Supplement of Earth Surf. Dynam., 6, 1115–1137, 2018
https://doi.org/10.5194/esurf-6-1115-2018-supplement

Earth Surface Dynamics
Open Access
EGU

Supplement of

Impacts of a large flood along a mountain river basin: the importance of channel widening and estimating the large wood budget in the upper Emme River (Switzerland)

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SUPPLEMENTARY INFORMATION

Some footages were recorded the day of the flood, and are available online:

- Beck, Hanspeter: Gewitter Schangnau 24.07.2014 [online]. 24.07.2014. http://www.youtube.com/watch?v=9m5kr0k1-u4. [Film]. 21.08.2014
- Watson: Hochwasser im Emmental [online]. 24.07.2014. http://www.youtube.com/watch?v=gPFoDXyh9p0. [Film]. 07.08.2014
- Fleuren, Max: Unwetter Schangnau / Emmental Juli 2014 Unwetterkatastrophe [online]. 29.07.2014. http://www.youtube.com/watch?v=bJBREWRiD6g. [Film]. 08.10.2014

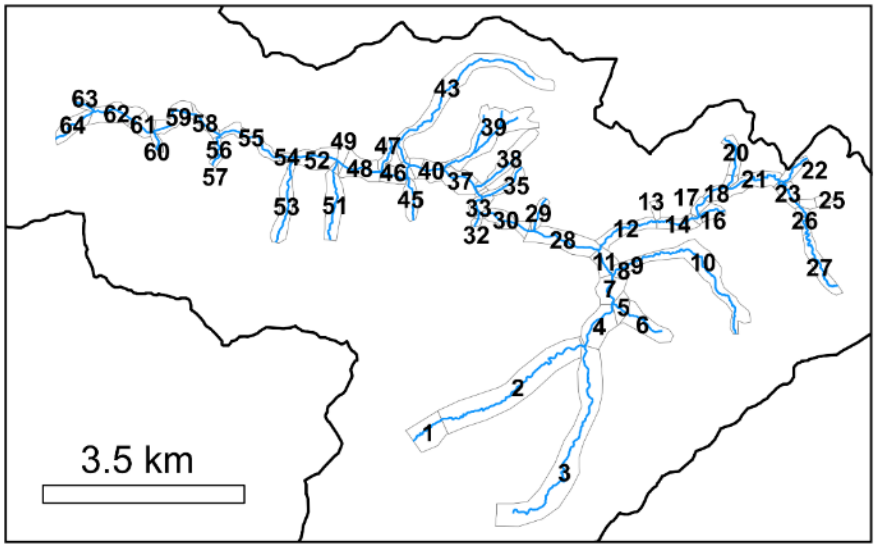

Figure S1: Overview of the 19 study streams divided into 64 subreaches (cf. Table 1). The criteria used to divide the stream network into sub-reaches are: tributary junctions and bridges crossing the river.

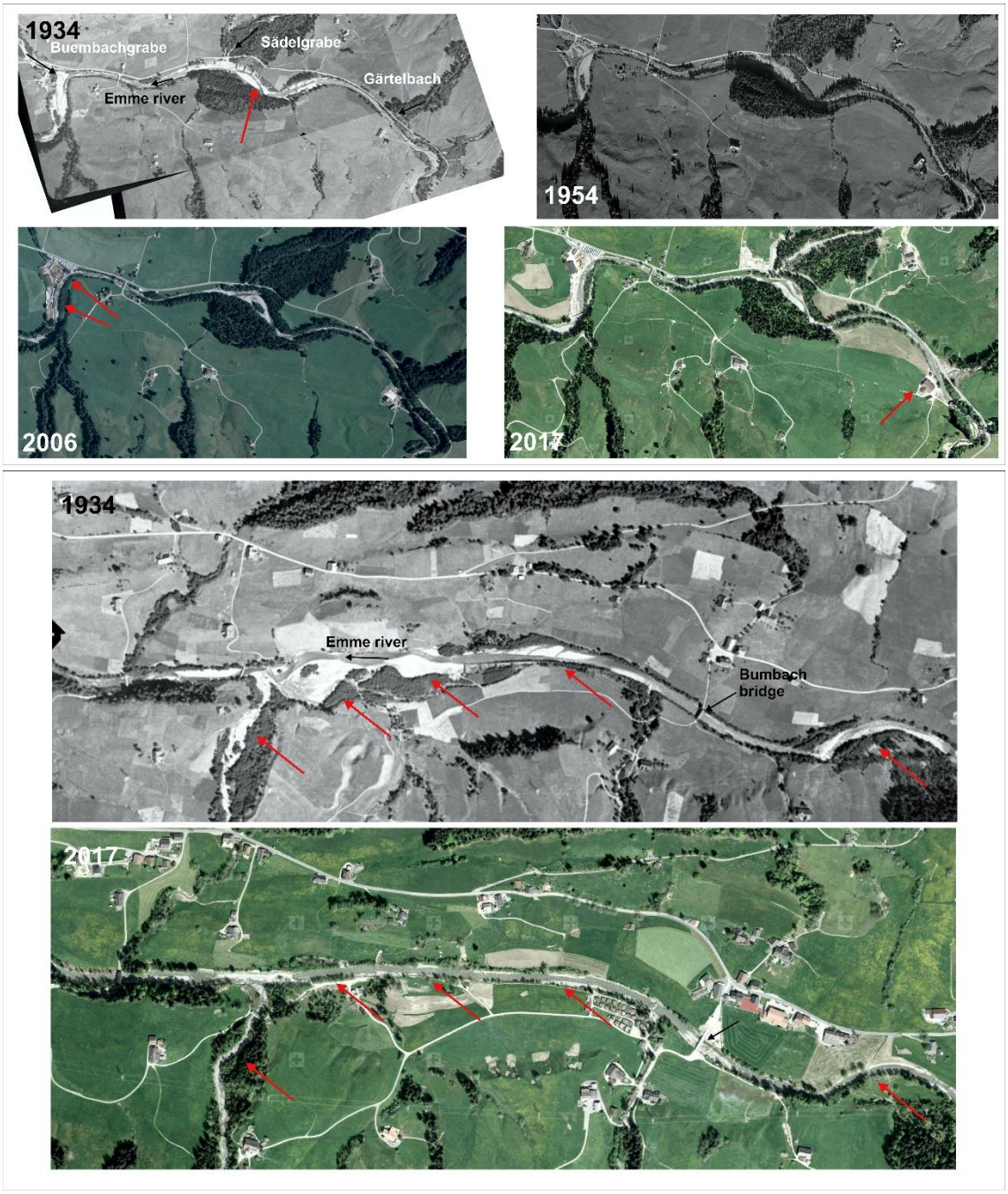

Figure S2: Historical aerial images (source: Swisstopo) showing some important morphological changes at the confluence of several tributaries with the Emme River (upper panel) and along the Emme River (lower panel). Red arrows show main changes.

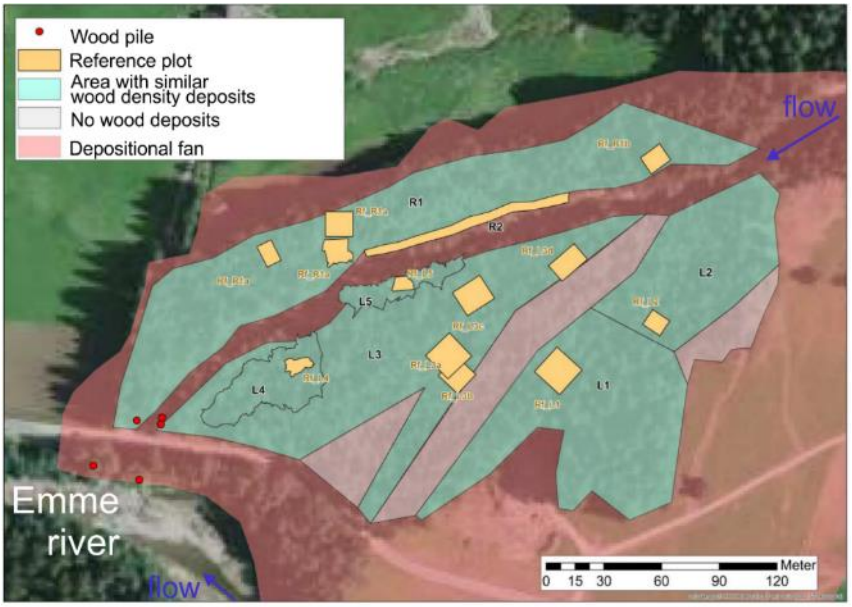

Figure S3: Map of the Sädelgrabe depositional fan showing the reference plots measured in the field and the areas with similar wood deposits.

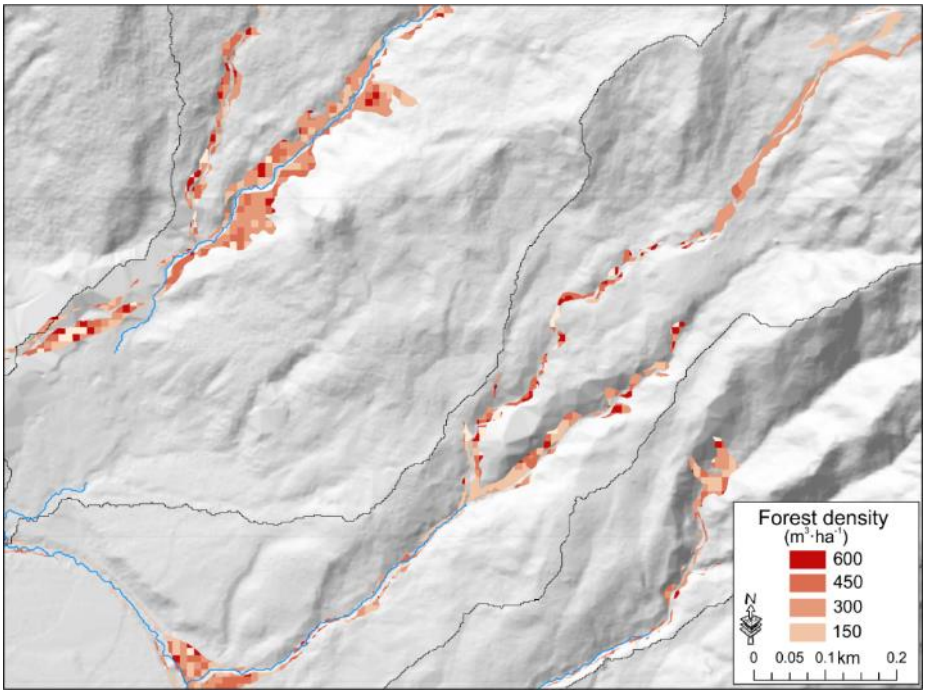

Figure S4: Eroded vegetation (in terms of forest density $m^3 \cdot ha^{-1}$, map shows mean values) during the flood in 2014 in two tributaries of the Emme River.

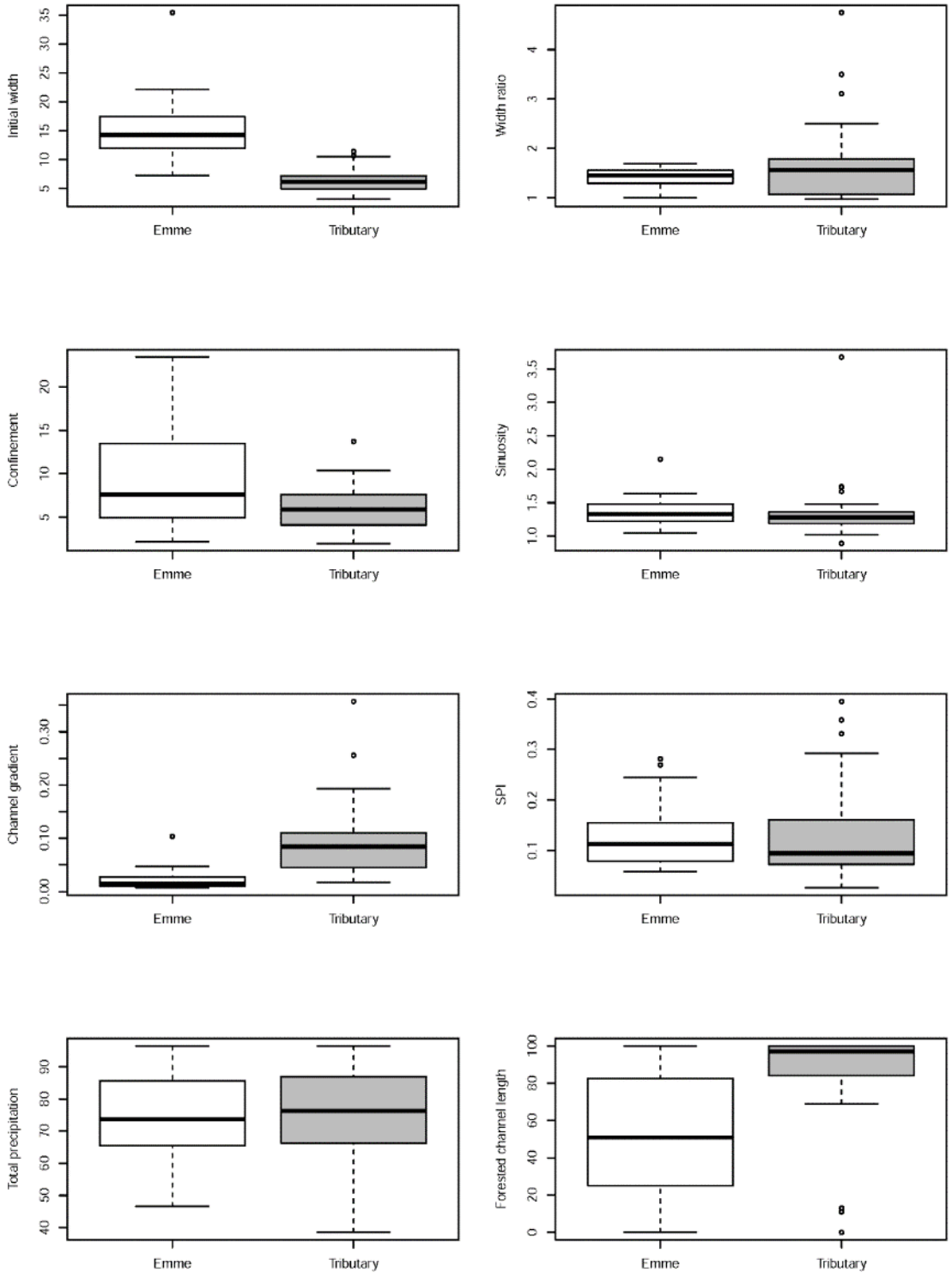

Figure S5: Boxplots of different variables for the sub-reaches grouped as sub-reaches along the Emme River (Emme) and sub-reaches along tributaries (Tributary). Significant differences are observed for initial channel width, confinement index, channel gradient, and forested channel length (according to the Mann-Whitney test).

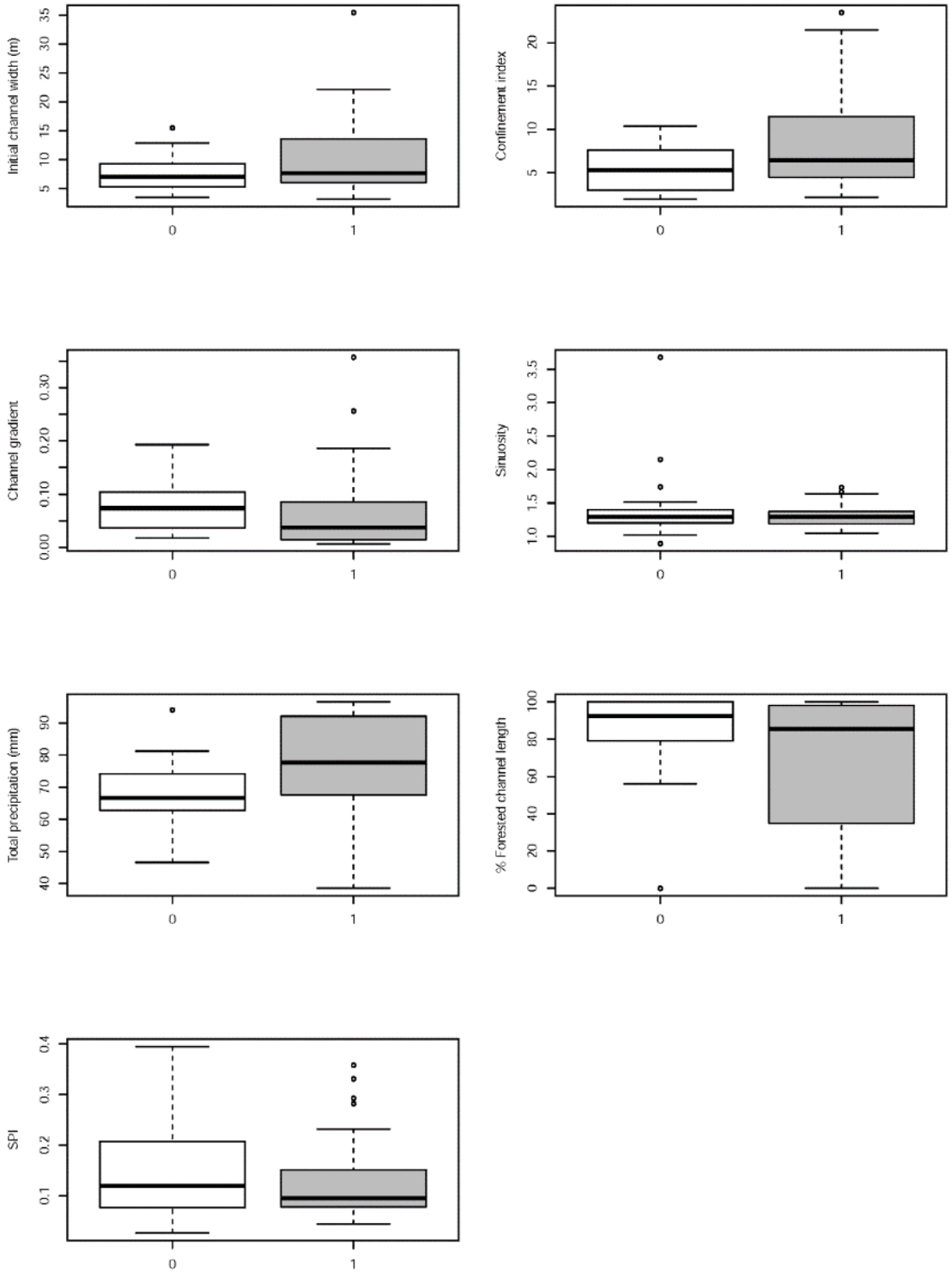

Figure S6: Boxplots of different variables for all sub-reaches (along the Emme River and along tributaries) grouped as sub-reaches experiencing widening (width ratio >1.2; 1) and not experiencing channel widening during the flood (0).

Table S1: Parameters obtained from the multivariate stepwise logistic regression model for width ratio class (widening: width ratio > 1.2 and no widening: width ratio < 1.2) versus different variables (scaled values). Bold indicates significant variables.

All subreaches, all variables	**Coefficient**	**p-value**
(Intercept)	**1.73**	**0.00**
Confinement index	0.87	0.21
Forested channel length (%)	0.56	0.29
Channel gradient	0.44	0.48
Total max. precipitation (mm)	**0.65**	**0.08**
Sinuosity	-0.75	0.07
SPI	**-0.86**	**0.06**
Initial channel width (m)	-0.66	0.39
Peak discharge ($m^3 \cdot s^{-1}$)	**2.03**	**0.10**
AIC	69.03	
All subreaches, final variables		
(Intercept)	1.35	0.00
Total max. precipitation (mm)	0.70	0.04
SPI	-0.50	0.11
Peak discharge ($m^3 \cdot s^{-1}$)	0.77	0.07
AIC	64.15	

Table S2: Parameters obtained from the multiple stepwise linear regression model for width ratio versus different variables (scaled values). Bold indicates significant variables.

All sub-reaches, all variables	**Coefficient**	**p-value**
(Intercept)	0.000	0.46
Confinement index	-0.086	0.62
Forested channel length (%)	0.114	0.54
Channel gradient	0.155	0.46
Total max. precipitation (mm)	0.421	**0.002**
Sinuosity	-0.049	0.73
SPI	-0.317	**0.05**
Initial channel width (m)	-0.156	0.54
Peak discharge ($m^3 \cdot s^{-1}$)	0.119	0.68
Multiple R^2	0.26	
Adjusted R^2	0.14	
p-value	0.04	
All subreaches, final variables		
(Intercept)	0.00	0.31
Channel gradient	0.26	**0.06**
Total max. precipitation (mm)	0.39	**0.002**
SPI	-0.31	**0.03**
Multiple R^2	0.23	
Adjusted R^2	0.19	
p-value	0.002	

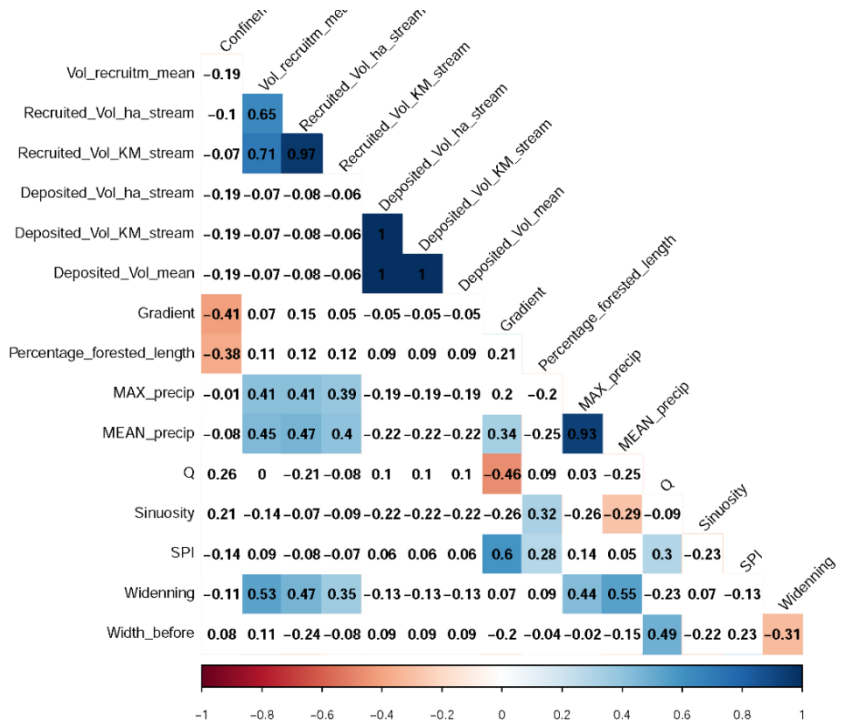

Figure S7: Spearman rank correlation matrix of all variables included in the analyses and for sub-reaches along the tributaries. Values shows the Spearman rank results (significant correlations are in bold). Red colours show significant negative correlations, blue shows significant positive correlation, white shows not significant correlations.

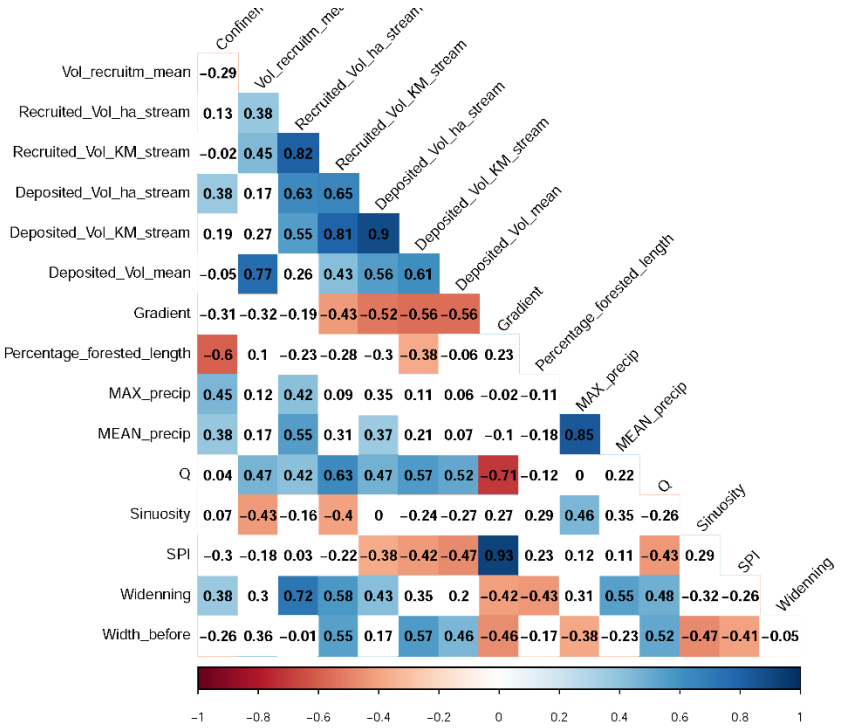

Figure S8: Spearman rank correlation matrix of all variables included in the analyses and for sub-reaches along the Emme River. Values shows the Spearman rank results (significant correlations are in bold). Red colours show significant negative correlations, blue shows significant positive correlation, white shows not significant correlations.

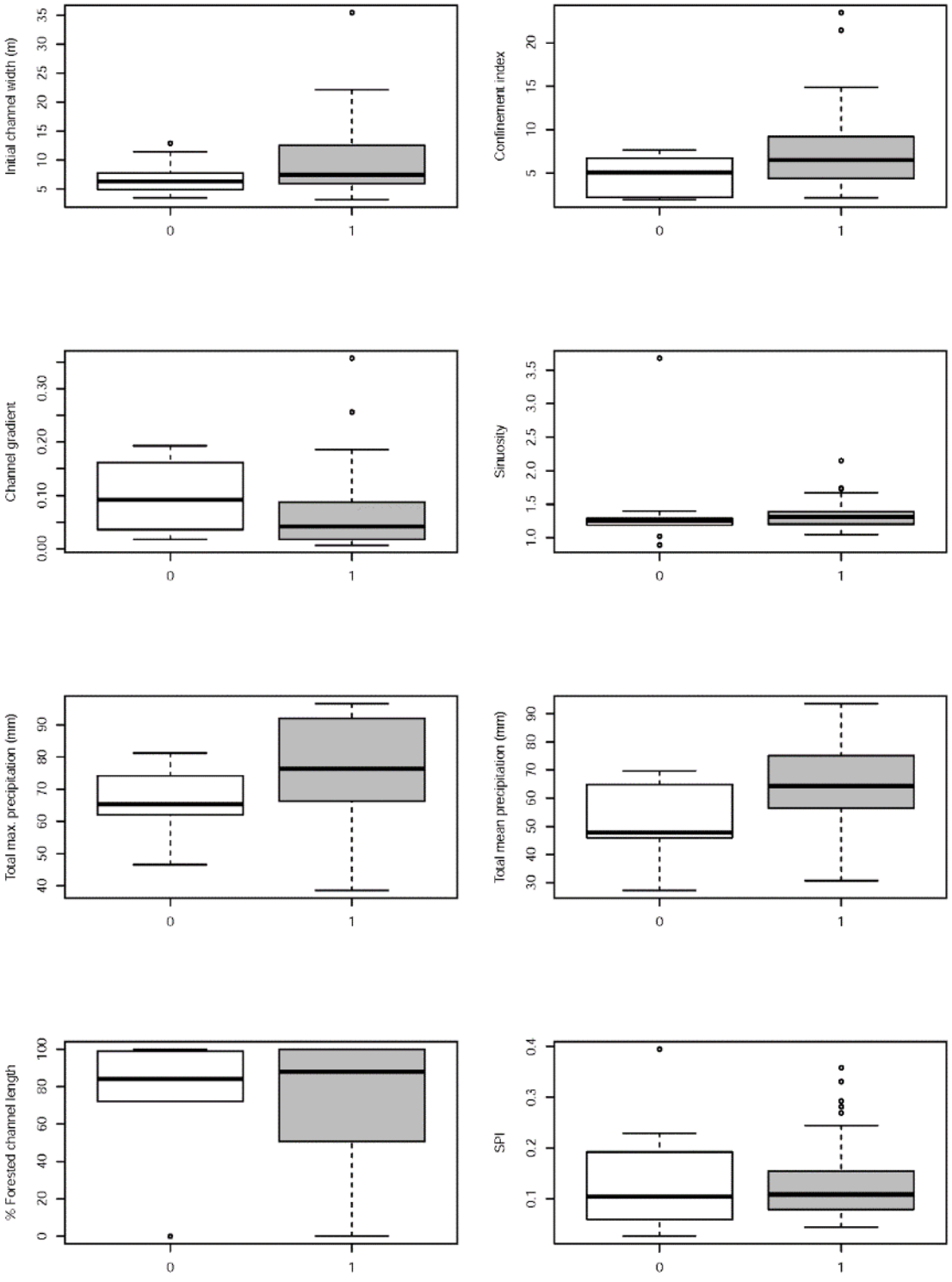

Figure S9: Boxplots of different variables for all sub-reaches (along the Emme River and along tributaries) grouped as sub-reaches recruiting (1) and not recruiting LW (0).

Table S3: Parameters obtained from the multivariate stepwise logistic regression model for LW recruitment class (LW recruitment and no LW recruitment) versus different variables (scaled values). Bold indicates significant variables.

All subreaches	**Coefficient**	**p-value**
(Intercept)	417.08	1.00
Confinement index	24.01	1.00
Forested channel length (%)	81.87	1.00
Channel gradient	36.06	1.00
Total max. precipitation (mm)	8.98	1.00
Peak discharge ($m^3 \cdot s^{-1}$)	219.38	1.00
Sinuosity	9.64	1.00
SPI	-28.57	1.00
Width ratio	414.49	1.00
Initial channel width (m)	-85.05	1.00
AIC	20	
(Intercept)	1386.10	0.99
Confinement index	134.30	0.99
Width ratio	1564.9	0.99
AIC	6	

Table S4: Parameters obtained from the multiple stepwise linear regression model for LW recruitment versus different variables (scaled values). Bold indicates significant variables.

All subreaches, all variables, LW recruited total volume (m^3)	**Coefficient**	**p-value**
(Intercept)	0.00	0.22
Confinement index	-0.08	0.63
Forested channel length (%)	0.18	0.30
Channel gradient	-0.19	0.32
Total max. precipitation (mm)	0.25	**0.06**
Peak discharge ($m^3 \cdot s^{-1}$)	-0.23	0.40
Sinuosity	-0.15	0.24
SPI	0.14	0.34
Width ratio	0.48	**<0.001**
Initial channel width (m)	0.30	0.20
Multiple R^2	0.40	
Adjusted R^2	0.29	
p-value	0.0015	
All subreaches, final variables, LW recruited total volume (m3)	**Coefficient**	**p-value**
(Intercept)	0.00	0.14
Forested channel length (%)	0.25	**0.06**
Total max. precipitation (mm)	0.24	**0.06**
Sinuosity	-0.17	0.13
Width ratio	0.46	**<0.001**
Initial channel width (m)	0.21	0.11
Multiple R^2	0.38	
Adjusted R^2	0.32	
p-value	< 0.001	
All subreaches, all variables, LW recruited volume per hectare ($m^3 \cdot ha^{-1}$)	**Coefficient**	**p-value**
(Intercept)	0.00	0.40
Confinement index	0.001	0.99
Forested channel length (%)	0.19	0.29
Channel gradient	0.17	0.40
Total max. precipitation (mm)	0.26	**0.06**
Peak discharge ($m^3 \cdot s^{-1}$)	-0.01	0.96
Sinuosity	-0.10	0.46
SPI	-0.18	0.25
Width ratio	0.32	**0.02**
Initial channel width (m)	0.01	0.97
Multiple R^2	0.35	

Adjusted R^2	0.23	
p-value	0.006	
All subreaches, final variables, LW recruited volume per hectare ($m^3 \cdot ha^{-1}$)	**Coefficient**	**p-value**
(Intercept)	0.00	0.02
Channel gradient	0.18	0.11
Total max. precipitation (mm)	0.17	0.16
Width ratio	0.40	**<0.001**
Multiple R^2	0.31	
Adjusted R^2	0.27	
p-value	< 0.001	
All subreaches, all variables, LW recruited volume per length ($m^3 \cdot km^{-1}$)	**Coefficient**	**p-value**
(Intercept)	0.02	0.44
Confinement index	0.00	1.00
Forested channel length (%)	0.21	0.28
Channel gradient	0.04	0.86
Total max. precipitation (mm)	0.31	**0.04**
Peak discharge ($m^3 \cdot s^{-1}$)	0.04	0.91
Sinuosity	-0.15	0.32
SPI	-0.15	0.39
Width ratio	0.25	**0.09**
Initial channel width (m)	0.25	0.36
Multiple R^2	0.24	
Adjusted R^2	0.10	
p-value	0.10	
All subreaches, final variables, LW recruited volume per length ($m^3 \cdot km^{-1}$)	**Coefficient**	**p-value**
(Intercept)	0.02	0.86
Total max. precipitation (mm)	0.23	0.09
Width ratio	0.32	0.02
Initial channel width (m)	0.18	0.15
Multiple R^2	0.19	
Adjusted R^2	0.15	
p-value	0.007	

Table S5: Parameters obtained from the multivariate stepwise logistic regression model for LW deposition and different variables (scaled values).

Emme subreaches	Coefficient	p-value
(Intercept)	-4.39	0.12
Confinement index	1.19	0.28
Forested channel length (%)	-0.30	0.77
Channel Gradient	1.40	0.38
Total max. precipitation (mm)	-0.16	0.87
Estimated peak discharge ($m^3 \cdot s^{-1}$)	**5.23**	**0.08**
Sinuosity	-0.09	0.90
SPI	-1.31	0.20
Width ratio	-5.01	0.26
Initial channel width (m)	-0.92	0.53
AIC	38.03	
(Intercept)	-3.56	0.036
Confinement index	**1.24**	**0.09**
Estimated peak discharge ($m^3 \cdot s^{-1}$)	**3.33**	**0.003**
Width ratio	-2.89	0.22
AIC	28.13	

Table S6: Parameters obtained from the multiple stepwise linear regression model for LW deposited volume versus different variables (scaled values). Bold indicates significant variables.

All sub-reaches, all variables, LW deposited total volume (m^3)	**Coefficient**	**p-value**
(Intercept)	0.00	1.00
Confinement index	-0.02	0.89
Forested channel length (%)	0.10	0.46
Channel gradient	0.23	0.15
Total max. precipitation (mm)	0.10	0.38
Peak discharge ($m^3 \cdot s^{-1}$)	0.66	**0.00**
Sinuosity	-0.06	0.57
SPI	-0.31	**0.02**
Width ratio	-0.03	0.80
Initial channel width (m)	0.29	0.15
Multiple R^2	0.59	
Adjusted R^2	0.51	
p-value	<0.001	
All subreaches, final variables, LW deposited total volume (m^3)	**Coefficient**	**p-value**
(Intercept)	0.00	1.00
Channel gradient	0.27	**0.07**
Peak discharge ($m^3 \cdot s^{-1}$)	0.63	**0.002**
SPI	-0.28	**0.01**
Initial channel width (m)	0.28	**0.10**
Multiple R^2	0.57	
Adjusted R^2	0.54	
p-value	<0.001	
All subreaches, all variables, LW deposited volume per hectare ($m^3 \cdot ha^{-1}$)	**Coefficient**	**p-value**
(Intercept)	0.00	0.32
Confinement index	0.16	0.20
Forested channel length (%)	-0.02	0.88
Channel gradient	0.23	0.13
Total max. precipitation (mm)	0.06	0.54
Peak discharge ($m^3 \cdot s^{-1}$)	0.81	**<0.001**
Sinuosity	0.03	0.78
SPI	-0.19	0.11
Width ratio	-0.02	0.85
Initial channel width (m)	0.01	0.96
Multiple R^2	0.63	
Adjusted R^2	0.56	

p-value	<0.001	
All subreaches, final variables, LW deposited volume per hectare ($m^3 \cdot ha^{-1}$)	**Coefficient**	**p-value**
(Intercept)	0.00	1.00
Confinement index	0.19	**0.05**
Channel gradient	0.23	**0.10**
Peak discharge ($m^3 \cdot s^{-1}$)	0.82	**<0.001**
SPI	-0.18	**0.09**
Multiple R^2	0.62	
Adjusted R^2	0.59	
p-value	<0.001	
All subreaches, all variables, LW deposited volume per length ($m^3 \cdot km^{-1}$)	**Coefficient**	**p-value**
(Intercept)	0.04	0.58
Confinement index	0.12	0.31
Forested channel length (%)	-0.07	0.59
Channel gradient	0.24	**0.09**
Total max. precipitation (mm)	0.03	0.73
Peak discharge ($m^3 \cdot s^{-1}$)	0.46	**0.02**
Sinuosity	0.02	0.79
SPI	-0.19	**0.09**
Width ratio	0.04	0.67
Initial channel width (m)	0.48	**0.01**
Multiple R^2	0.7	
Adjusted R^2	0.65	
p-value	<0.001	
All subreaches, final variables, LW deposited volume per length ($m^3 \cdot km^{-1}$)	**Coefficient**	**p-value**
(Intercept)	0.04	0.57
Confinement index	0.16	**0.09**
Channel gradient	0.26	**0.05**
Peak discharge ($m^3 \cdot s^{-1}$)	0.50	**0.01**
SPI	-0.20	**0.05**
Initial channel width (m)	0.47	**0.003**
Multiple R^2	0.7	
Adjusted R^2	0.67	
p-value	<0.001	