

**Several mechanisms drive the heterogeneity in browning
across a boreal stream network**

Xudan Zhu¹, Frank Berninger¹, Liang Chen¹, Johannes Larson², Ryan A. Sponseller³, Hjalmar Laudon²

¹Department of Environmental and Biological Sciences, Joensuu Campus, University of Eastern Finland, 80100 Joensuu, Finland.

²Department of Forest Ecology and Management, Swedish University of Agricultural Science, 90183 Umeå, Sweden.

³ Department of Ecology and Environmental Sciences, Umeå University, 901 87 Umeå, Sweden.

Corresponding author: Xudan Zhu (xudanzhu@uef.fi).

Contents of this file

Tables S1 to S3

Figures S1 to S4

Introduction

This document contains additional information on the modeling outputs (Table S1-S3), clearcut records (Figure S1), conceptual diagram of MODIS GPP extraction (Figure S2), daily data interpolations (Figure S3) and mean chemical data across sites (Figure S4).

Table S1. The relationship between gross primary productivity derived from eddy-covariance measurements (EC GPP) and MODIS GPP (MGPP) extracted by three methods) in C2, C4 and C6. MGPP_coordinate means MGPP extracted from coordinate, MGPP_riparian represents MGPP extracted from riparian zone, while MGPP_watershed is MGPP extracted from the watershed. EC GPP are from Svartberget and Degerö station.

Sites (EC towers)	EC GPP~MGPP_coordinate		EC GPP~MGPP_riparian		EC GPP~MGPP_watershed	
	² R	p-value	² R	p-value	² R	p-value
C2 (Svartberget)	0.565	<0.001	0.665	<0.001	0.565	<0.001
C4 (Degerö)	0.557	<0.001	0.656	<0.001	0.567	<0.001
C6 (Svartberget)	0.561	<0.001	0.660	<0.001	0.576	<0.001

Table S2. The performance of distributed-lag linear model (DLM2: $DOC = \beta_1 MGPP_{lag}$) with MODIS GPP (MGPP) from three different methods. MGPP_coordinate means MGPP extracted from coordinate, MGPP_riparian represents MGPP extracted from riparian zone, while MGPP_watershed is MGPP extracted from the watershed.

DLM2	Lag\day	AIC	R ²
DOC=MGPP_coordinate _{lag}	4–30	243156.9	0.020
DOC= MGPP_riparian _{lag}	4–30	243021.7	0.022
DOC= MGPP_watershed _{lag}	4–30	243076.8	0.021

Table S3. Coefficients table of DLM7 ($DOC \sim DIS_{lag} + MGPP_{lag} + SO_4 + T_{soil} + Area + Mire\%$). $MGPP_{lag}$ means the cross basis of MODIS GPP from riparian zone; DIS_{lag} represents the cross basis of discharge; T_{soil} is soil temperature at 20cm; Area means the size of catchment. Wetland% is the proportion of wetland according to the landcover of catchment. cb.dis1, cb.dis2 and cb.dis3 are the second-degree polynomial cross basis of discharge, while cb.MGPP1, cb.MGPP2 and cb.MGPP3 are the fourth-degree polynomial cross basis of MGPP. Signif. codes: < 0.001 '***', < 0.01 '**', < 0.05 '*', >0.05 'NS'.

Index	Estimate	Std. Error	t value	Pr(> t)	
(Intercept)	-0.0950314	0.0053484	-17.768	< 0.001	***
cb.dis1	0.0735426	0.003605	20.4	< 0.001	***
cb.dis2	-0.271298	0.0224589	-12.08	< 0.001	***
cb.dis3	0.2156376	0.0222629	9.686	< 0.001	***
cb.MGPP1	-0.2823892	0.0361552	-7.81	< 0.001	***
cb.MGPP2	2.0973512	0.3549015	5.91	< 0.001	***
cb.MGPP3	-5.1436045	1.1318383	-4.544	< 0.001	***
cb.MGPP4	5.0050337	1.4433395	3.468	< 0.001	***
cb.MGPP5	-1.6310001	0.6359909	-2.565	< 0.05	*
SO ₄	-0.365123	0.0033677	-108.42	< 0.001	***
T _{soil}	0.1348511	0.0067255	20.051	< 0.001	***
Area	-0.0187109	0.0001348	-138.854	< 0.001	***
Mire%	0.0164285	0.000273	60.182	< 0.001	***

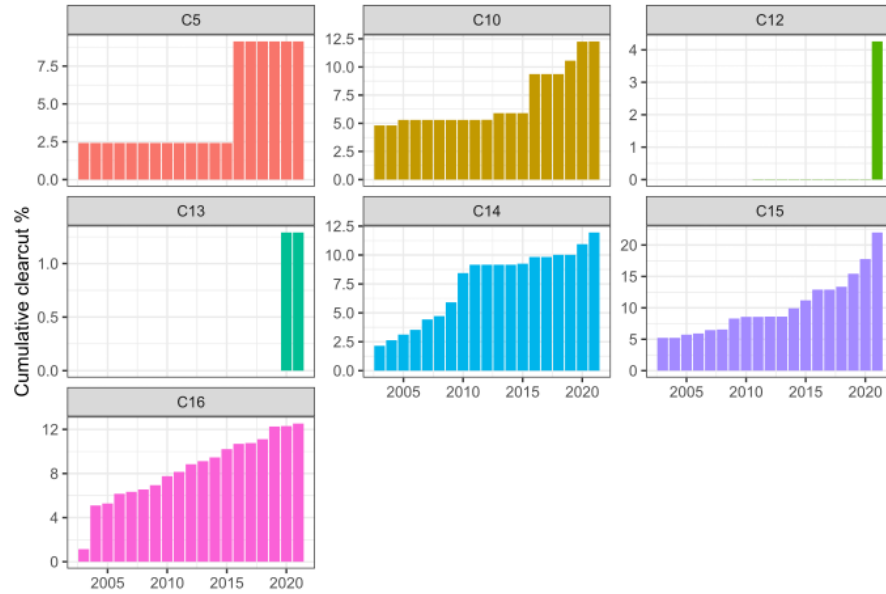


Figure S1. The cumulative clearcut proportion across sites with clearcutting during 2003 to 2021 in Krycklan. C16 is the outlet of Krycklan catchments, therefore represent clearcut record of the whole Krycklan. The annual clearcut proportion of Krycklan is 1%.

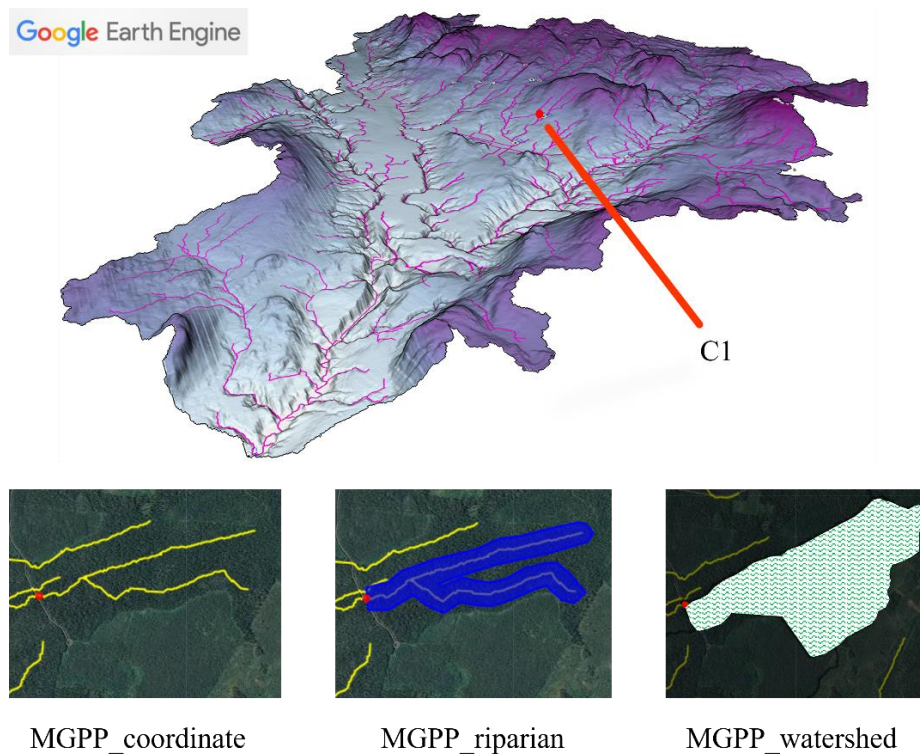


Figure S2. Schematic for extract MODIS GPP (MGPP) from coordinate, riparian zone and watershed of each site in Google Earth Engine

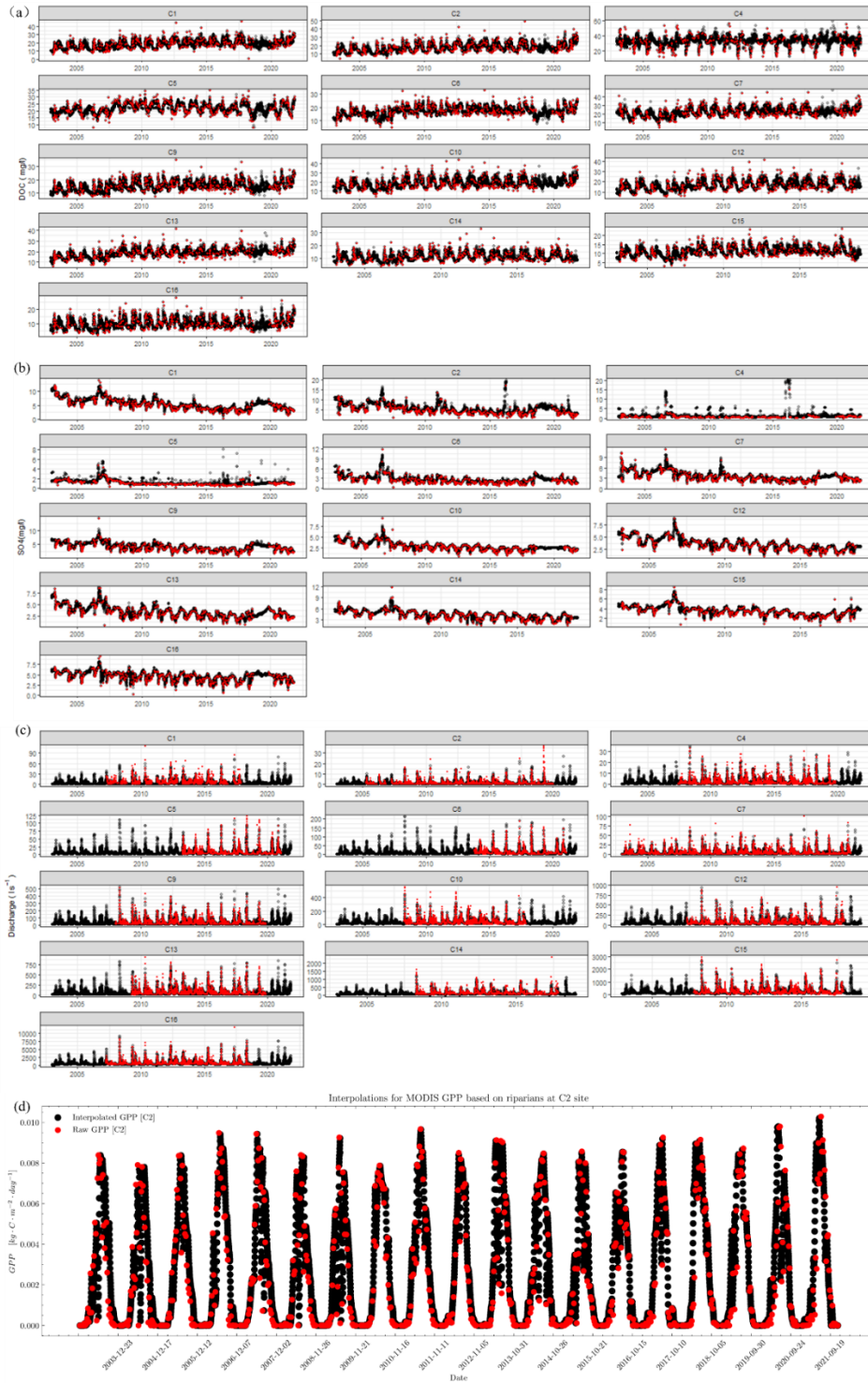


Figure S3. The raw observations vs interpolated daily data in DOC (a), SO₄(b), Discharge (c) and MODIS GPP (d). Individual observations are given as red dots, while the interpolated data are shown as black dots. Daily DOC and SO₄ were interpolated by Random Forest; Daily Discharge was predicted by an ensemble version of a bucket-type, semi-distributed hydrological model (HBV); Daily MODIS GPP was gap filled linearly according to 8-day MODIS GPP.

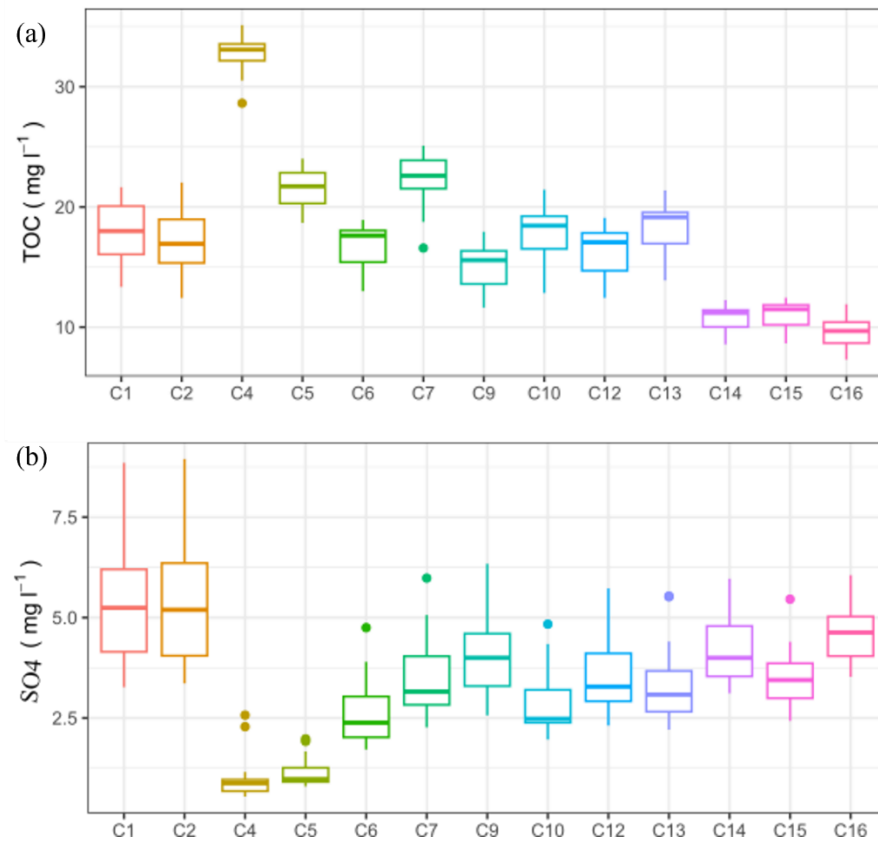


Figure S4. The mean DOC (a) and SO₄ (b) concentrations during 2003 to 2021 across catchments in Krycklan.