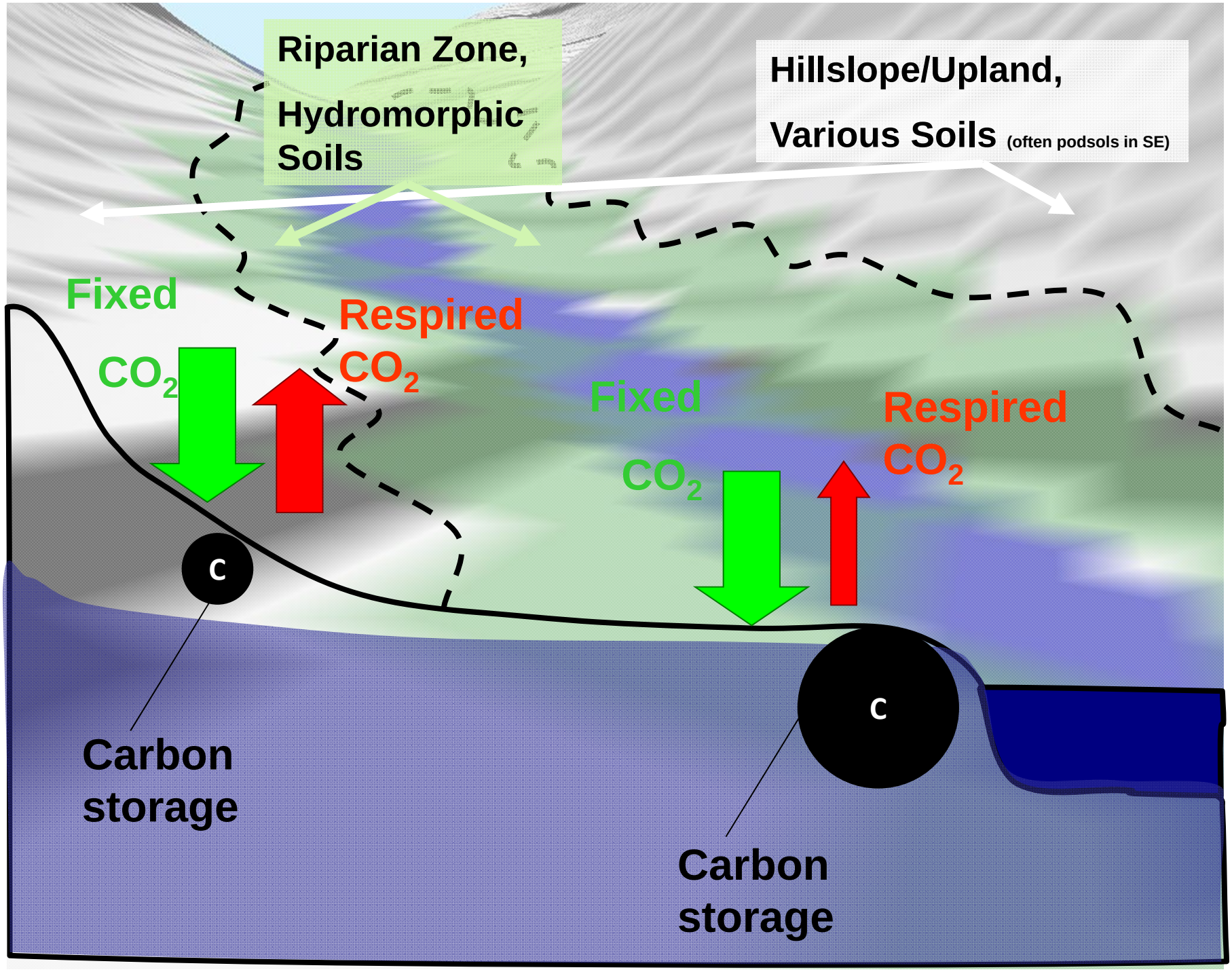


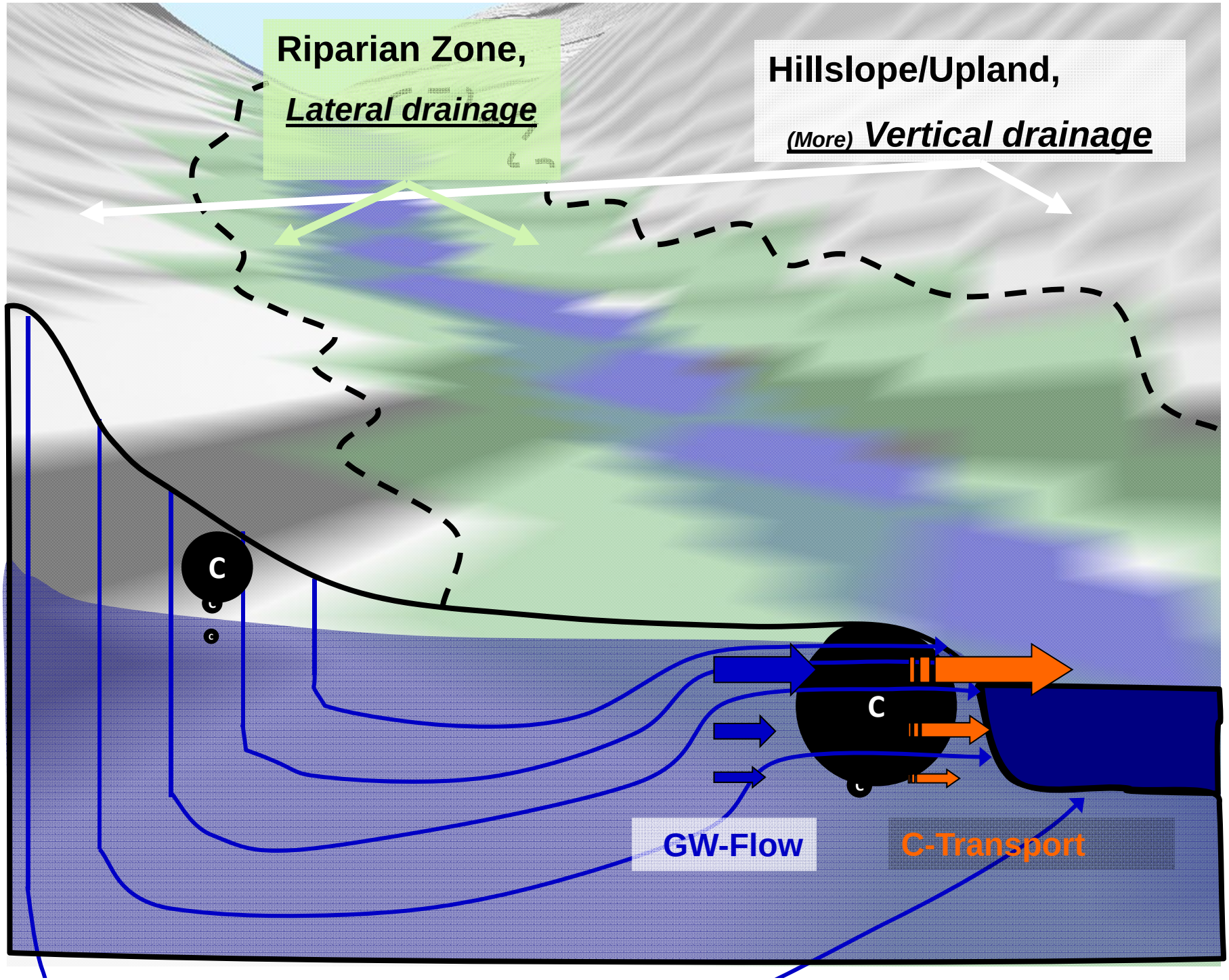
Building the Boreal Landscape –

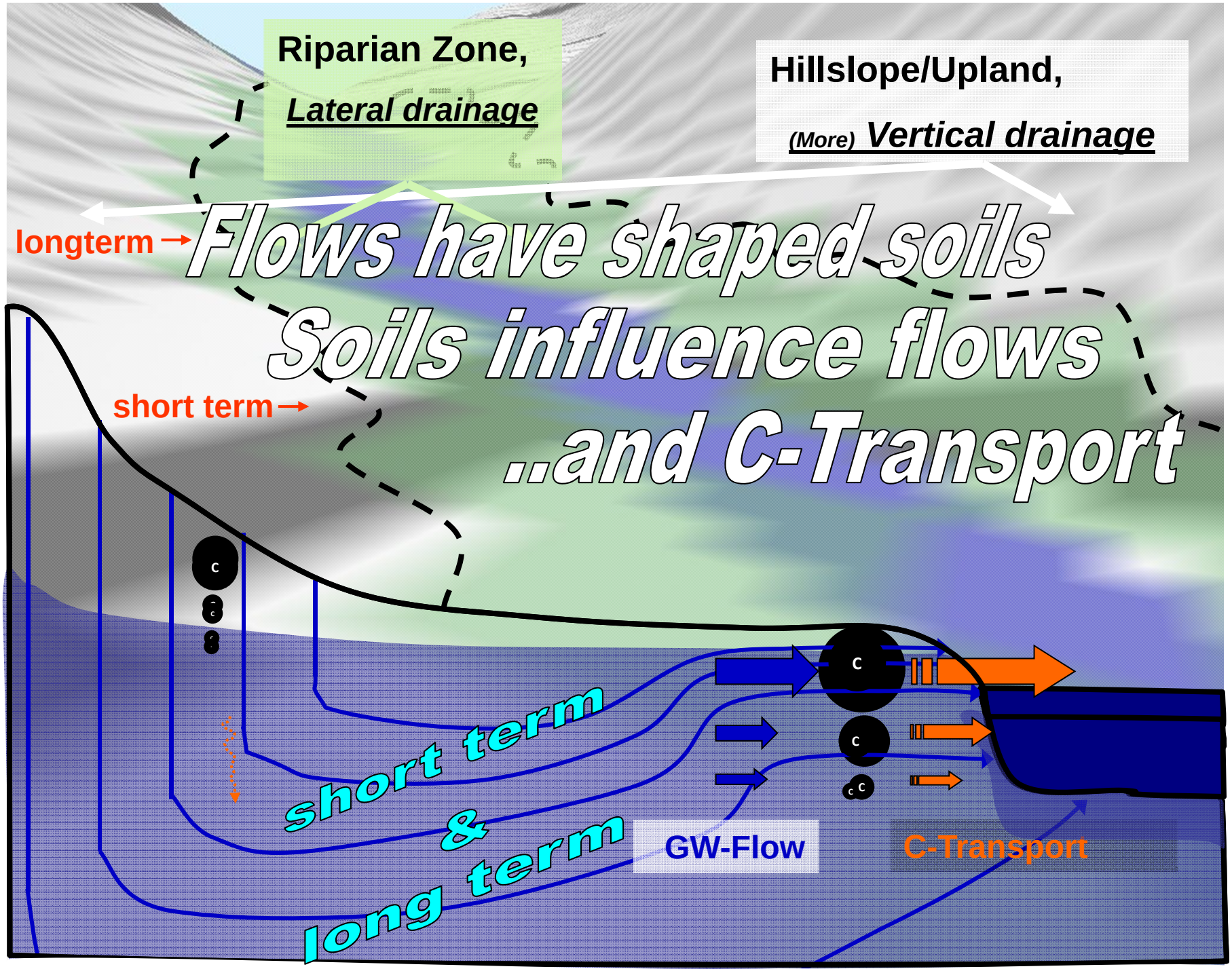
Landcape vs Local – or both?

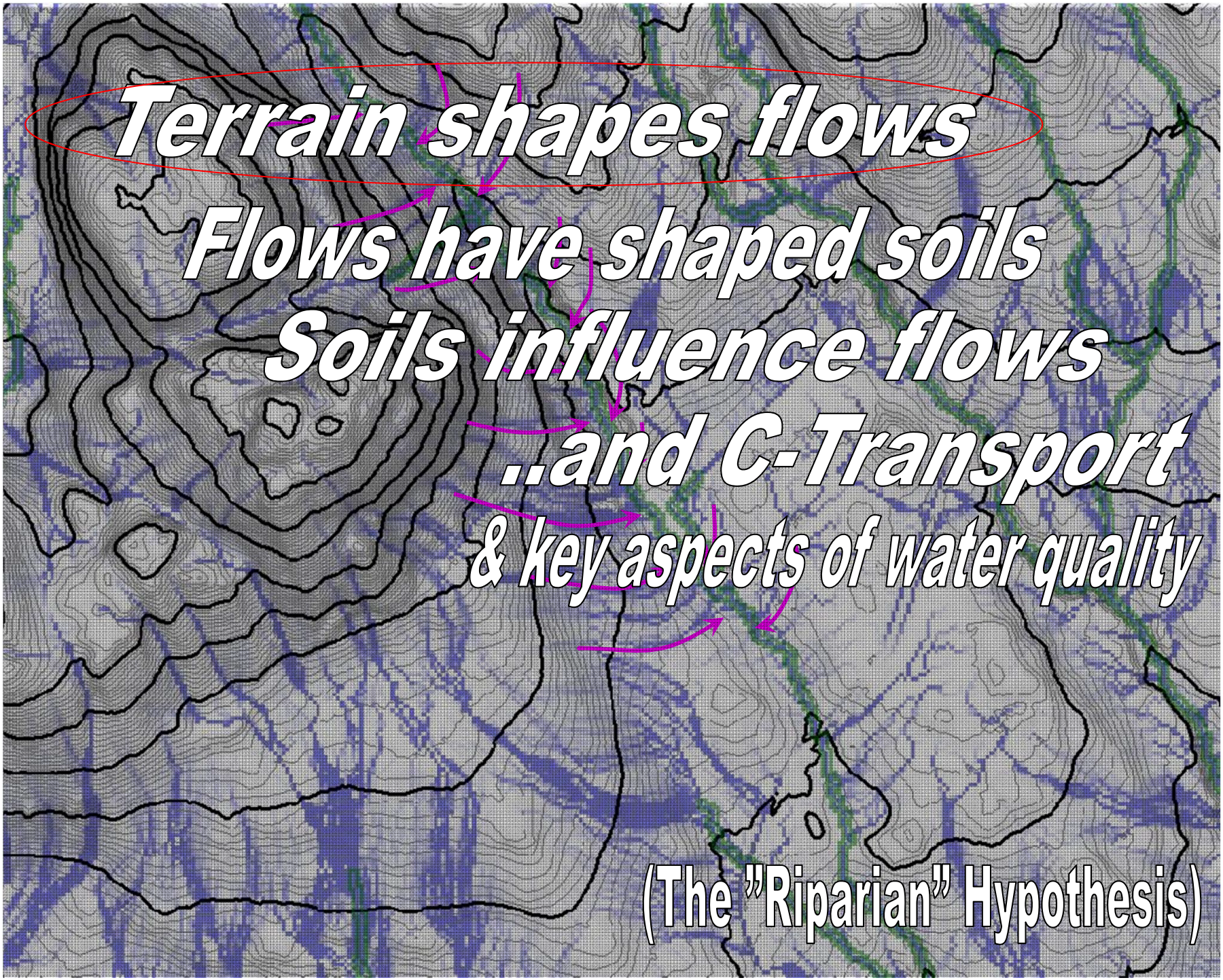



Riparian Zone,
Hydromorphic Soils
Hillslope/Upland,
Various Soils (often podsols in SE)
Fixed
CO_2
Respired
CO_2
Fixed
CO_2
Respired
CO_2
Depth to Gw-Table
Oxic conditions
Biological Activity ↑
µ-bial Decomposition ↑
Anoxic conditions
Biological Activity ↓
µ-bial Decomposition ↓

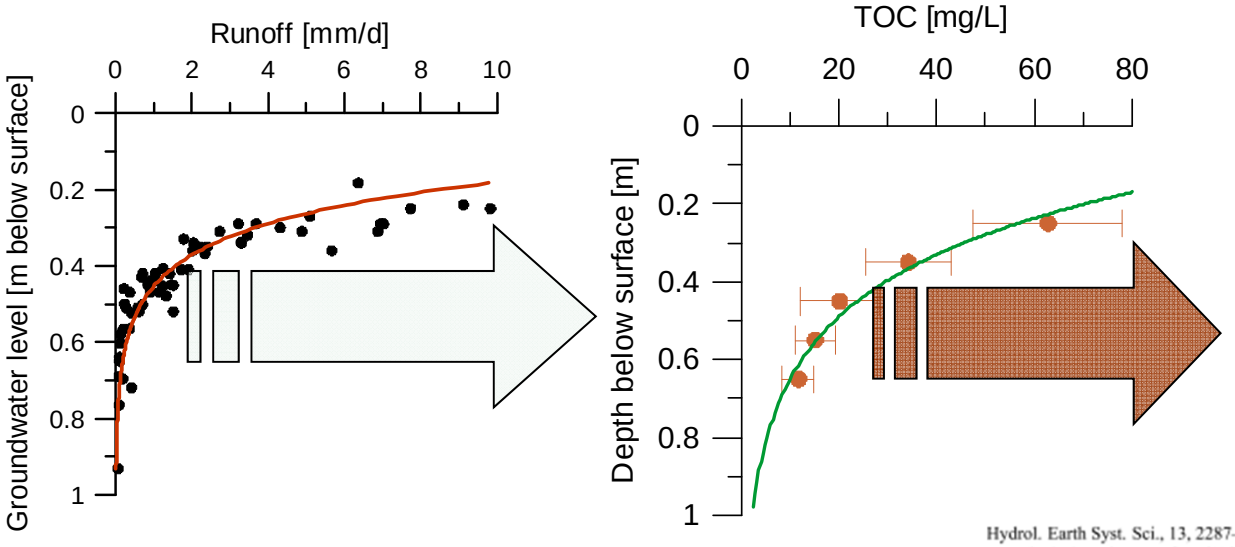

Riparian Zone,
Hydromorphic Soils
Hillslope/Upland,
Various Soils (often podsols in SE)
Fixed
CO_2
Respired
CO_2
Fixed
CO_2
Respired
CO_2
C
C
Carbon storage
Carbon storage


Riparian Zone,
Lateral drainage
Hillslope/Upland,
(More) Vertical drainage
C
C
C
C
GW-Flow
C-Transport


Riparian Zone,
Lateral drainage
Hillslope/Upland,
(More) Vertical drainage
longterm
Flows have shaped soils
Soils influence flows
..and C-Transport
short term
C
short term
&
long term
GW-Flow
C-Transport


Terrain shapes flows
Flows have shaped soils
Soils influence flows
..and C-Transport
& key aspects of water quality
(The "Riparian" Hypothesis)

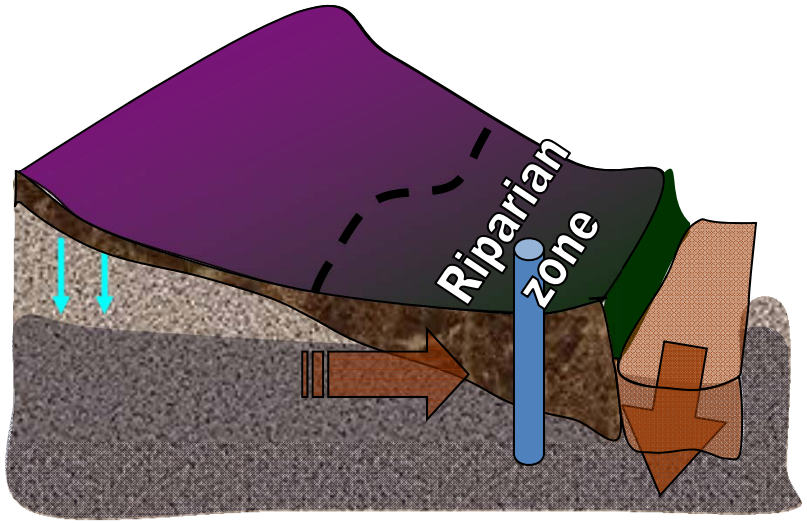
Riparian Concentration Integration Model (RIM)



$$\text{Load} = \int q(z) \cdot c(z)\, dz$$

Hydrol. Earth Syst. Sci., 13, 2287–2297, 2009
www.hydrol-earth-syst-sci.net/13/2287/2009/

Hydrology and Earth System Sciences



Seibert et al. 2009 (Hess)

Linking soil- and stream-water chemistry based on a Riparian Flow-Concentration Integration Model

J. Seibert[1,2], T. Grabs[2], S. Köhler[3], H. Laudon[4], M. Winterdahl[3], and K. Bishop[3]

[1]Department of Geography, University of Zurich, Winterthurerstr. 190, 8057 Zurich, Switzerland
[2]Department of Physical Geography and Quaternary Geology, Stockholm University, 106 91 Stockholm, Sweden
[3]Department of Aquatic Sciences and Assessment, Swedish University of Agricultural Sciences (SLU), P.O. Box 7050, 750 07 Uppsala, Sweden
[4]Department of Forest Ecology and Management, Swedish University of Agricultural Sciences (SLU), Umeå, Sweden

Received: 15 July 2009 – Published in Hydrol. Earth Syst. Sci. Discuss.: 26 August 2009
Revised: 6 November 2009 – Accepted: 17 November 2009 – Published: 2 December 2009

Abstract. The riparian zone, the last few metres of soil through which water flows before entering a gaining stream, has been identified as a first order control on key aspects of stream water chemistry dynamics. We propose that the distribution of lateral flow of water across the vertical profile of

1 Introduction

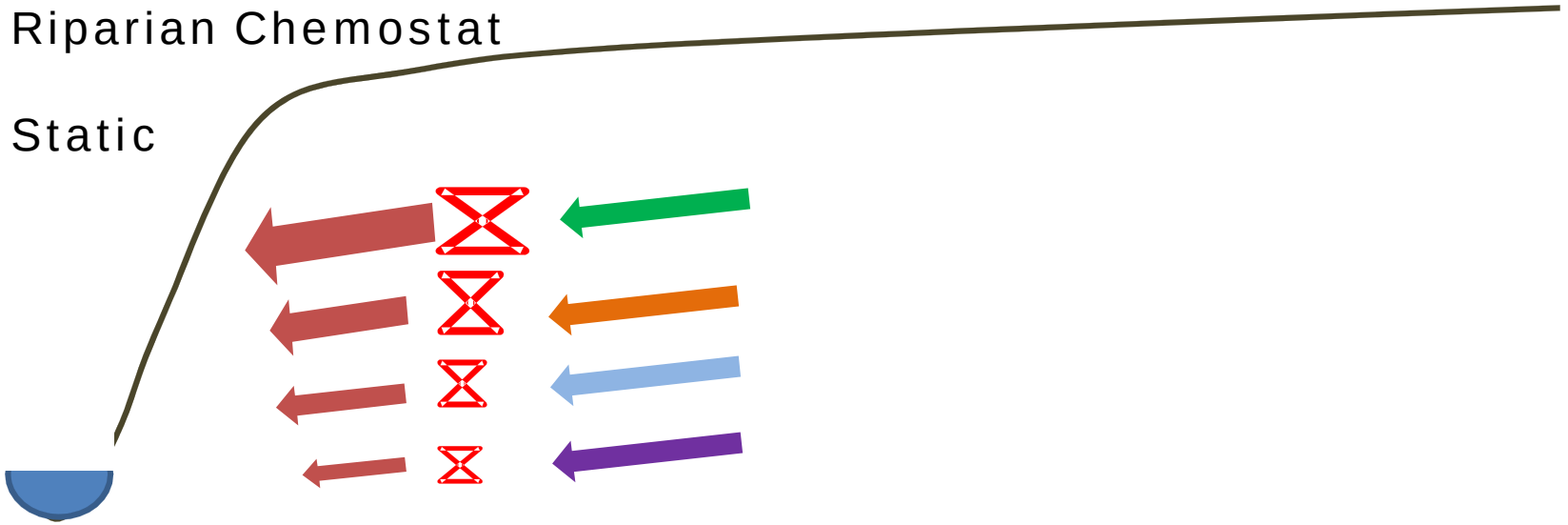
In the effort to understand how stream water is influenced by catchment inputs, the riparian zone (RZ) has been identified as a key part of the catchment, especially when consid-

Chemostat

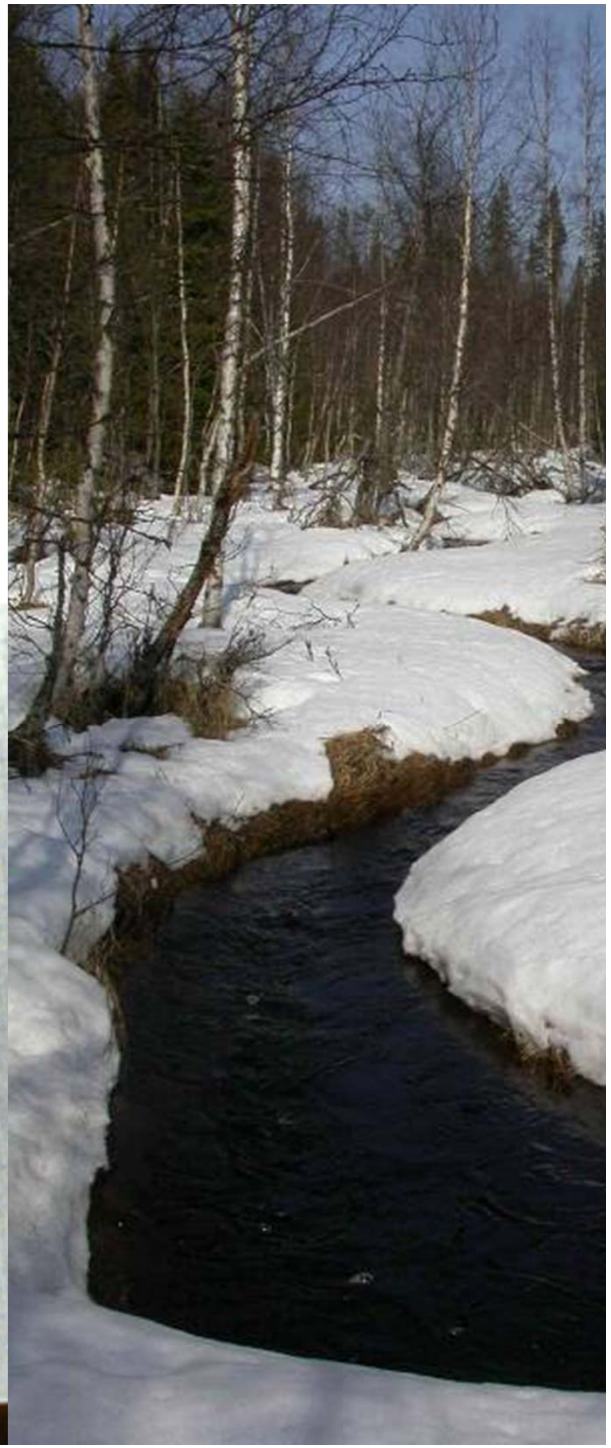
– whatever passes gets the same ”color”

-- Instantaneous, no storages involved

- Vertically differentiated

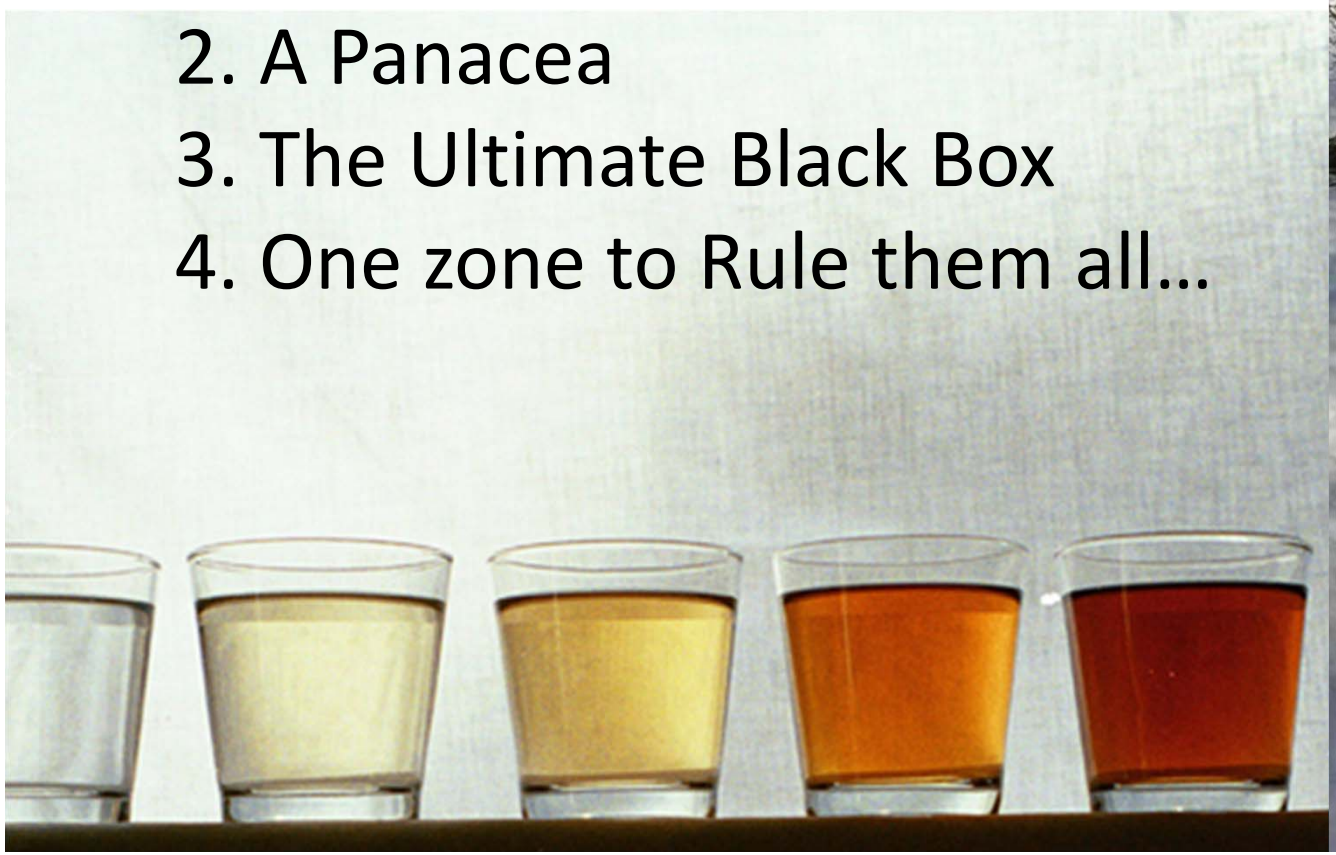


Landscape/Catchment Water ≠ Runoff Chemistry



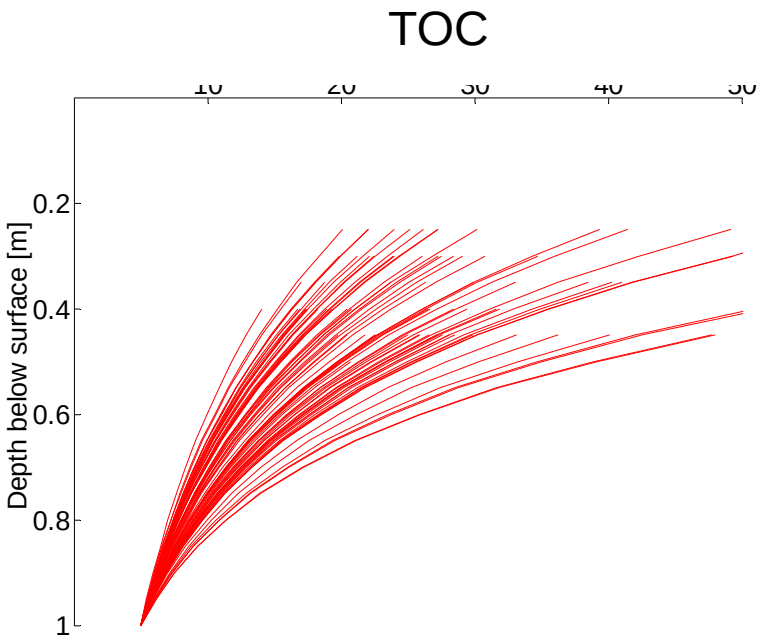
The Riparian Zone is:

1. A Solution
2. A Panacea
3. The Ultimate Black Box
4. One zone to Rule them all…

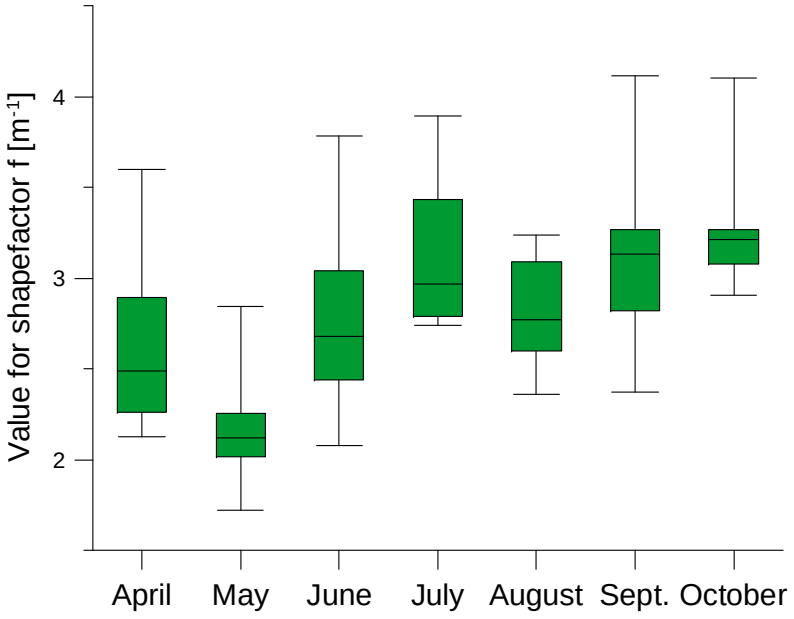


Riparian Model - Tool for Hypothesis Testing, Conceptual Development

Example: Seasonal variation of shape-factor *f*

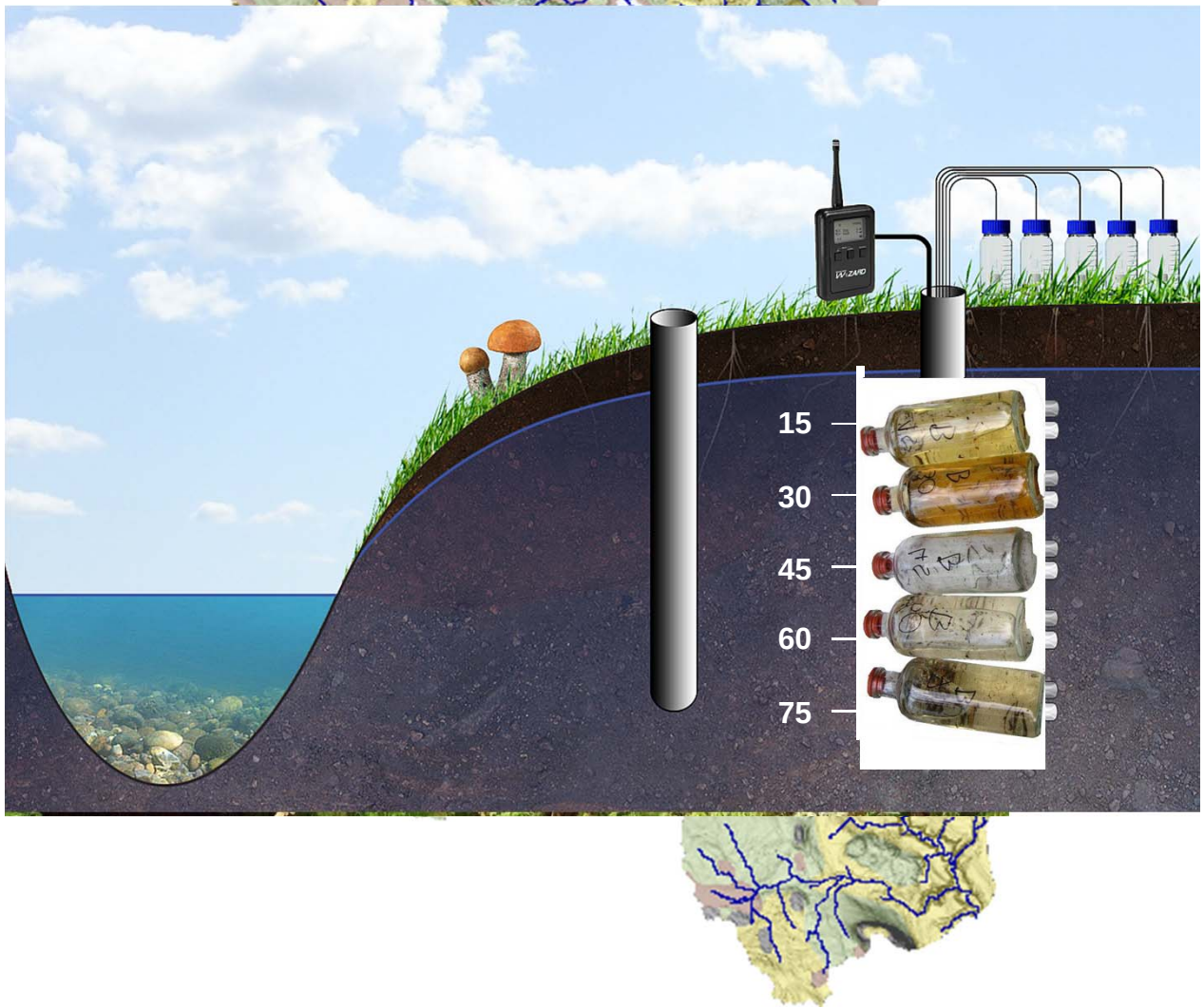


Soil profiles estimated on 77 occasions 2001



Seasonal variation of *f*

Krycklan Riparian Observatory
Testing the Riparian Hypothesis/Dream



Riparian observatory

13 Sites

5 Depths/ Site

2 Lysimeters/ Depth

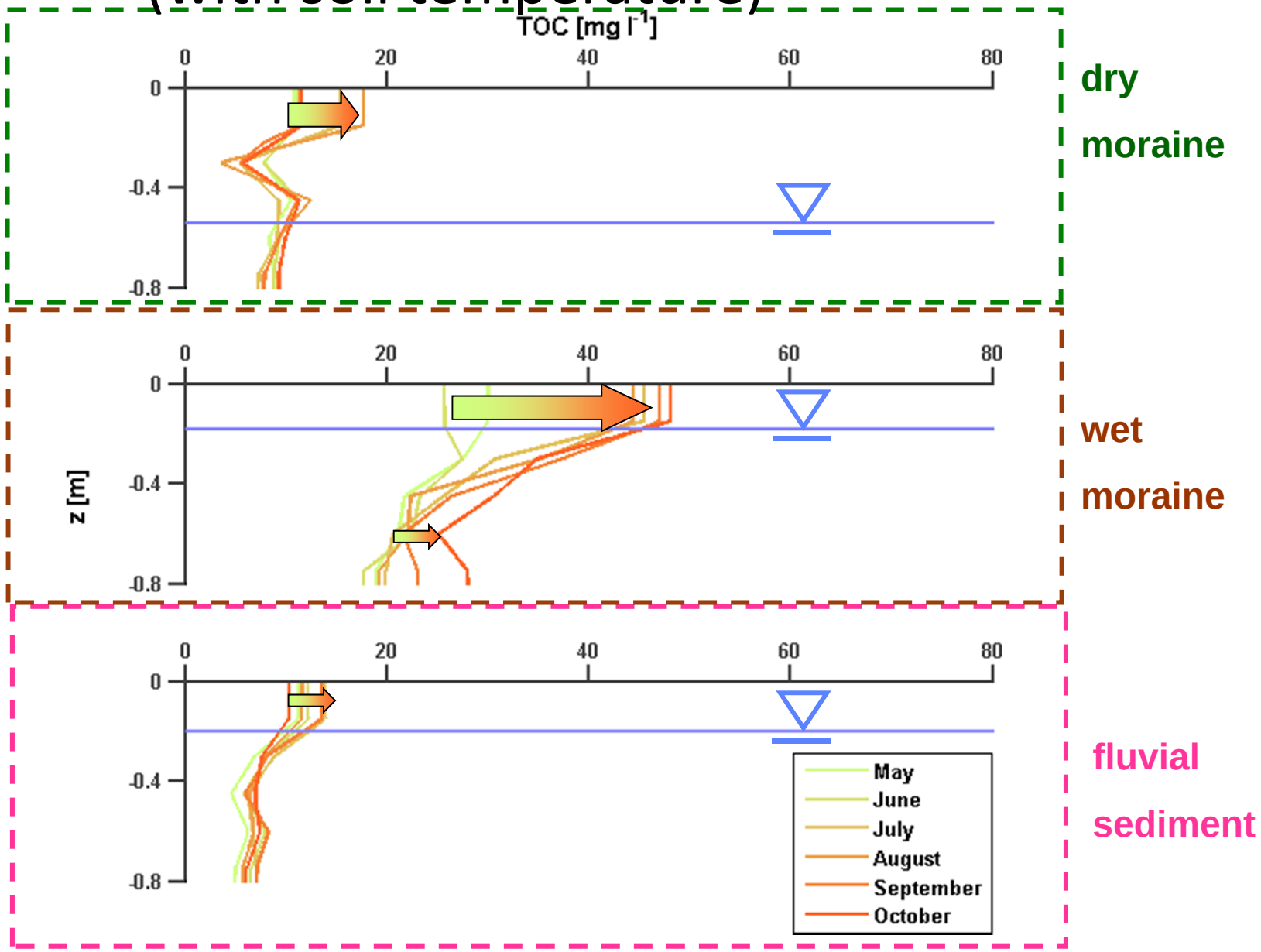
1 Gw-Well/ Site

9 Sampling Campaigns

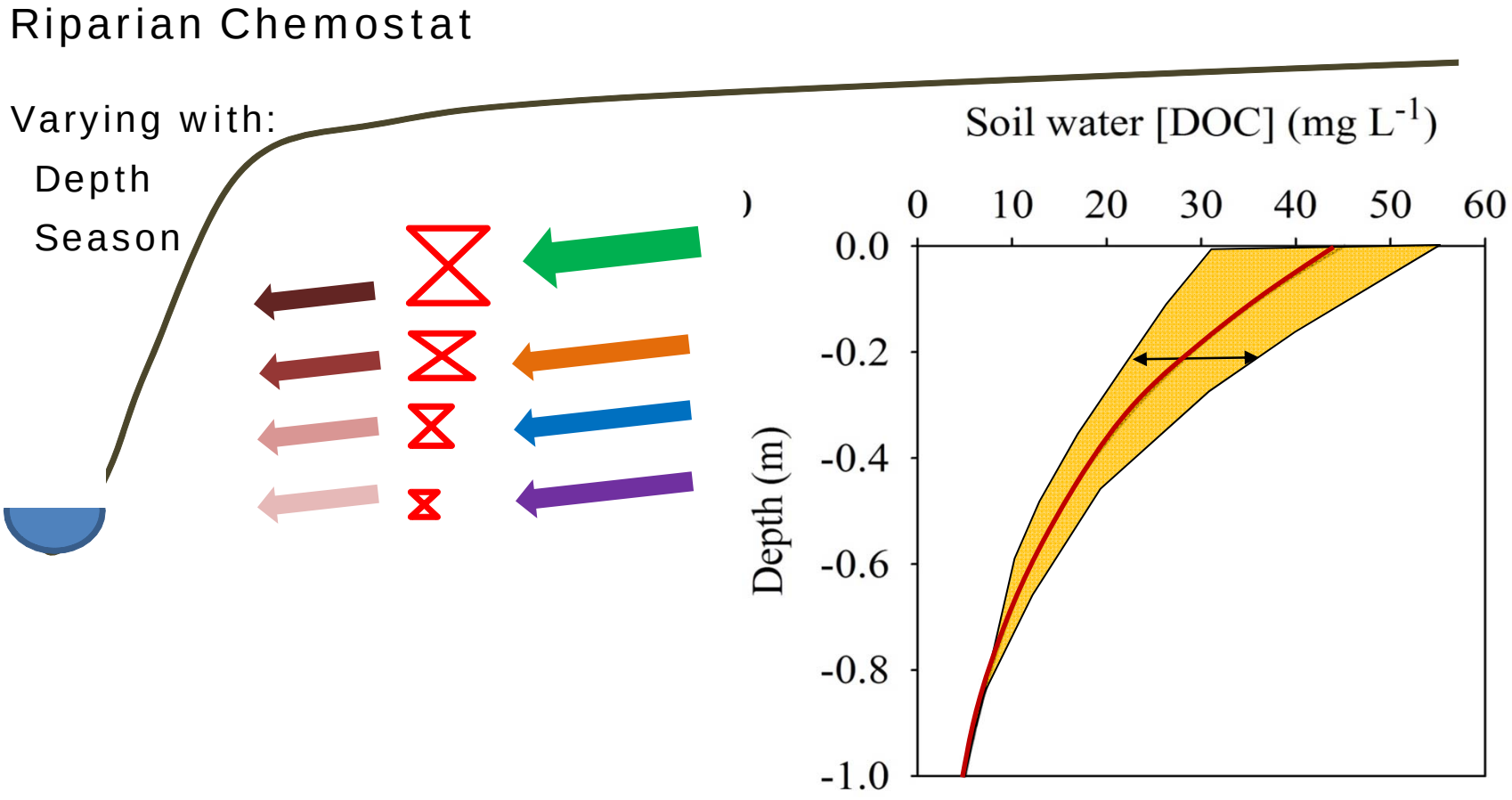
TOC*, pH, absorbance, anions, cations, O18

+ lots of help!

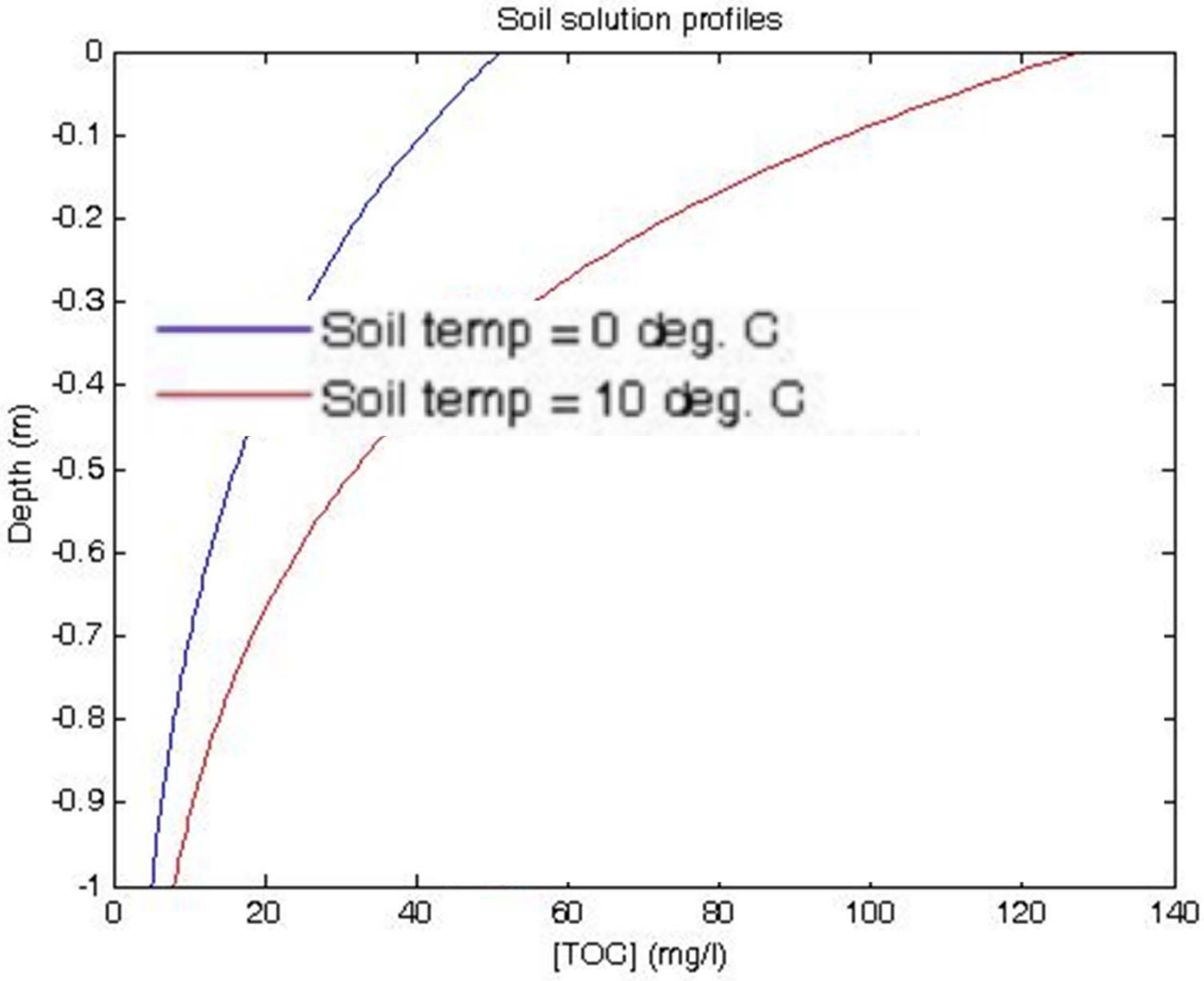
Riparian Soils: Temporal Variations (with soil temperature)



Seasonally Variable Chemostat [sic]

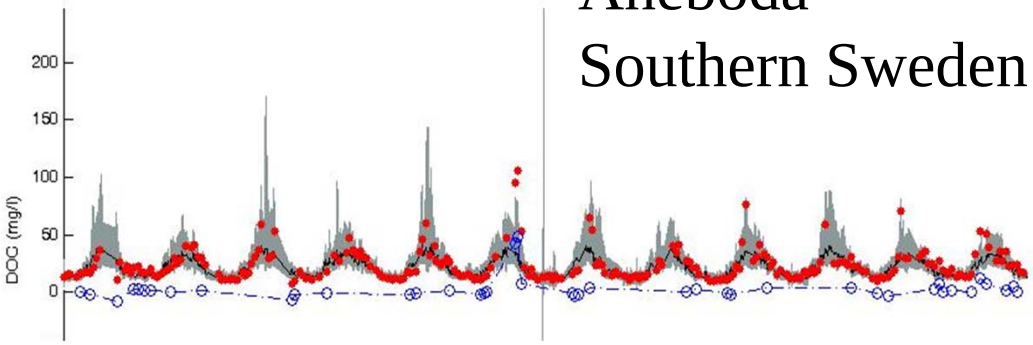


Temperature Sensitivity of DOC profile – captures seasonality, improves fit!

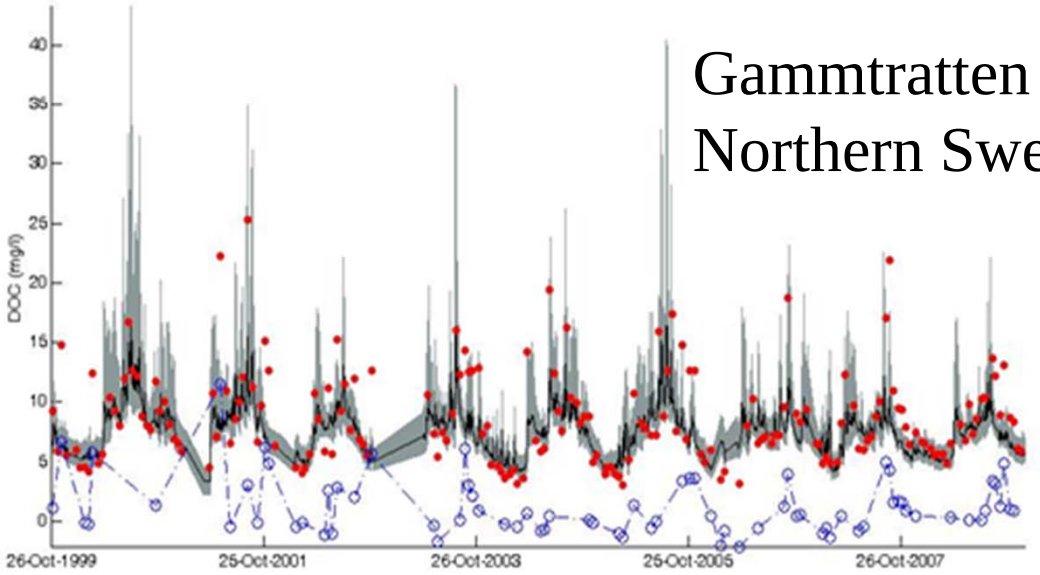


Modeling a decade of DOC Dynamics

Aneboda –
Southern Sweden



Gammtratten –
Northern Sweden

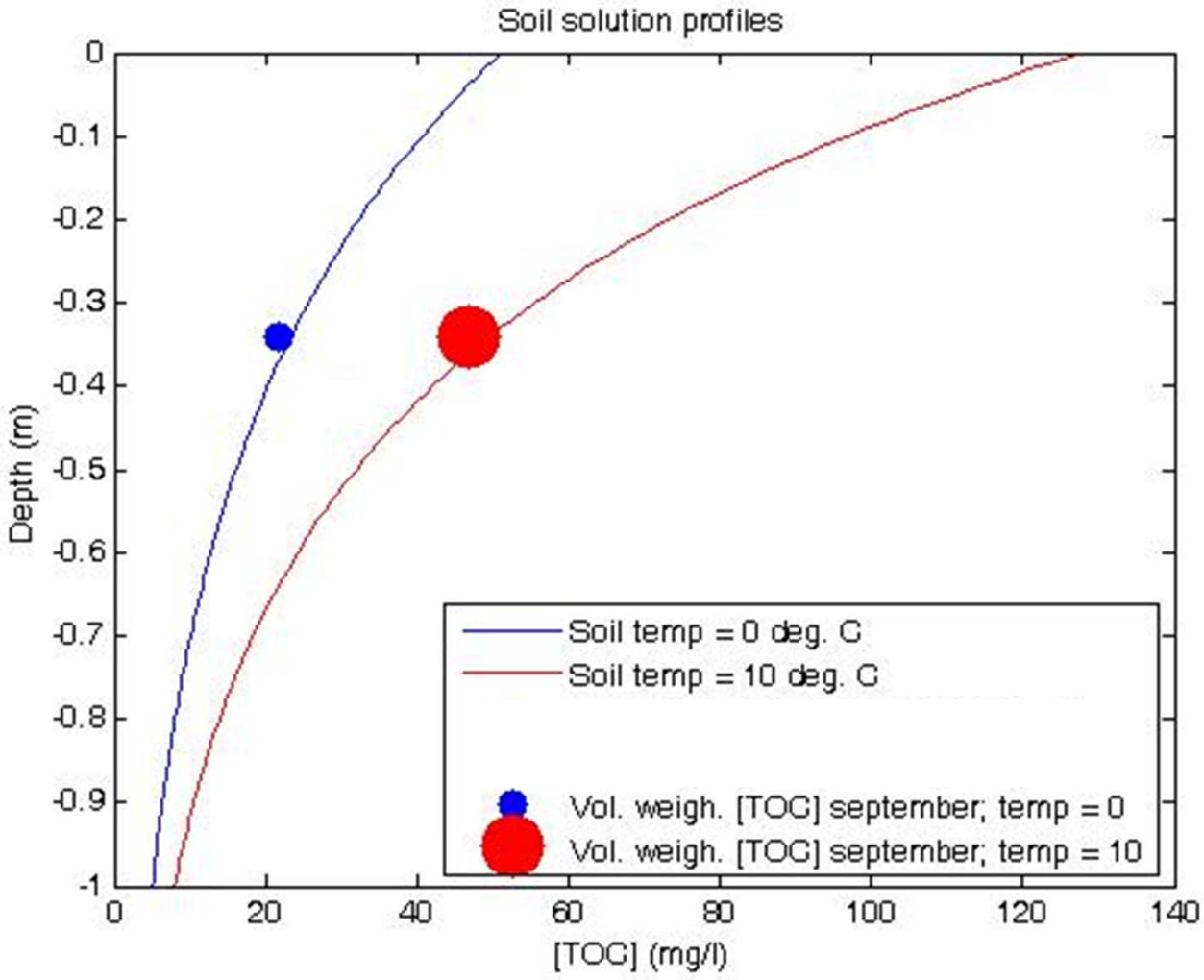


Why does the Riparian Zone Amplify Climate Change effects on DOC?

- Warmer
- More rain
- Less snow
- More runoff all year

Seasonal Chemostat and Climate Change

- less snowmelt, more autumn flow
- more flows when soils warm



TOC increases in a future climate

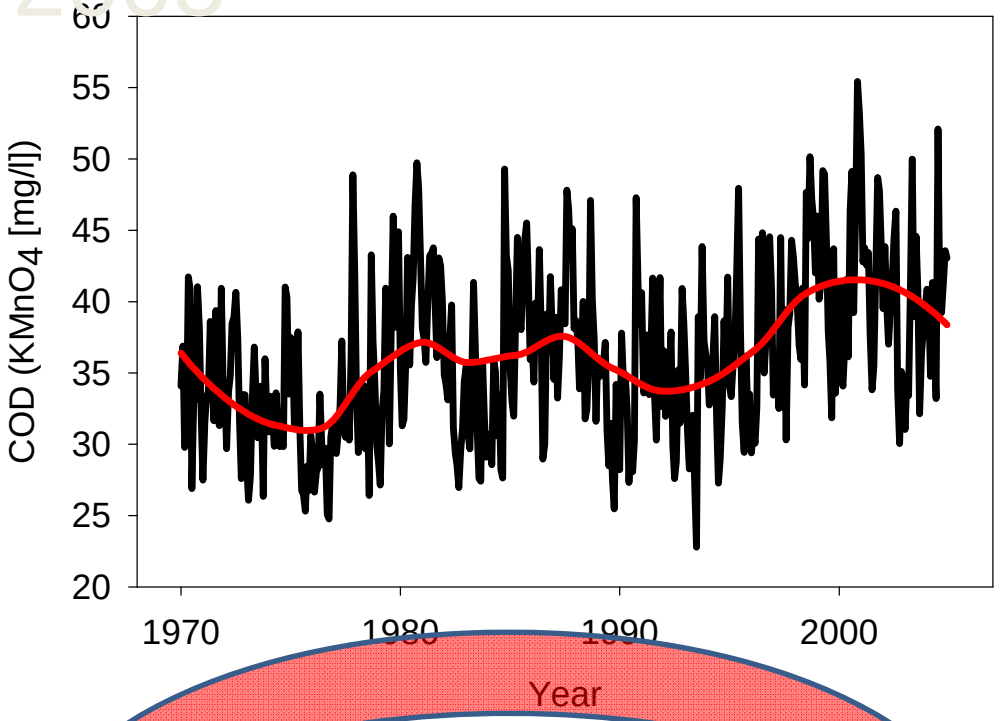
	Statistical Regression [a]	Riparian Model [b]
Mean TOC Increase	**~1 mg/L (6%)**	**~4 mg/L (25%)**
Autumn peak difference	**…**	**~10 mg/L**

IPCC Hadley A Scenario,
1.5 C temperature increase, 25% more runoff (HBV modeling).

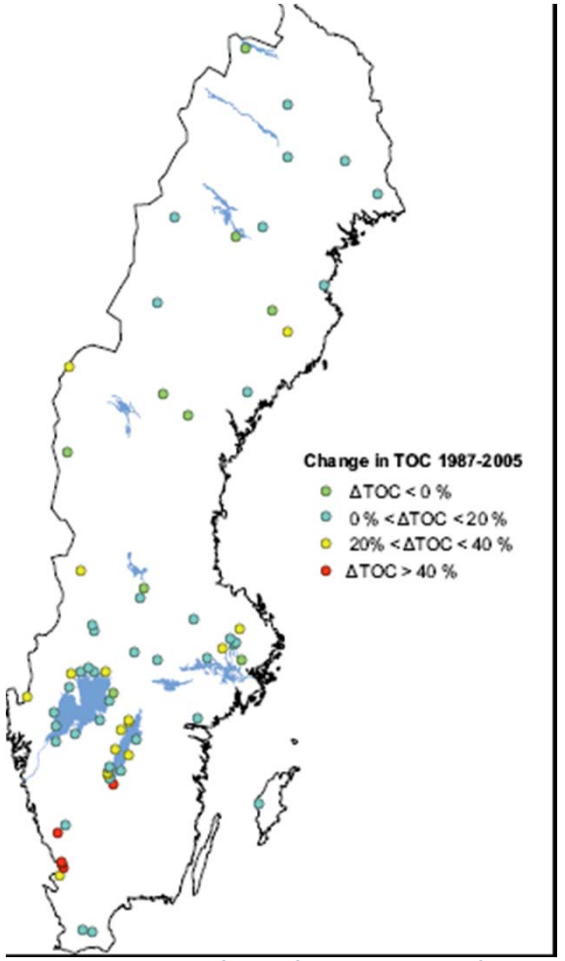
Department of Aquatic Science and Assessment

[a]Erlandsson et al., 2008 Global Change Biology ; [b]Winterdahl et al., in revision, Water Resources Research.

Flow and Sulfate Predict DOC in 28 Swedish Rivers 1970-2005



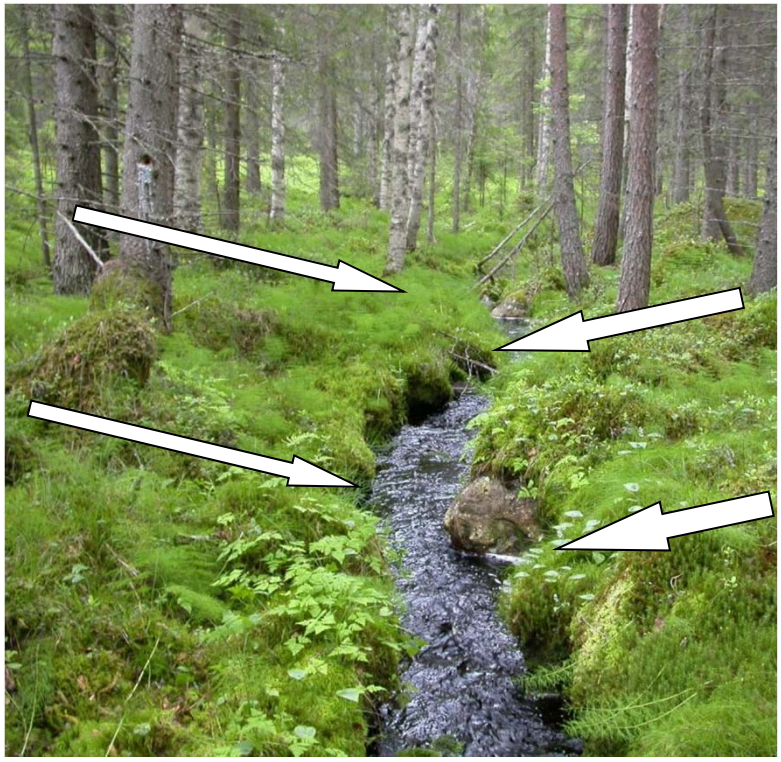
Statistical Predicton of Future Climate:
25% increase in runoff
6% higher DOC

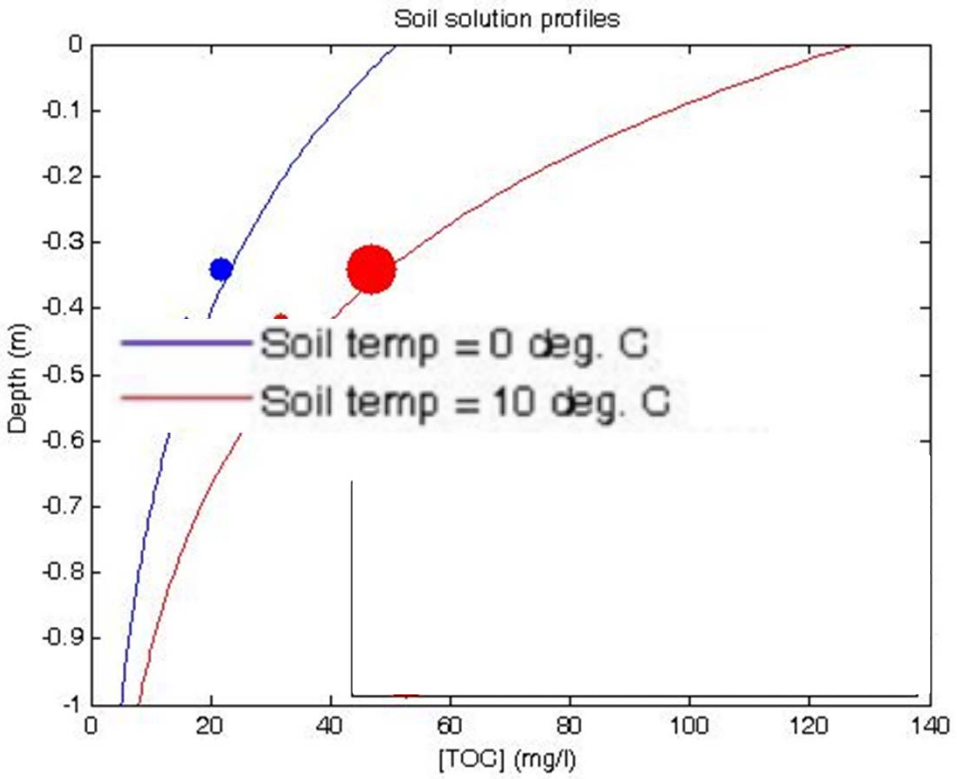


Erlandsson et al., Global Change Biology (2007)

Warmer, wetter climate amplifies DOC export from the Riparian Zone:

Shift flow from Spring flood (cold soil) to rain events through warmer soils





Thanks for your time!

…and all these years
to dig into the RZ with
friends and colleagues.