Hydraulics, water quality, biodiversity and policy research to support nature-based water management using vegetated floodplains

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In collaboration with national and international colleagues

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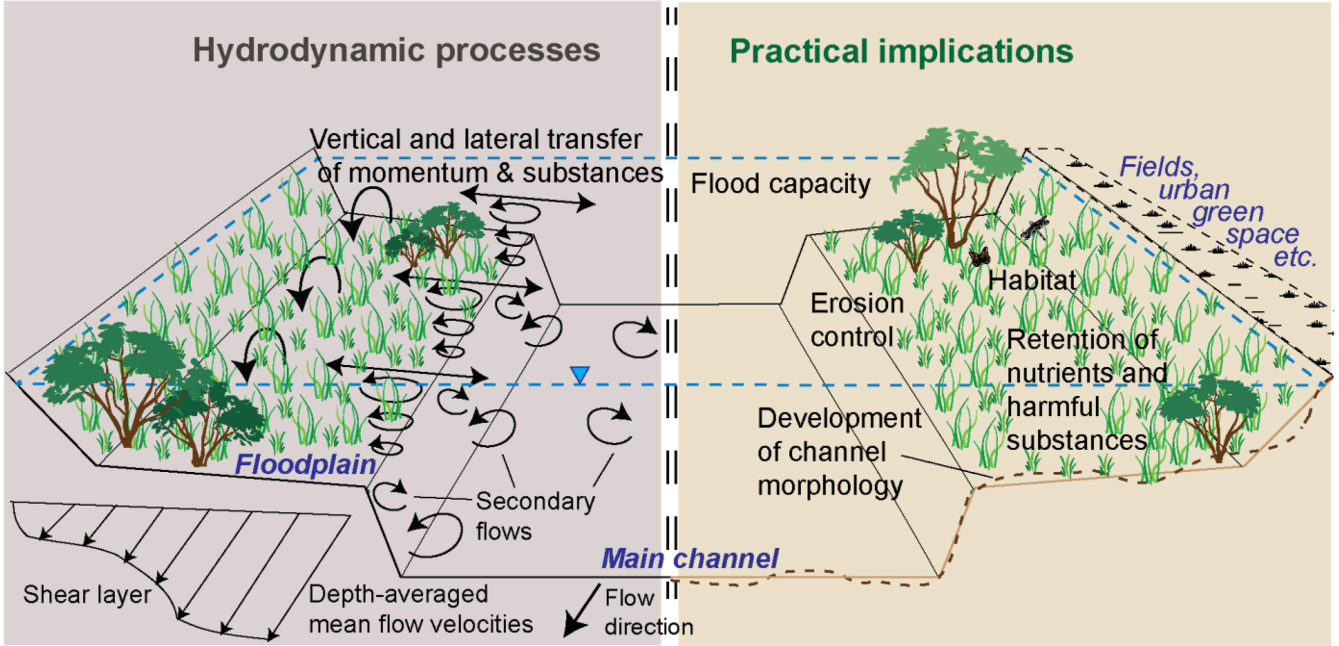
Presentation topics

- Why floodplain vegetation matters?
- Interactions between floodplain vegetation and hydrodynamics
  - Lab, field and model development
- Evaluation and co-development of nature-based solutions for river and water management
  - Case two-stage channels & vegetation management
  - Sediments, water quality, biodiversity
- Natural sciences and engineering supported by economical, policy, governance, and legal considerations



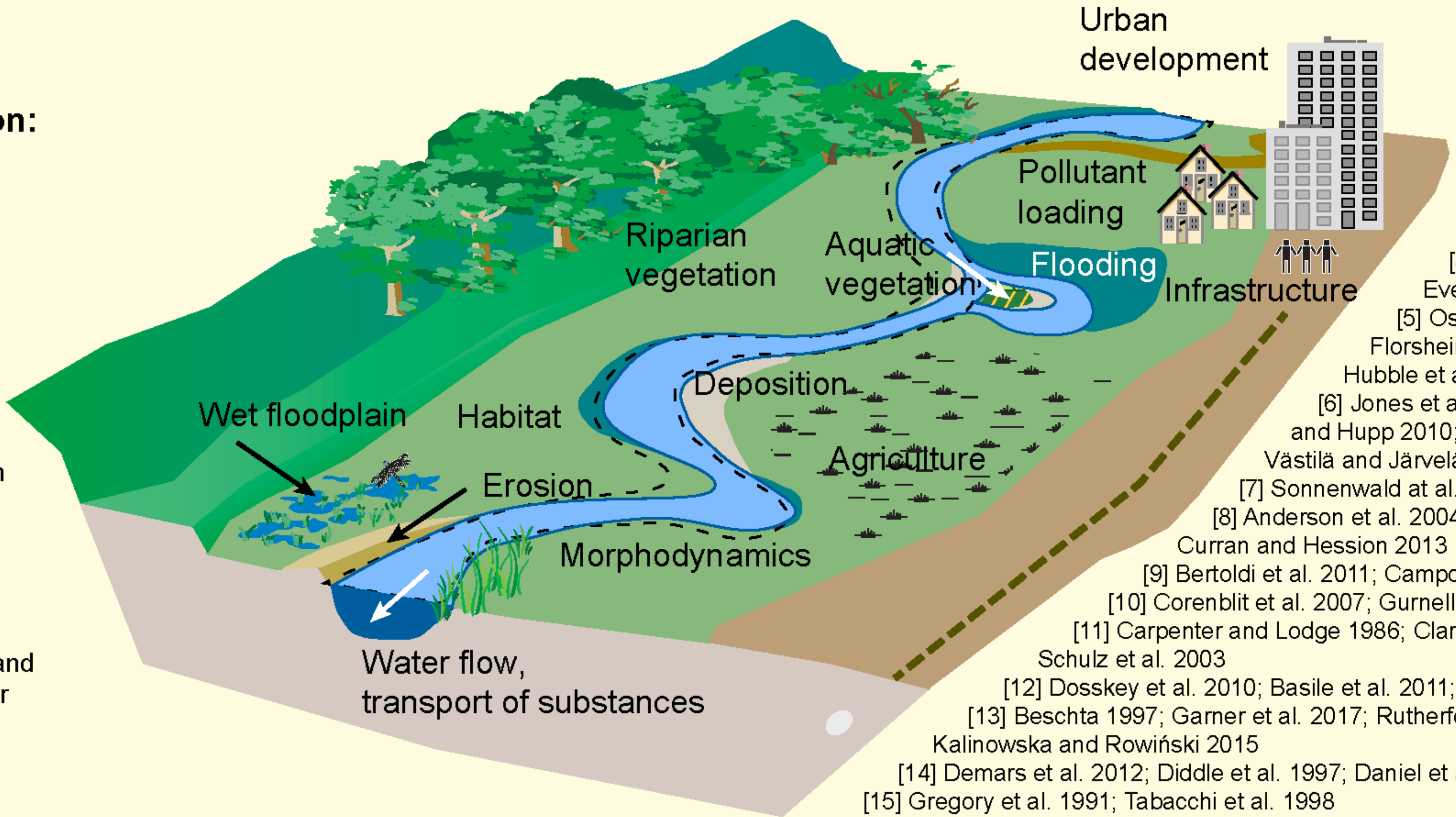
(Rowiński, P.M., Västilä, K., Aberle, J., Järvelä, J. & Kalinowska, M. 2018 How vegetation can aid in coping with river management challenges: A brief review. Ecohydrology and Hydrobiology. doi: 10.1016/j.ecohyd.2018.07.003).

Why floodplain vegetation matters?

Riverine vegetation has important ecological and technical impacts

Implications of riverine vegetation on:

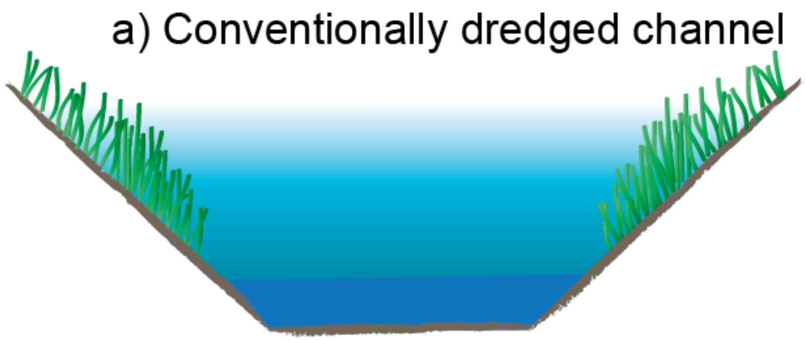
- **Water flow**: e.g. hydraulic resistance[1], flood conveyance[2], agricultural drainage[3], erosion control[4]
- **Transport and mixing processes:** e.g. erosion[5], deposition[6], mixing[7]
- **Morphodynamics:** cross-sectional geometry[8], channel planform[9], landform development[10]
- **Water quality:** e.g. nutrients[11], pollutants[12], temperature[13]
- **Ecology:** e.g. physical habitat[14], source of energy and matter[15], moderation of solar energy fluxes[16]



Literature sources:
[1] Järvelä 2002; Knight et al. 2010; Nikora et al. 2008; Rowiński et al. 2005
[2] Geerling et al. 2008; Knight et al. 2010
[3] Blann et al. 2009; Västilä et al. 2016
[4] EFIB 2015; Evette at al. 2009
[5] Osterkamp et al. 2012; Florsheim et al. 2008; Hubble et al. 2010
[6] Jones et al. 2012; Osterkamp and Hupp 2010; Gurnell, 2014; Västilä and Järvelä 2017
[7] Sonnenwald at al. 2017; Nepf 2012
[8] Anderson et al. 2004; McBride et al. 2010; Curran and Hession 2013
[9] Bertoldi et al. 2011; Camporeale et al. 2013
[10] Corenblit et al. 2007; Gurnell 2014
[11] Carpenter and Lodge 1986; Clarke 2002; Schulz et al. 2003
[12] Dosskey et al. 2010; Basile et al. 2011; Virendra et al. 2008
[13] Beschta 1997; Garner et al. 2017; Rutherford et al. 2004; Kalinowska and Rowiński 2015
[14] Demars et al. 2012; Diddle et al. 1997; Daniel et al. 2006
[15] Gregory et al. 1991; Tabacchi et al. 1998
[16] Dugdale et al. 2018

(Rowiński, P.M., Västilä, K., Aberle, J., Järvelä, J. & Kalinowska, M. 2018 How vegetation can aid in coping with river management challenges: A brief review. Ecohydrology and Hydrobiology. doi: 10.1016/j.ecohyd.2018.07.003.)

Reality: Problems of conventional agricultural water management



Frequent maintenance dredging

poor ecological status

Floodplains disconnected

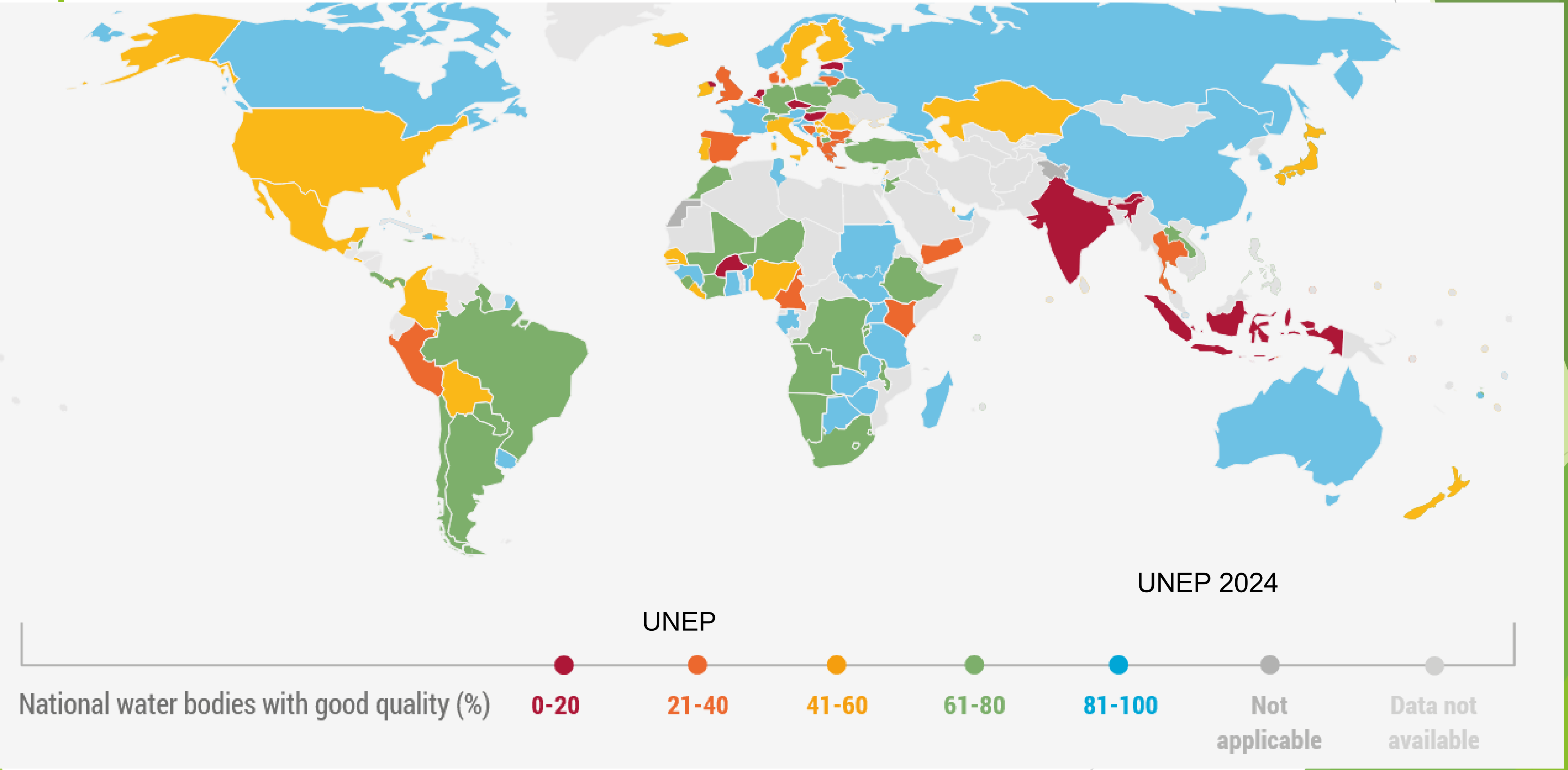
Siltation, overgrowing

Incapable of handling variable flow and sediment transport conditions

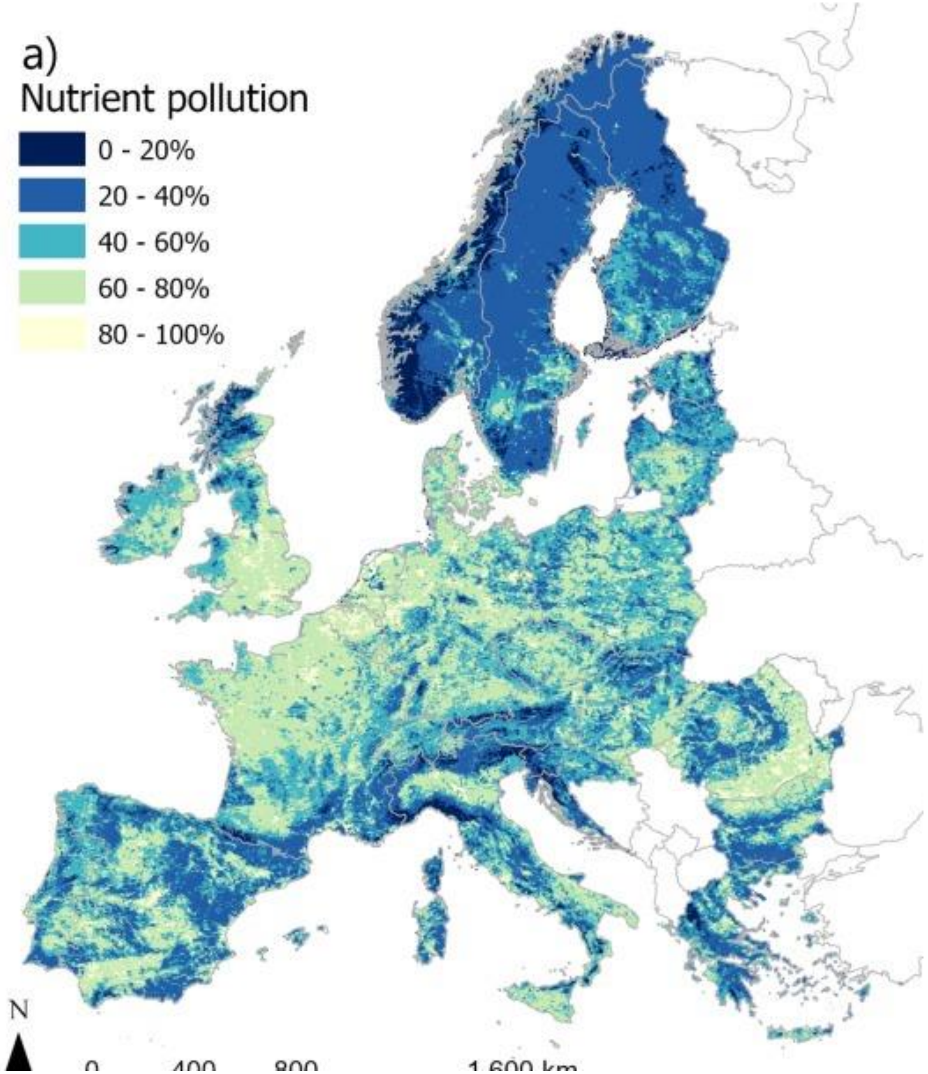
Channel erosion

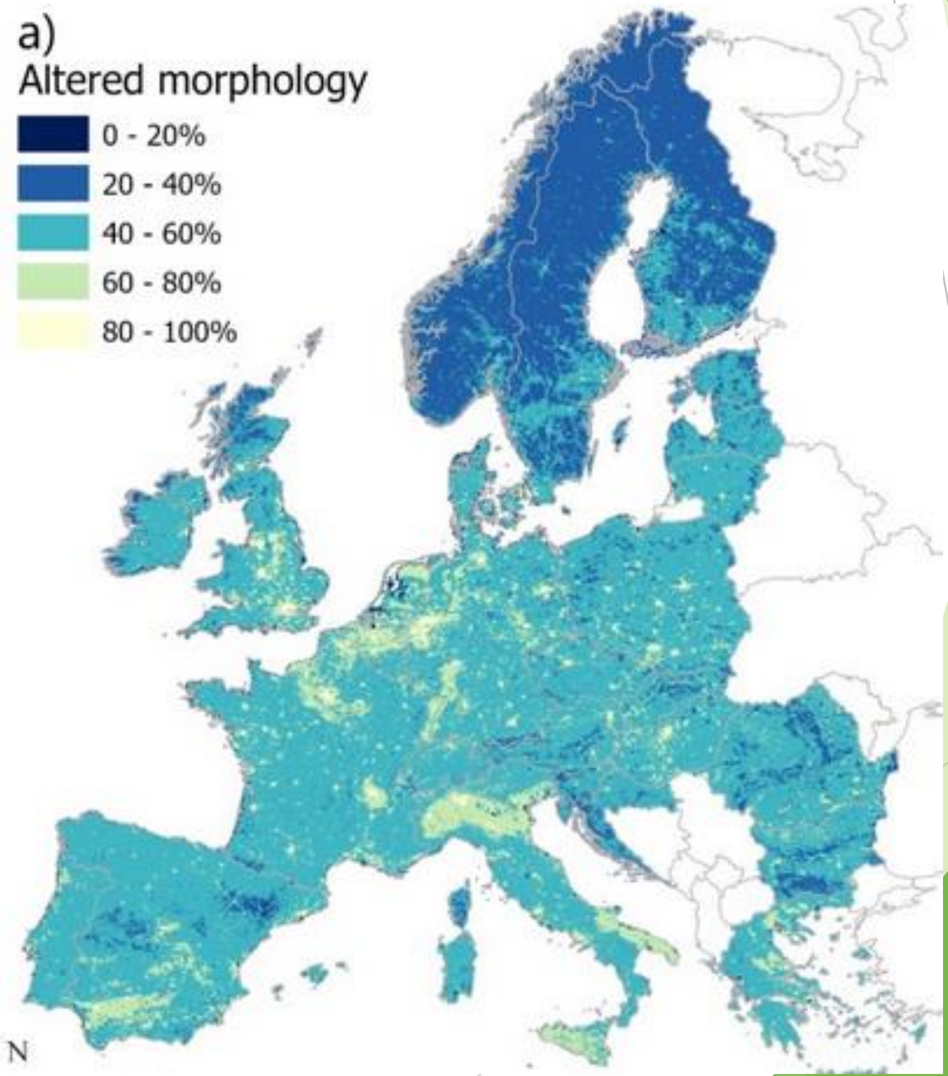
limited water storage capacity

Surface water quality is degraded in large parts of the world



European rivers severely affected by agricultural pollution and hydro-morphological pressures

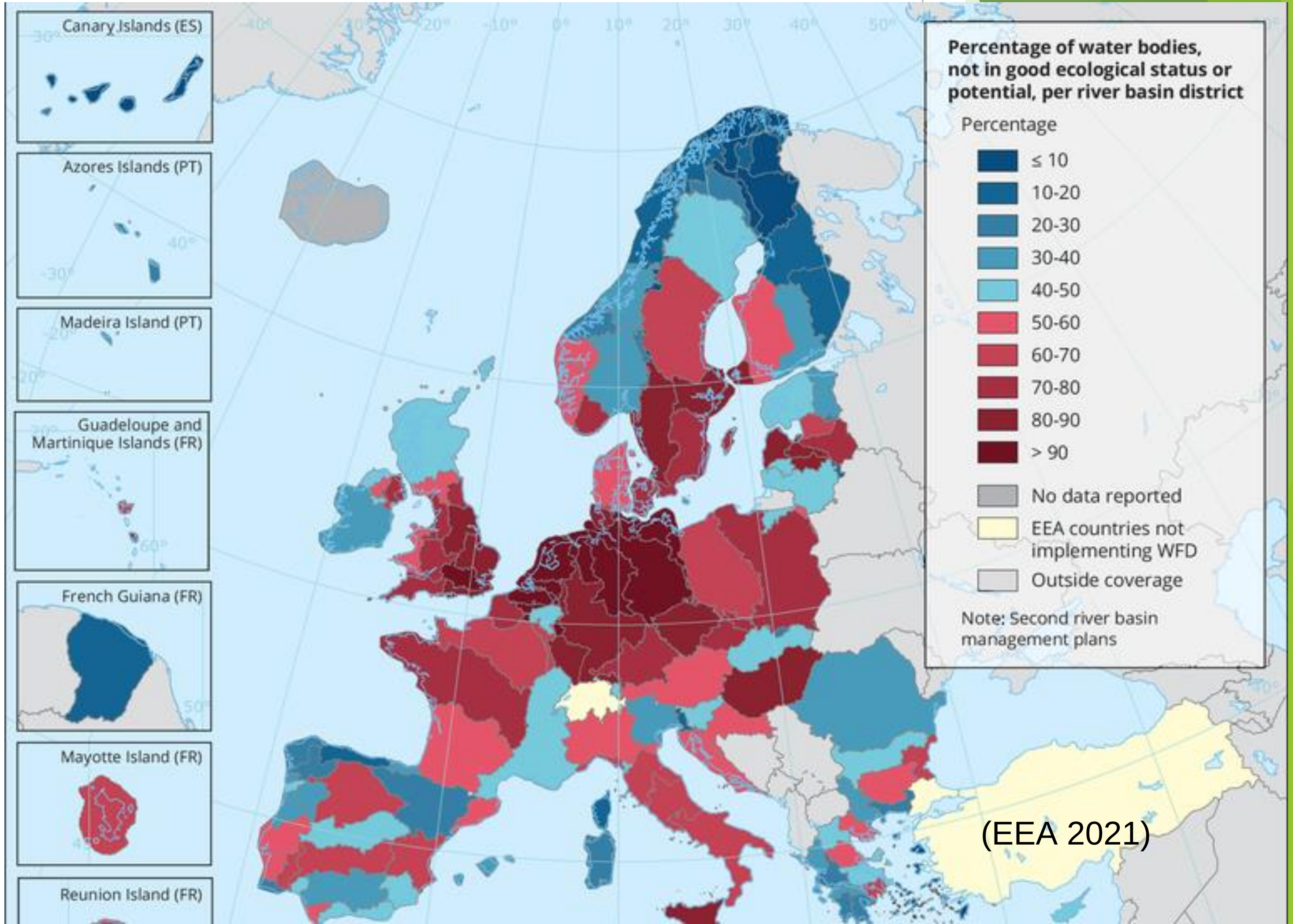




(Vigiak et al. 2021)

Ecological status in Europe’s river basin districts largely below good

- Little improvement since 2010
- NbS recommended for multi-objective river management
  - More vegetation
  - Natural forms and functions



(EEA 2021)

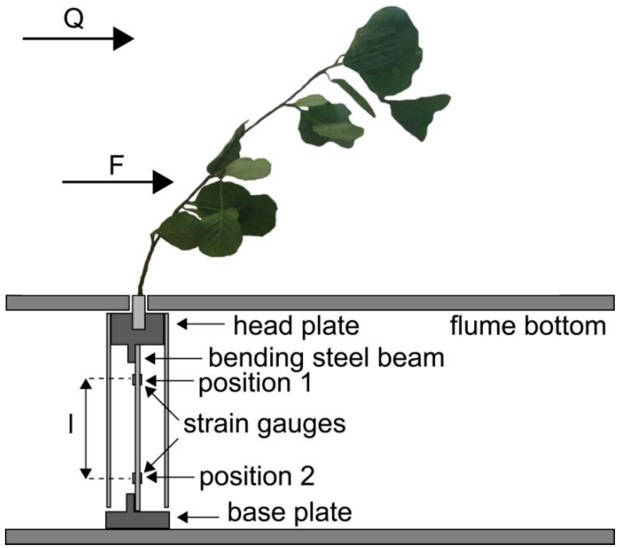
Interactions between floodplain vegetation and hydrodynamics

Vegetative impacts on hydrodynamics is the starting point: flow resistance description

Formulation	Common usage
Vegetative Manning coefficient, n_{veg} [−]	describes reach-scale flow resistance in practical applications and 1D models, or roughness in 2D depth-averaged models
Drag force, F [N]	characterizes drag forces exerted by plants under flow and is commonly applied in experimental investigations
Drag – density parameter, $C_D a$ [m^2 m^{-3}]	describes vegetative drag per unit water volume and is used as a sink or source term in 3D models
Drag – area parameter, $C_D aH$ [m^3 m^{-3}]	characterizes the bulk drag of submerged vegetation in approaches that have separate vertical layers for vegetation and overflow
Vegetative friction factor, f'' [−]	describes roughness in 2D depth-averaged models and represents plant-stand scale flow resistance in flume studies

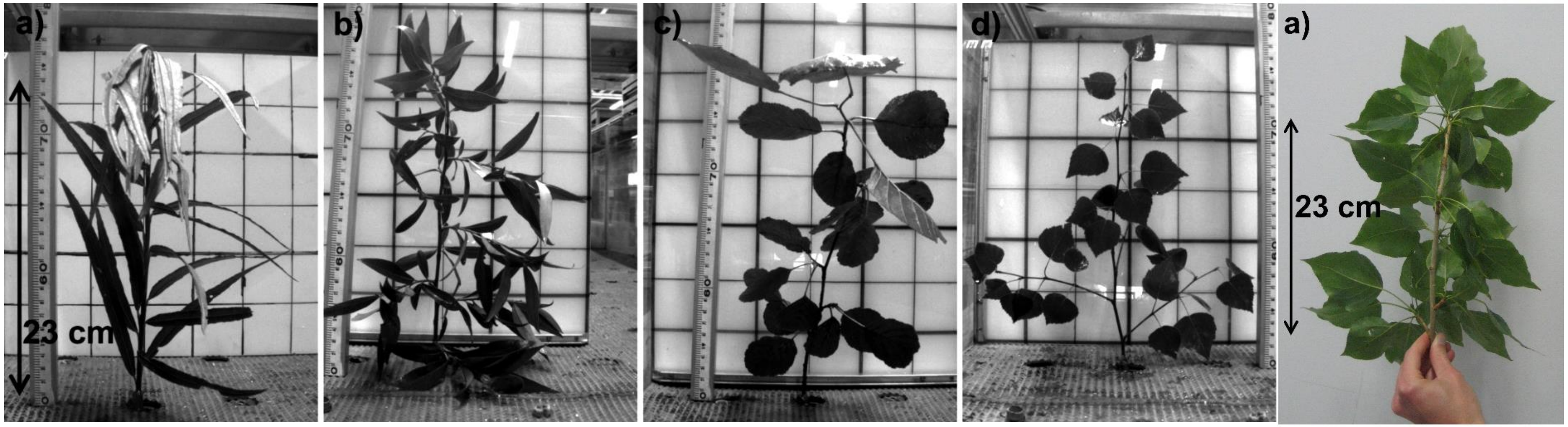
Västilä, K. & Järvelä, J. 2018 Characterizing natural riparian vegetation for modeling of flow and suspended sediment transport. Journal of Soils and Sediments.

Direct drag force measurements at TU Braunschweig



Västilä, K., Järvelä, J. & Aberle, J. 2013 Characteristic reference areas for estimating flow resistance of natural foliated vegetation. Journal of Hydrology.

Västilä, K. & Järvelä, J. 2014. Modeling flow resistance of woody vegetation using physically-based parameters for foliage and stem. Water Resources Research.

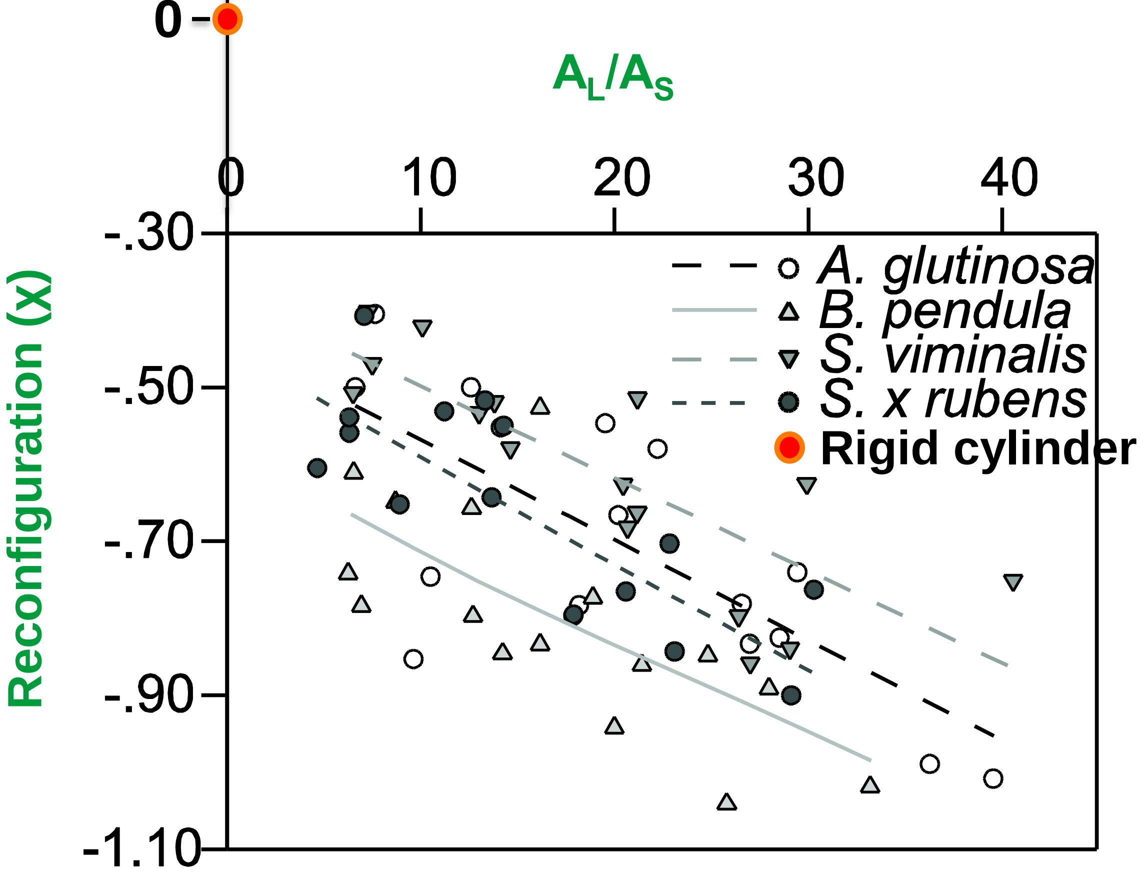


Common Osier (*Salix viminalis*) (Koripaju)	hybrid Crack Willow (*Salix x rubens*) (Kujapaju)	Common Alder (*Alnus glutinosa*) (Tervaleppä)	Silver Birch (*Betula pendula*) (Rauduskoivu)	Black Poplar (*Populus nigra*) (Mustapoppeli)

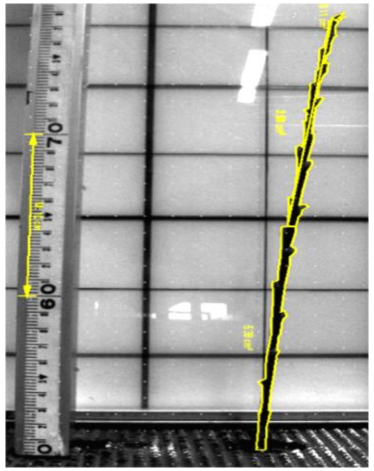
Natural riparian vegetation ≠ rigid cylinders

$$F = \frac{1}{2}\rho C_D A_C u_C^{\,2+\chi}$$

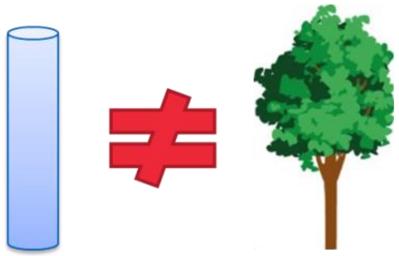
F = drag force
C_D = drag coefficient
A_C = reference area
u_c = characteristic approach velocity



stem area, A_S

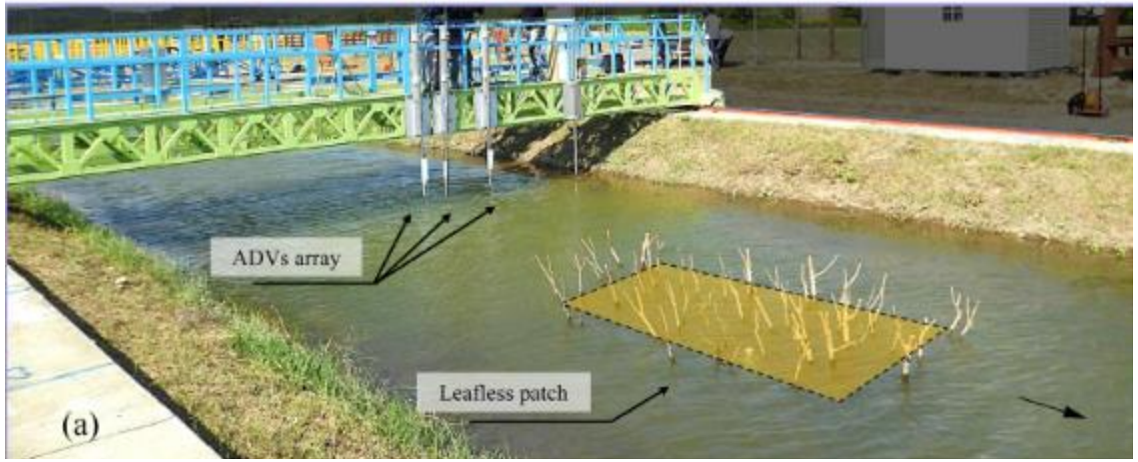


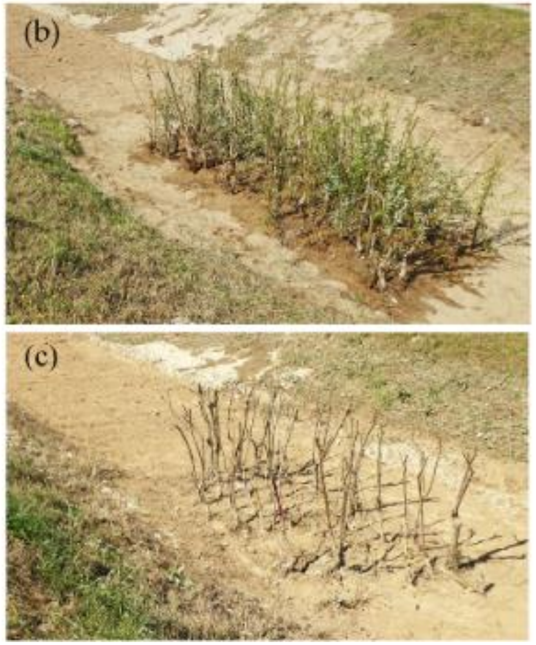
leaf area, A_L

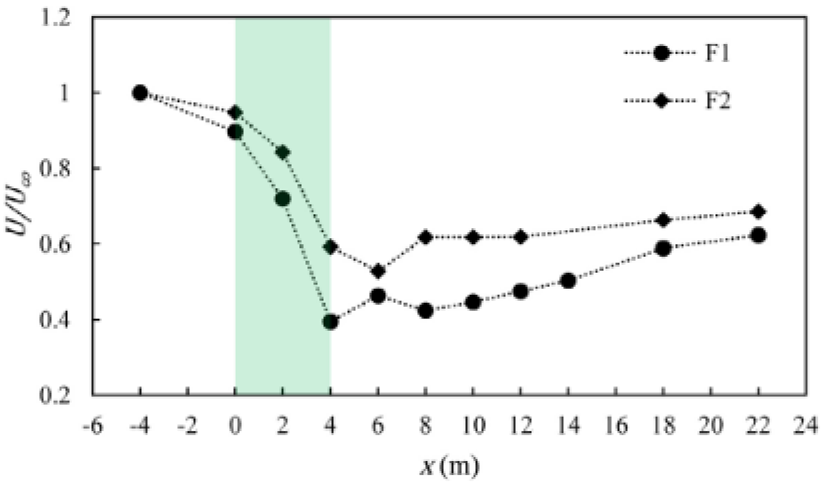


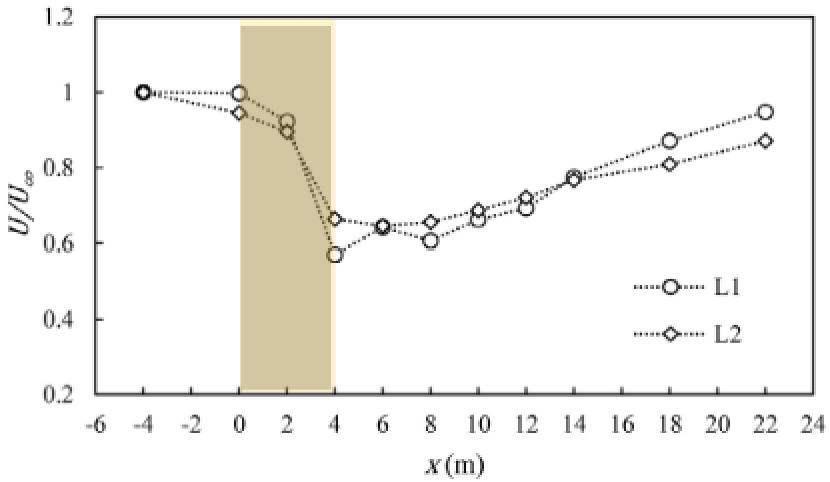
Västilä, K. & Järvelä, J. 2014. Modeling flow resistance of woody vegetation using physically-based parameters for foliage and stem. Water Resources Research 50(1): 229-245. DOI: 10.1002/2013WR013819

Substantial seasonal impacts of vegetation on flow hydraulics



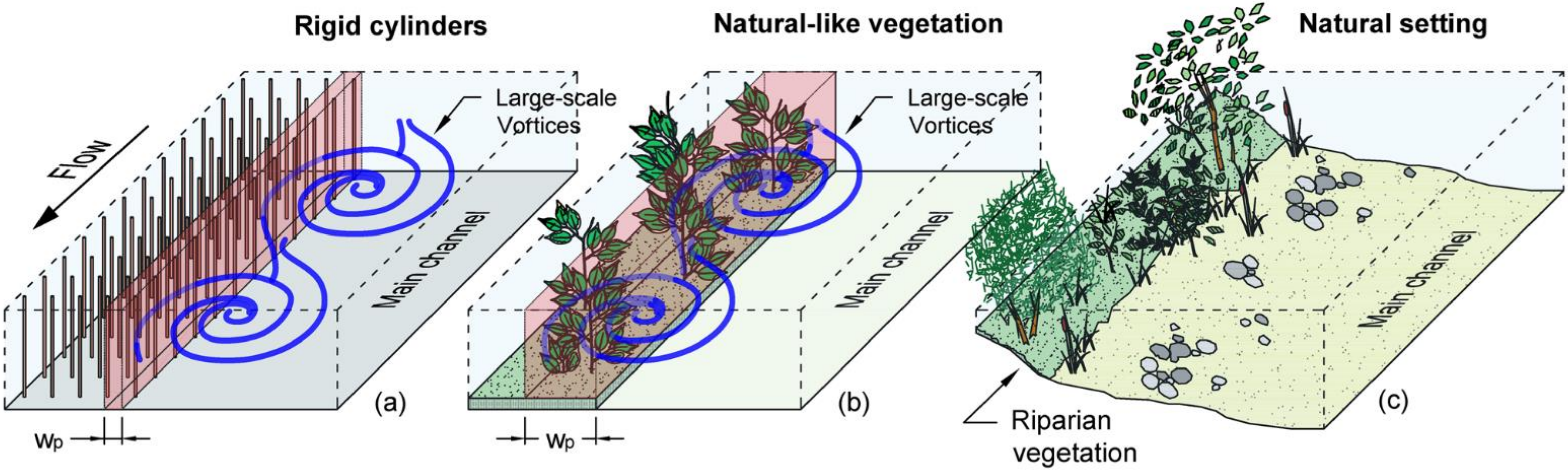






(Caroppi, G., Västilä, K., Järvelä, J., Lee, C., Ji, U., Kim, H. S., & Kim, S. (2022). Flow and wake characteristics associated with riparian vegetation patches: Results from field-scale experiments. Hydrological Processes, 36(2), e14506. https://doi.org/10.1002/hyp.14506)

Differences in turbulent flow structures



For natural-like vegetation (compared to rigid cylinders)

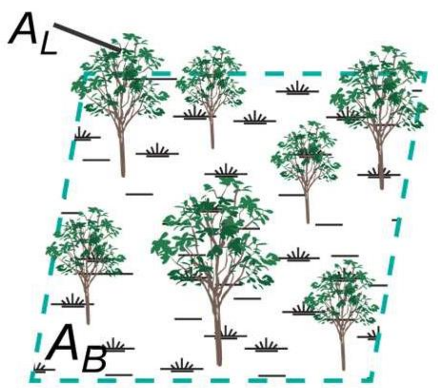
- Shear penetration 6-10 x greater
- Mass transport across interface 40% more efficient

Caroppi et al. 2021 Comparison of Flexible and Rigid Vegetation Induced Shear Layers in Partly Vegetated Channels, Water Resources Research

From the conventional to an enhanced parameterization of vegetative drag

Conventional: $C_D a$

C_D = drag coefficient
a = frontal area per unit volume



New:

$$C_D a = \frac{A_L}{A_B z} C_{D\chi,F} \left(\frac{u_C}{u_{\chi,F}} \right)^{\chi_F} + \frac{A_S}{A_B z} C_{D\chi,S} \left(\frac{u_C}{u_{\chi,S}} \right)^{\chi_S}$$

Density of foliage | Reconfiguration of foliage | Density of stems | Reconfiguration of stems

A_L and A_S are the total leaf area and total stem area, respectively, in a vertical layer with the depth z, A_B=unit ground area, $C_{D\chi,F}$ and $C_{D\chi,S}$ are the drag coefficients of the foliage and stem, respectively, χ_F and χ_S are the reconfiguration parameters of the foliage and stem, respectively, and u_χ is a reference velocity.

Total drag = Stem drag + Foliage drag

Västilä, K. & Järvelä, J. 2014. Modeling flow resistance of woody vegetation using physically-based parameters for foliage and stem. Water Resources Research

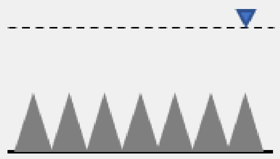
Västilä, K. & Järvelä, J. 2018 Characterizing natural riparian vegetation for modeling of flow and suspended sediment transport. Journal of Soils and Sediments

Development needs of numerical models for quantifying flow resistance of flexible woody vegetation

Conventional use of Manning's *n*

Static approach does not consider effect of vegetation height, plant density, water level or discharge on flow resistance

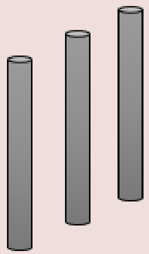
Similar deficits for static Chezy coefficient *C* and friction factor *f*



Simple cylindrical representation

Neglects velocity-dependency of flow resistance

Laborious or unreliable calibration when used for leafy vegetation



Realistic representation of natural vegetated conditions

Key properties properly described:

- density and distribution of vegetation
- velocity dependence of flow resistance (bending and streamlining of flexible plants)
- relative submergence (considering deflected height)
- seasonality of vegetation (from leafless winter to densely foliated summer)
- impact of vegetation on bed shear stress (for sediment transport computations)

Parameterization:

- LAI, A_S/A_B, C_{Dx} → density and distribution of vegetation
- C_{Dx}, χ, h_d → velocity-dependent reconfiguration
- u_v → velocity in vegetated layer (for flow resistance and bed shear stress estimates)
- α → adjustment for velocity profile considering canopy roughness and relative submergence of flexible vegetation

(Västilä, Berends et al., to be submitted)

Developments of the 2D Delft3D FM

Vegetation characteristics

Rigid cylinder (BAP$_{orig}$):

$$C_r = \left(C_b^{-2} + \frac{C_d m D h_v}{2g}\right)^{-\frac{1}{2}} + \frac{\sqrt{g}}{\kappa}\ln K$$

Emergent vegetation — Submerged vegetation

Järvelä (JAR):

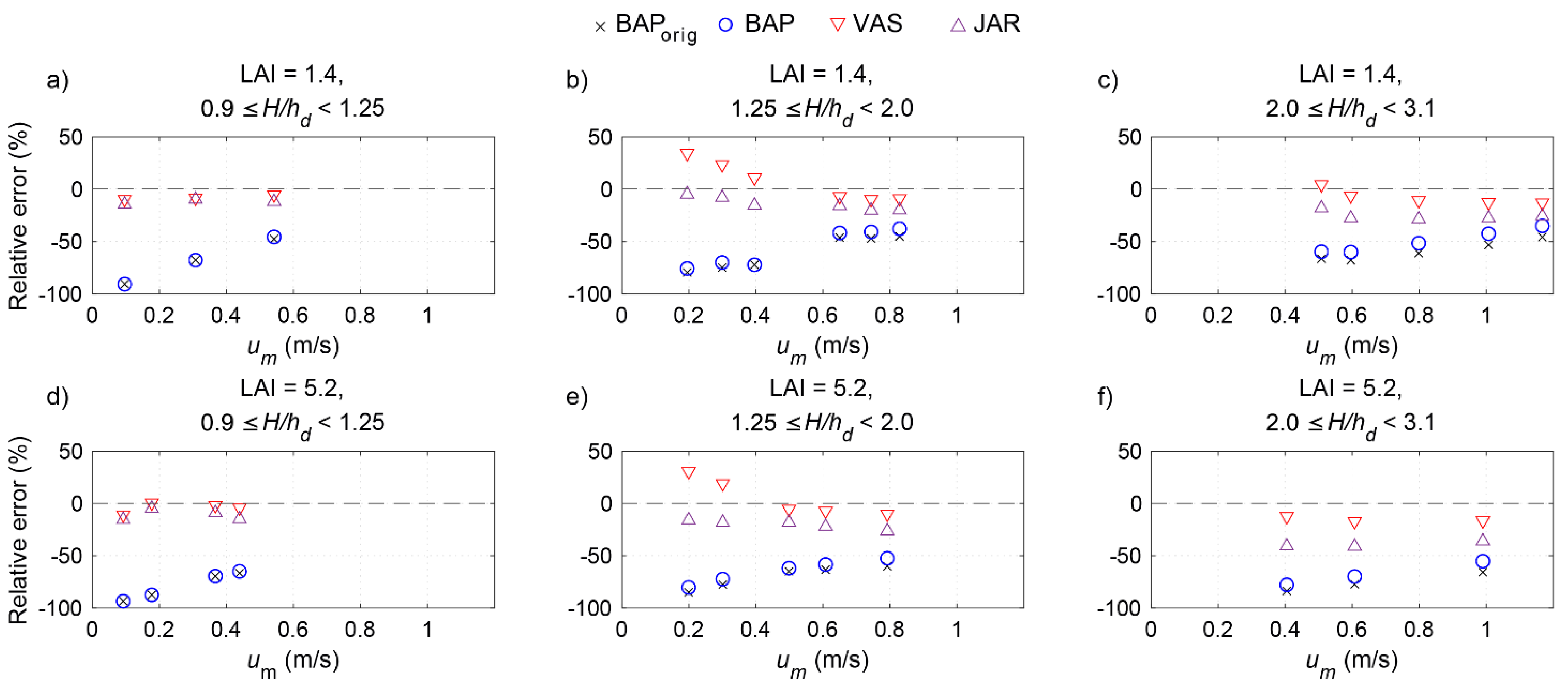
$$C_{D\chi}\mathrm{LAI}\left(\frac{u_c}{u_\chi}\right)^{\chi}$$

Västilä (VAS):

$$C_{D_{\chi,F}}\frac{A_L}{A_B}\left(\frac{u_c}{u_{\chi,F}}\right)^{\chi_F} + C_{D_{\chi,S}}\frac{A_S}{A_B}\left(\frac{u_c}{u_{\chi,S}}\right)^{\chi_S}$$

(Västilä, Berends et al., to be submitted)

Developed Delft3D FM with VAS & JAR more reliable across different flow and vegetative conditions than original model



Parameter values of VAS for common trees and shrubs

Species	$C_{DX,F}$	χ_F	$C_{DX,S}$	χ_S	Data source
Alnus glutinosa (Common Alder)	0.18	−1.11	0.89	−0.27	Västilä & Järvelä (2014) WRR
Betula pendula (Silver Birch)	0.20	−1.06	1.02	−0.32	Västilä & Järvelä (2014) WRR
Populus nigra (Black Poplar)	0.13	−0.97	0.95	−0.27	Västilä et al. (2013) JOH
Salix viminalis (Common Osier)	0.11	−1.21	1.03	−0.20	Västilä & Järvelä (2014) WRR
Salix x rubens (hybrid Crack Willow)	0.19	−1.21	0.96	−0.25	Västilä & Järvelä (2014) WRR
White Birch (*Betula pubescens*)	0.10	-1.09	0.82	-0.25	Jalonen & Järvelä (2014)
Goat Willow (*Salix caprea*)	0.09	-1.09	0.84	-0.27	Jalonen & Järvelä (2014)
Blackberry (*Rubus armeniacus*)	0.40	-1.00	1.20	0.16	Niewerth et al. (2019)

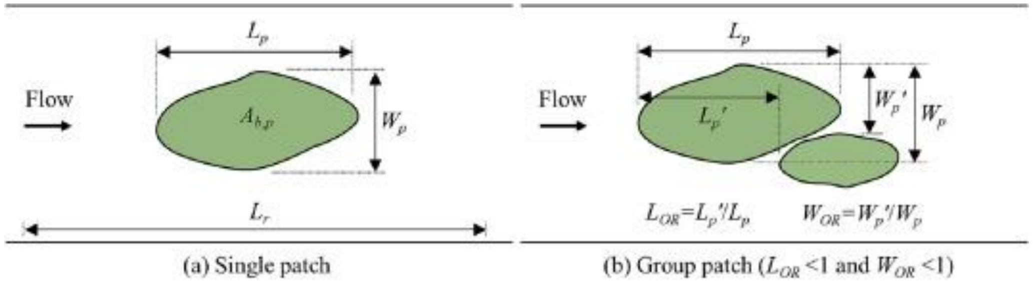
($u_{x,F}$= $u_{x,S}$=0.2 m/s)

Västilä, K. & Järvelä, J. 2018 Characterizing natural riparian vegetation for modeling of flow and suspended sediment transport. Journal of Soils and Sediments, doi: 10.1007/s11368-017-1776-3.

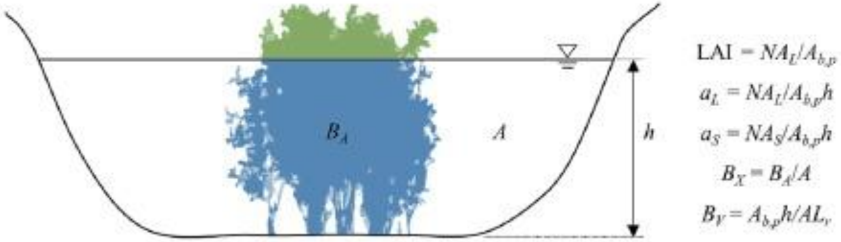
Västilä, Berends et al., to be submitted

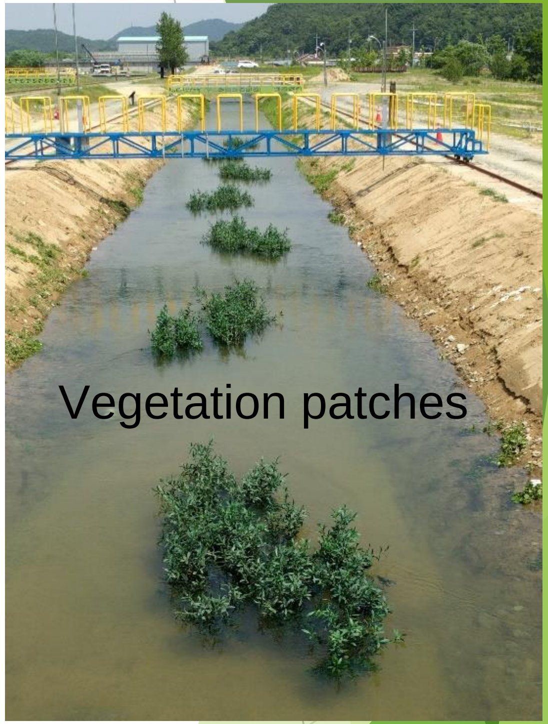
Blockage controls flow resistance of patchy woody vegetation

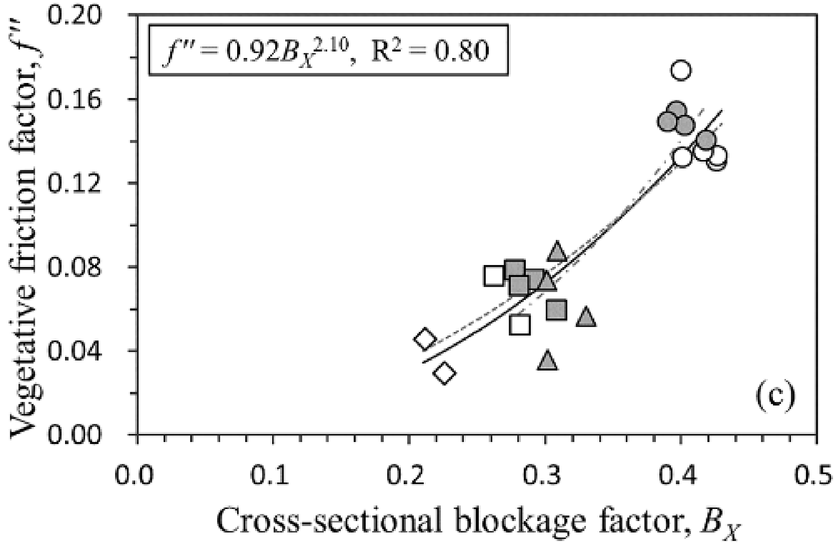
Volumetric: B_V

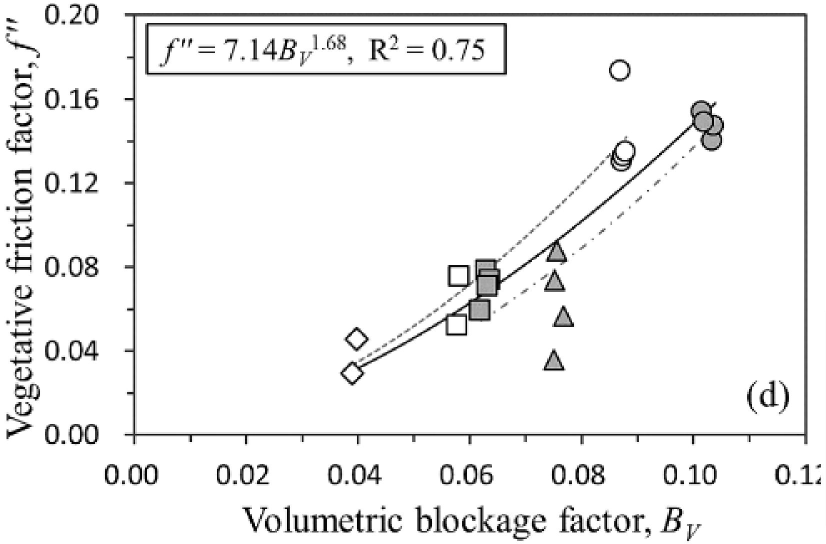


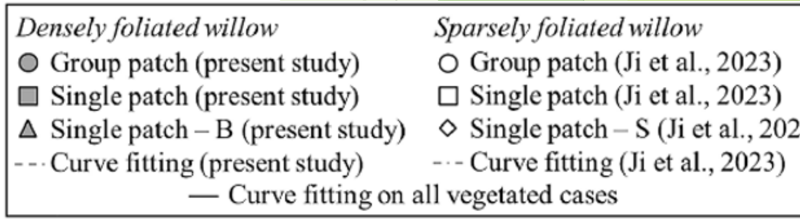
Cross-sectional: B_X







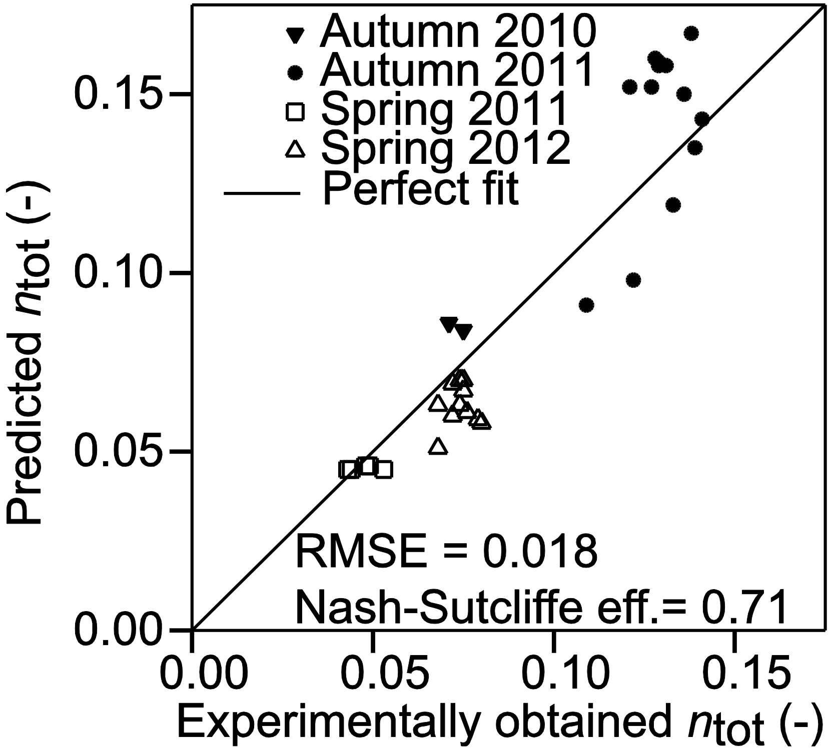




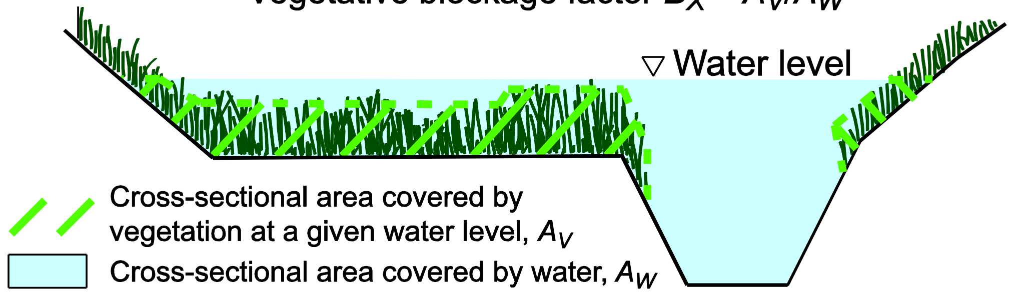
Ji et al. 2023 Experimentation and Modeling of Reach-Scale Vegetative Flow Resistance due to Willow Patches. J Hydraul Eng

Bae et al. 2024 Blockage effect of emergent riparian vegetation patches on river flow. J Hydrol

Cross-sectional blockage factor is key for predicting flow resistance (n_{tot}) in grassed two-stage channels



Vegetative blockage factor $B_X = A_V/A_W$



Luhar & Nepf 2013:

$$n = \left(\frac{KR^{1/6}}{g^{1/2}}\right)\left(\frac{C*}{2}\right)^{1/2}(1-B_x)^{-3/2}$$

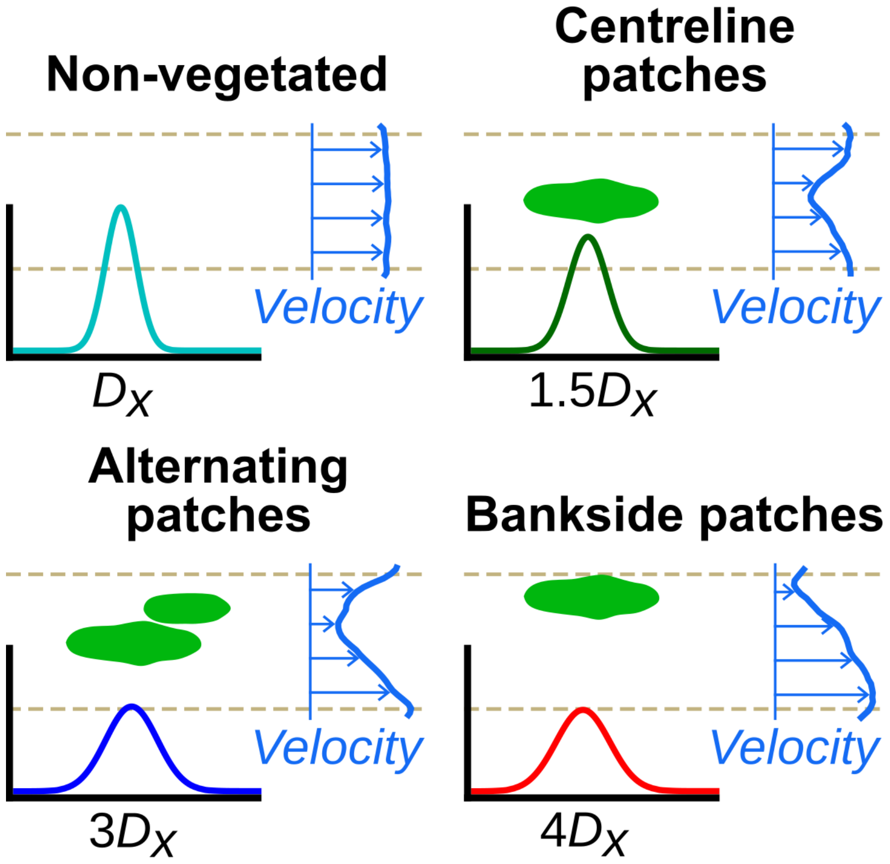
Channel geometry | **Boundary & interface resistance** | **Vegetative resistance**

The seasonal C* was calibrated at the lowest B_X at one water level in spring (2011, n=0.044) and in autumn (2010, n=0.072).

n at higher blockages could be predicted using only the blockage factor

Västilä et al. 2016 Flow–vegetation–sediment interaction in a cohesive compound channel. Journal of Hydraulic Engineering

Describing the effects of patchy vegetation on reach-scale dispersion



Longitudinal dispersion D_X is controlled by the lateral velocity differential, which depends on vegetation patch layout.

$$\frac{D_x}{u_m H} = \frac{D_{x,NV}}{u_{m,NV} H_{NV}} + \varepsilon (U_d - U_{d,NV})$$

values in vegetated conditions

values in non-vegetated conditions

influence of U_d
(ε is a scaling factor)

Västilä, K., Oh, J., Sonnenwald, F., Ji, U., Järvelä, J., Bae, I., and Guymer, I.: Longitudinal dispersion affected by willow patches of low areal coverage, Hydrological Processes, https://doi.org/10.1002/hyp.14613

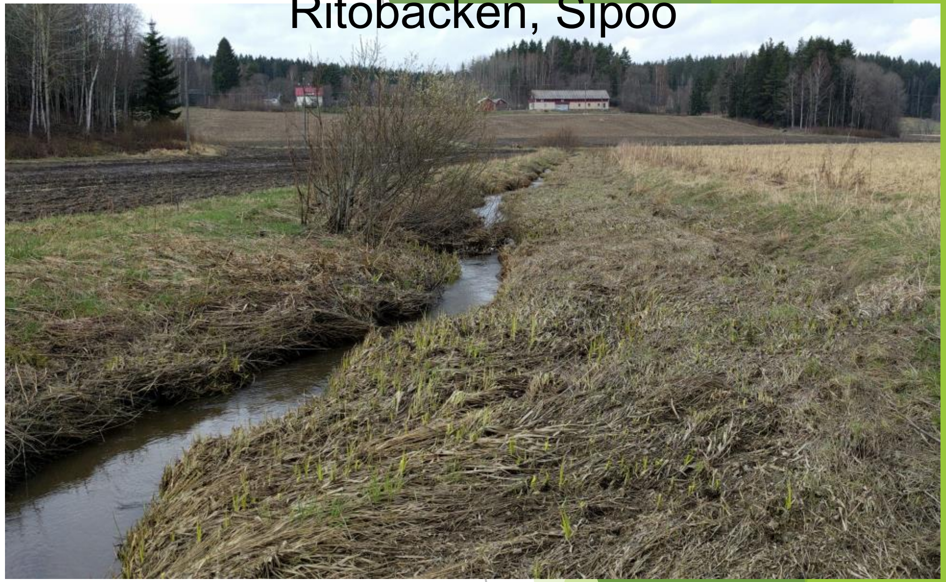
Evaluation and co-development of nature-based solutions for river and water management

Typical nature-based solutions for small headwater catchments in Northern Europe

Restoration of mires/peatlands to balance extreme discharges

Erosion protection: e.g. sowing grasses, fascines, erosion control blankets

Natural-like bottom ramps or rocky sills for erosion protection, raising low water levels, diversifying habitats


Ritobäcken, Sipoo

Constructed wetlands for water quality and wildlife benefits, for retaining water

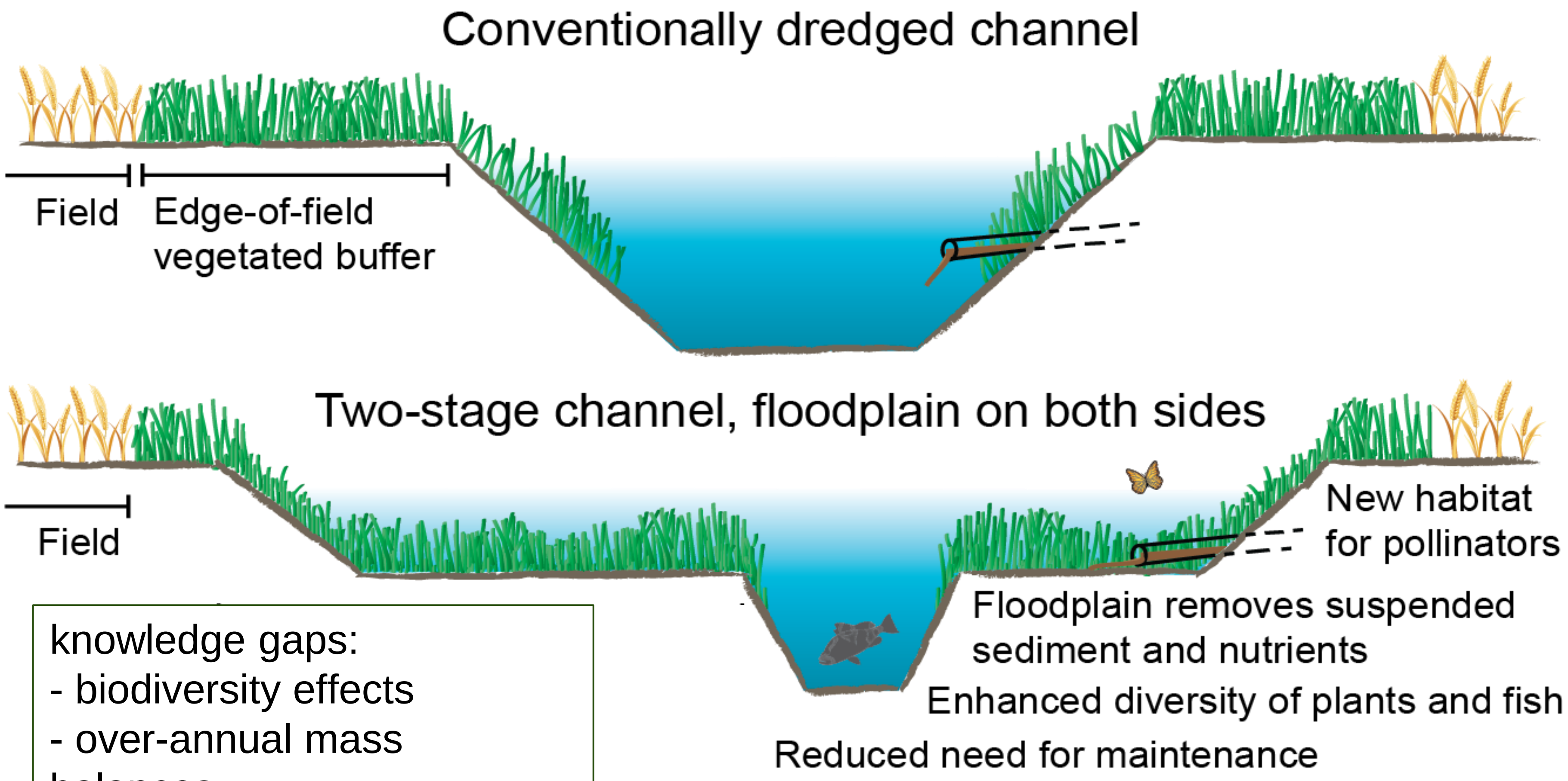

Raaseporinjoki


Juottimenoja, Perniö

Two-stage channels for enhancing drainage and flood mitigation + environmental benefits

In-stream habitat restoration & LWD structures

Two-stage channel (TSC) design as a nature-based alternative to conventional dredging



knowledge gaps:
- biodiversity effects
- over-annual mass balances
- the potential of vegetation maintenance to enhance the benefits

(Västilä et al. 2021, Agricultural Water Management Using Two-Stage Channels: Performance and Policy Recommendations Based on Northern European Experiences. Sustainability 13(16), 9349. https://doi.org/10.3390/su13169349)

Example TSC study sites in Finland

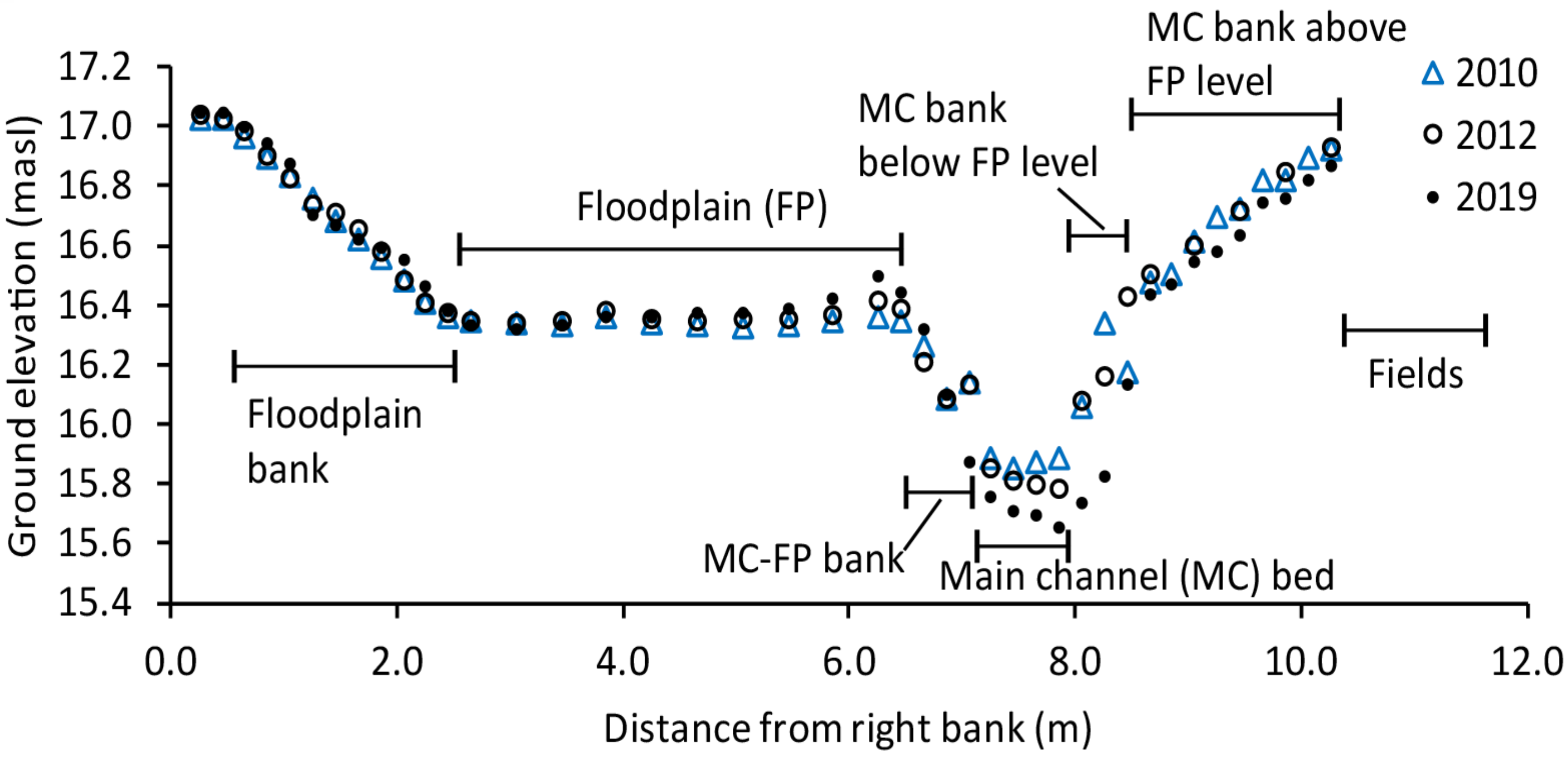
- Floodplains excavated ~at the level of mean discharge in 2008-2018
- Clayey-sandy soils
- Top widths ~8-15 m
- 6…40 km^2 catchment areas
- Q_m ~0.06-0.4 m^3/s

Västilä & Järvelä 2011. DOI: 10.1080/15715124.2011.572888

Västilä, et al 2016. DOI: 10.1061/(ASCE)HY.1943-7900.0001058

Huttunen et al. 2024

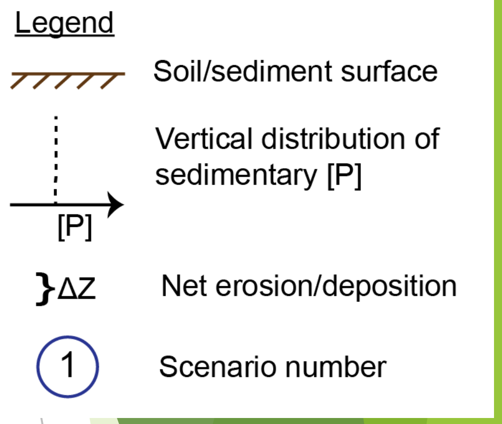
Investigations of morphological development under different channel designs

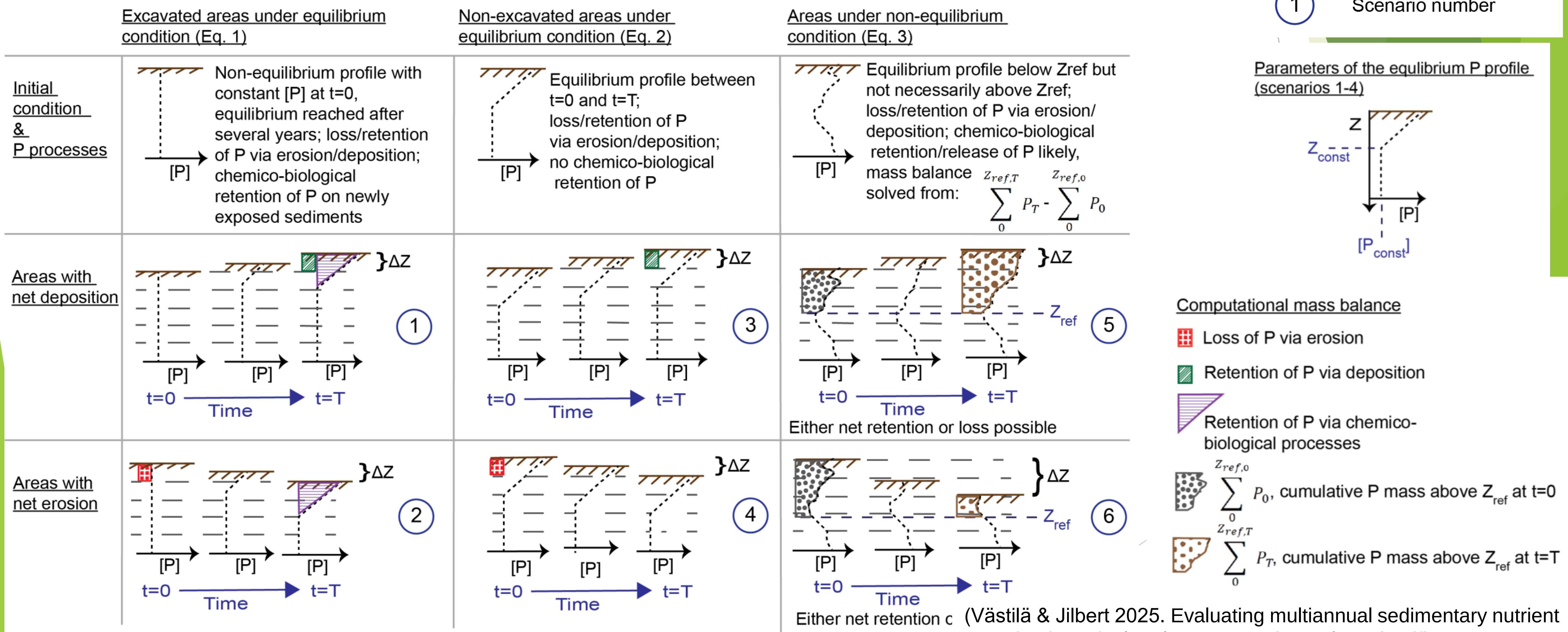


-Two-stage channel had an excellent self-cleansing capacity -> flow conveyance and drainage depth well maintained
-Nature-based rocky sills/rock ramps etc. may be used for decreasing re-suspension
-Erosion in the low-flow channel? -> long-term monitoring needed

(Västilä & Jilbert 2025. Evaluating multiannual sedimentary nutrie retention in agricultural two-stage channels. Scientific Reports

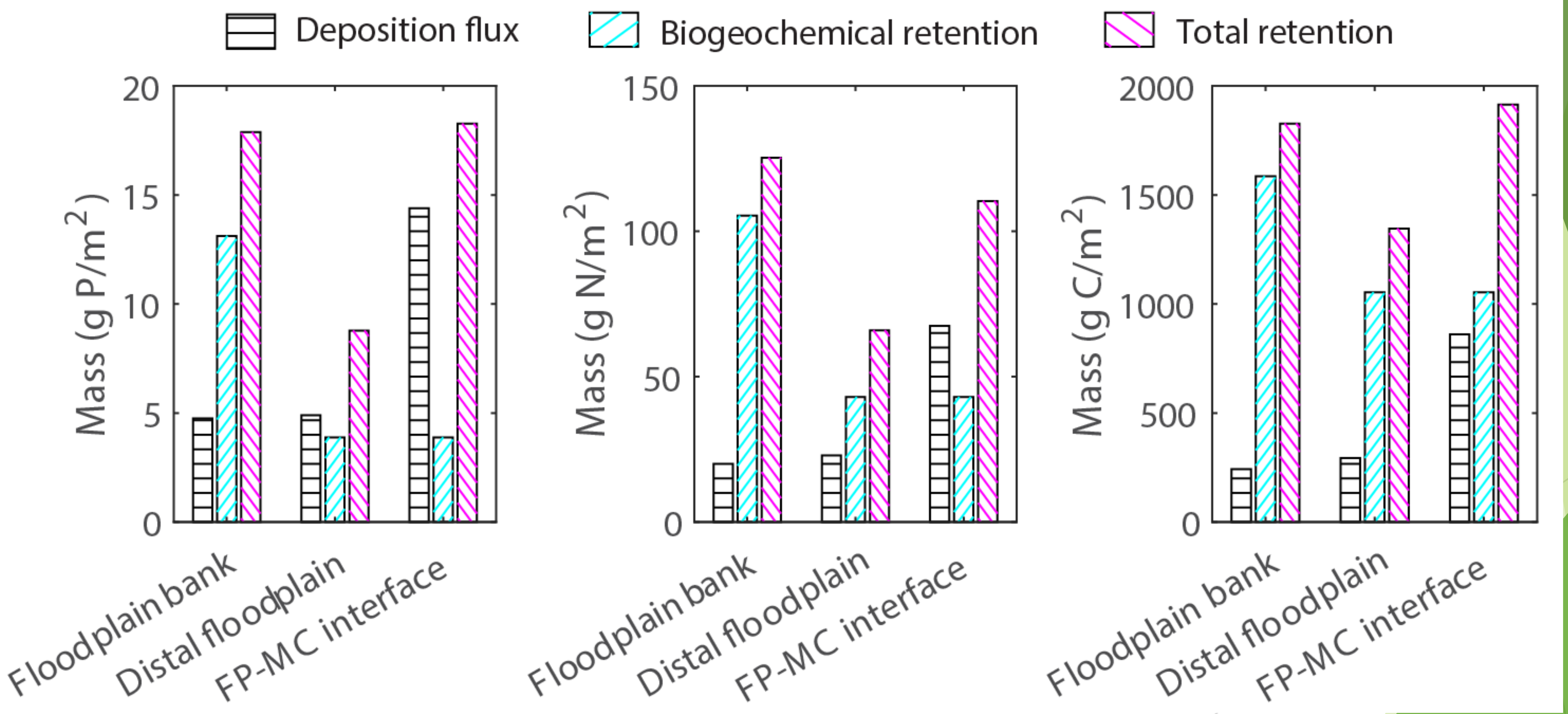
New framework for quantifying sedimentary retention of nutrients to overcome limitations with water sampling / water quality sensor / lab assay -based estimates





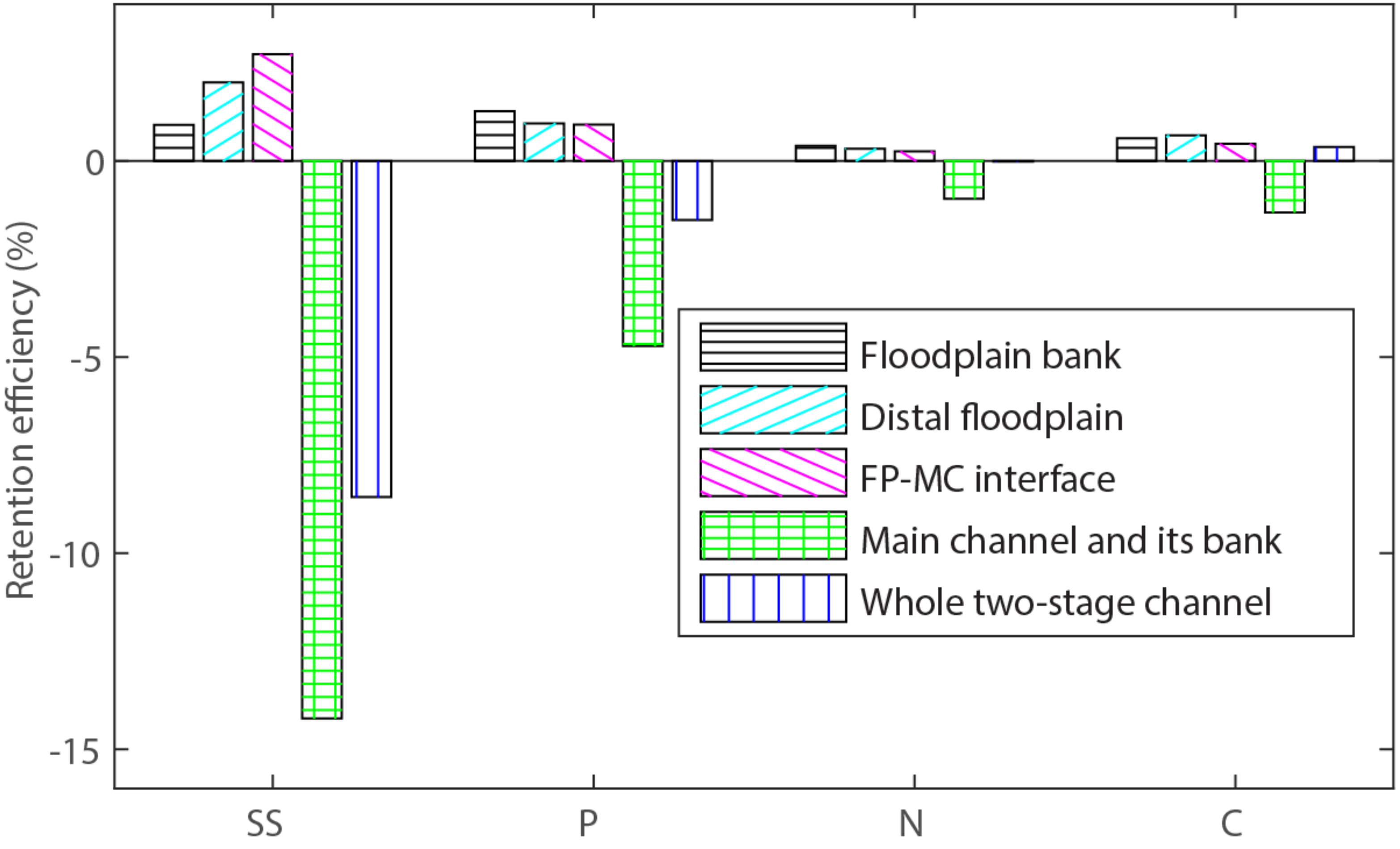
(Västilä & Jilbert 2025. Evaluating multiannual sedimentary nutrient retention in agricultural two-stage channels. Scientific Reports

Both physical and biochemical sedimentary retention mechanisms important



(Västilä & Jilbert 2025, Evaluating multiannual sedimentary nutrient retention in agricultural two-stage channels. Scientific Reports)

9-y retention efficiencies in different channel parts



Most of deposits already re-suspended: lower release from MC in the future?

Rock ramp weirs, removal of deposits, or design of floodplain at lower level to take into account re-suspension?

(Västilä & Jilbert 2025, Evaluating multiannual sedimentary nutrient retention in agricultural two-stage channels. Scientific Reports)

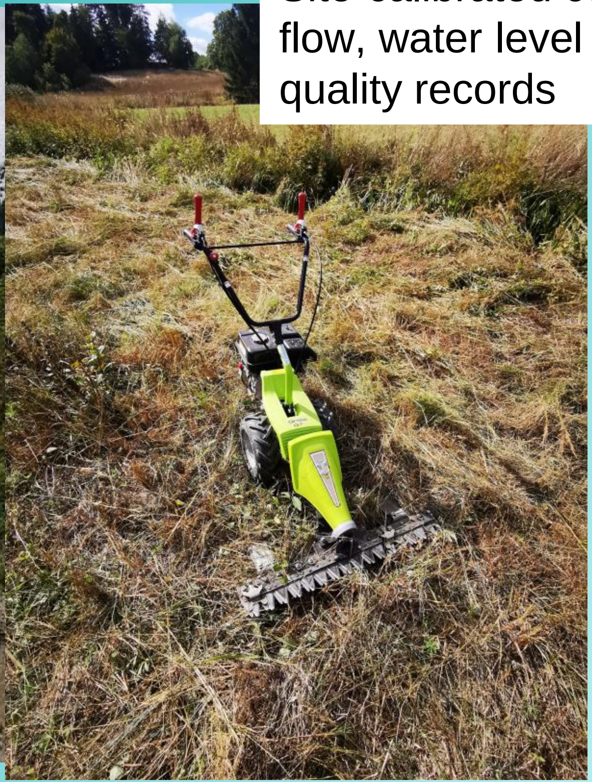
Selective vegetation cutting + natural-like rock ramp weirs to enhance floodplain inundation frequency while decreasing water levels at high flows

Selective floodplain vegetation cutting to the height of ~10 cm

- 3 mowed reaches (~50 m long)
- 2 control reaches

grade control, low-flow passability and structural diversity

Site-calibrated continuous flow, water level and water quality records

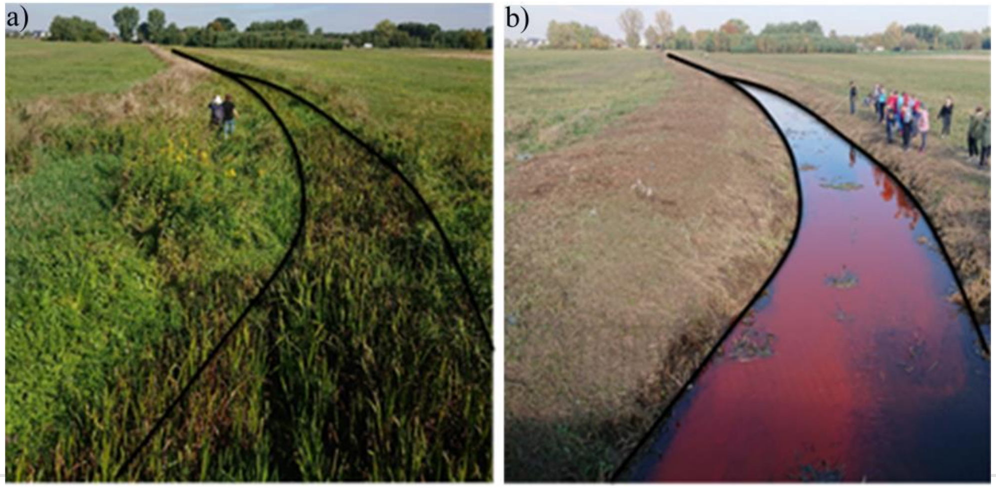


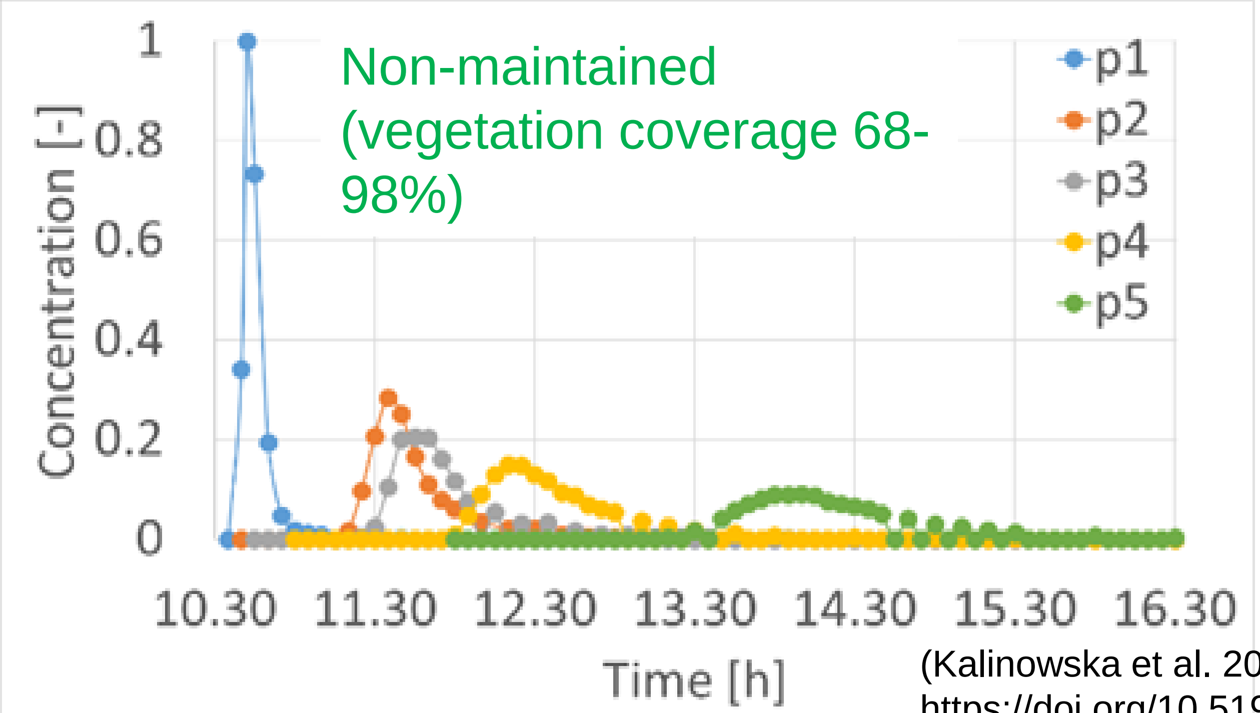
Sediment traps

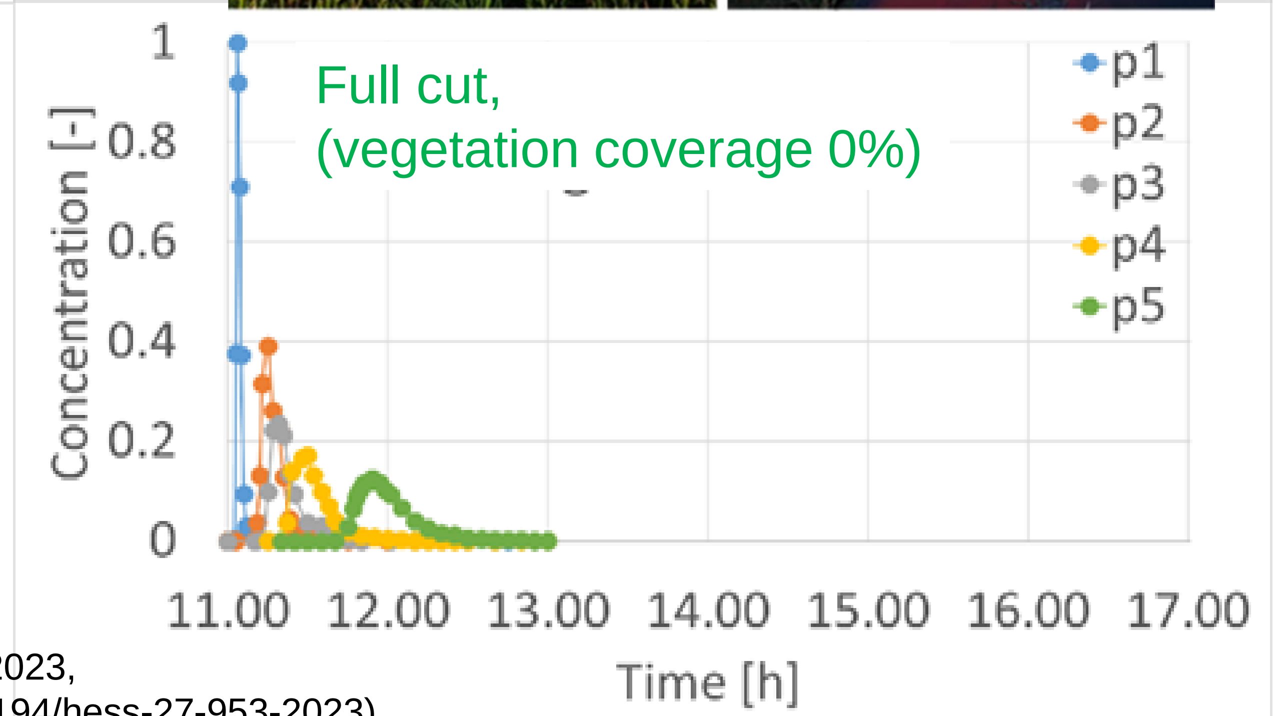
Full cut of vegetation leads to more flashy passage of pollutants

In the 4 sub-reaches, full cut caused

- **150-360% faster passage of the concentration peak**
- **Increase in peak concentrations (C_{max}) by 15-38%**



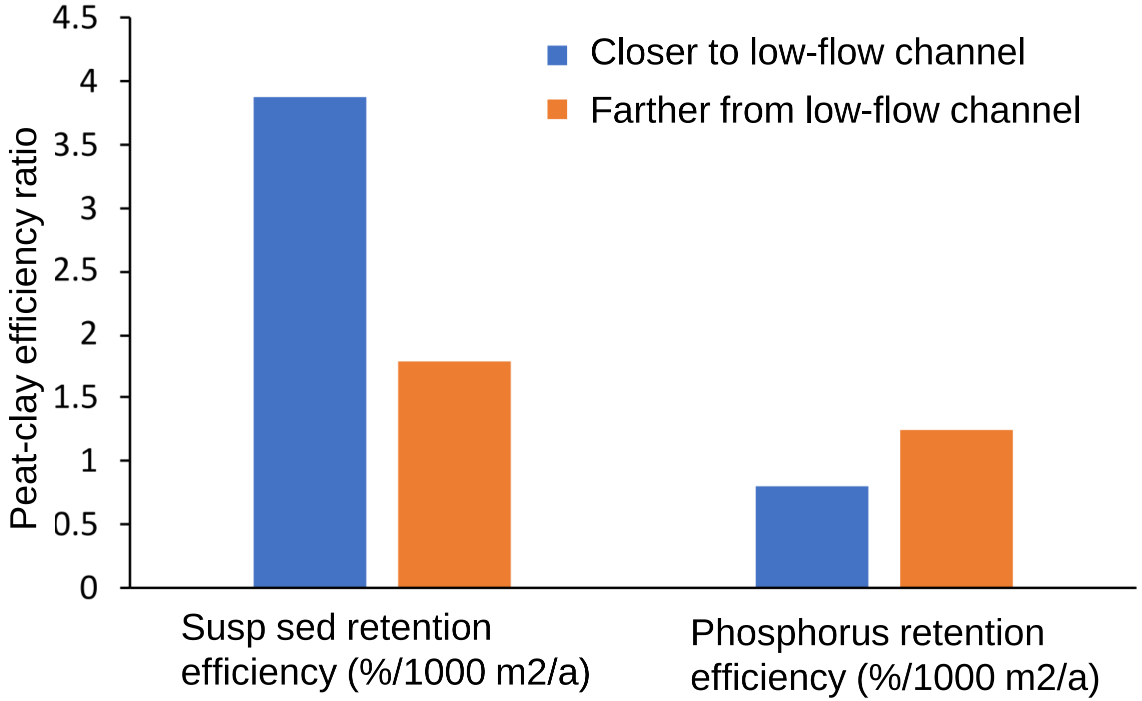


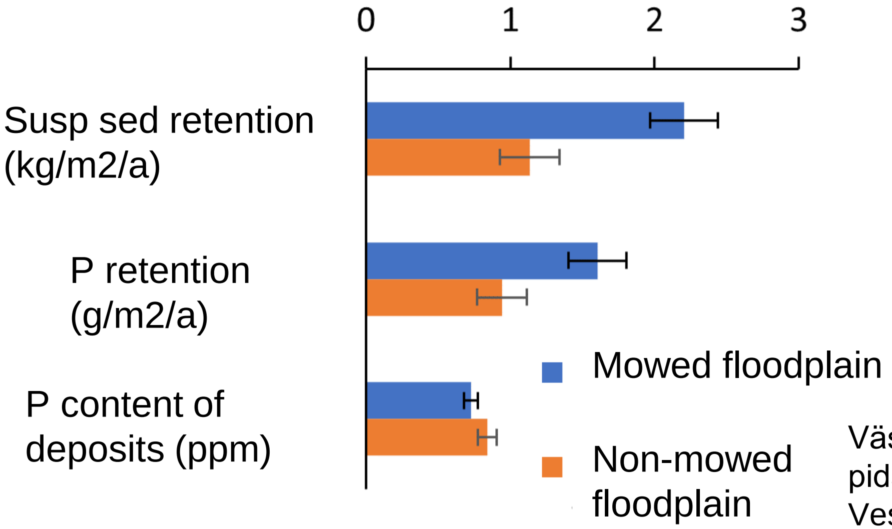


(Kalinowska et al. 2023,
https://doi.org/10.5194/hess-27-953-2023)

New knowledge on water quality processes on two-stage channel floodplains

Selective vegetation mowing & collection found efficient in improving floodplain sedimentary retention





New knowledge on targeting and design of TSCs

- efficiency better in peat soils
- mass reductions as agricultural land use % and as discharge
- design recommendations on floodplain level and width

Västilä et al. 2024 Kaksitasouomien tulvatasanteet kiintoaineen ja fosforin pidättäjinä: tietoa mitoituksen, hoidon ja valuma-aluetekijöiden vaikutuksista, Vesitalous 06/2024. https://emagz.fi/reader/issue/10617/397833/32

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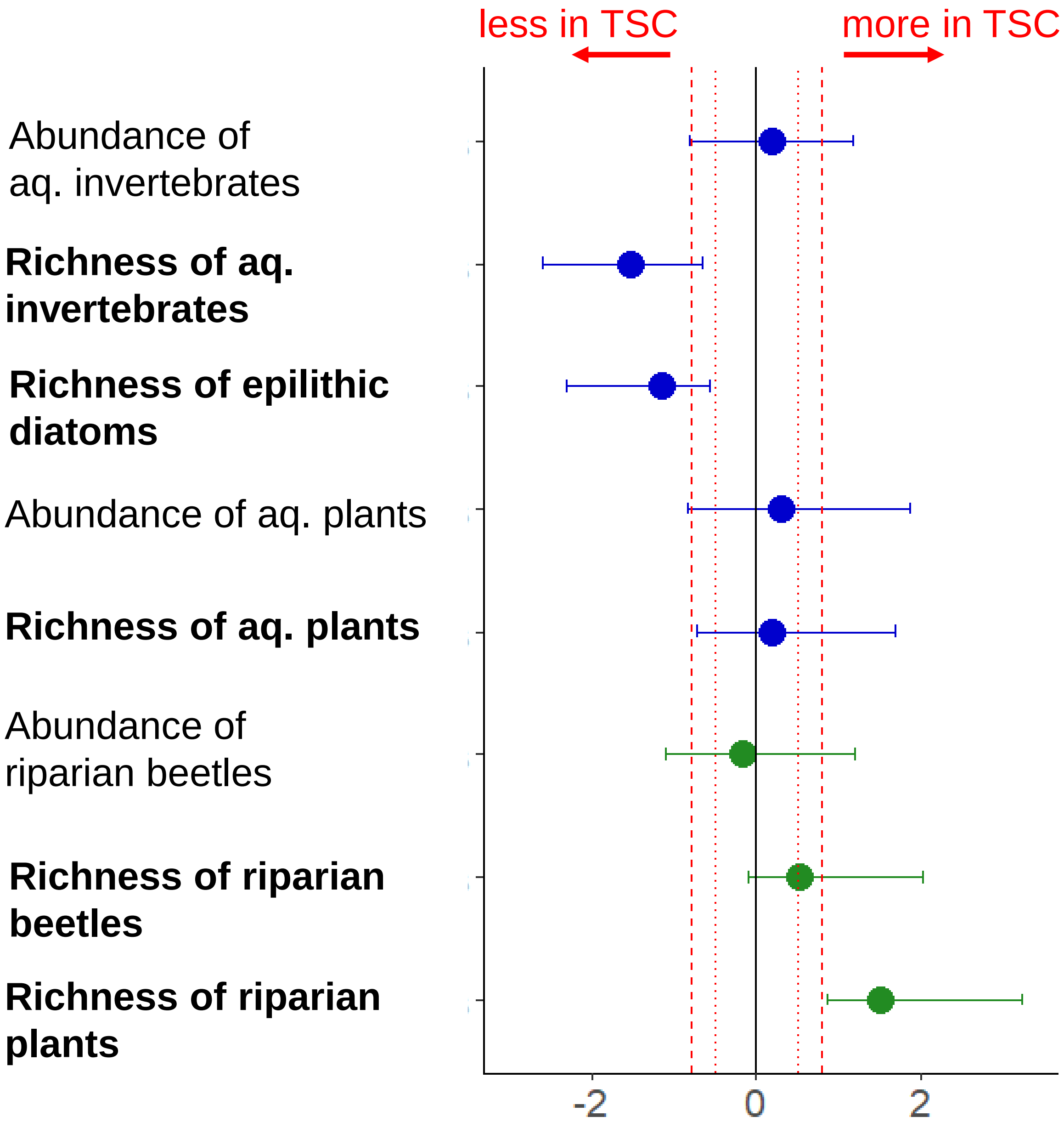
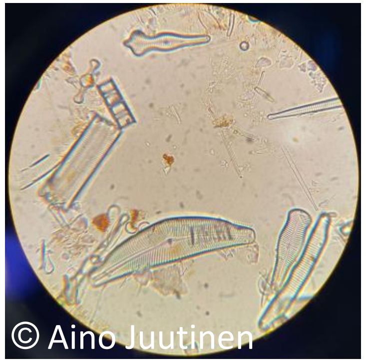
Combining technical and ecological expertise: biodiversity impacts of two-stage channel design

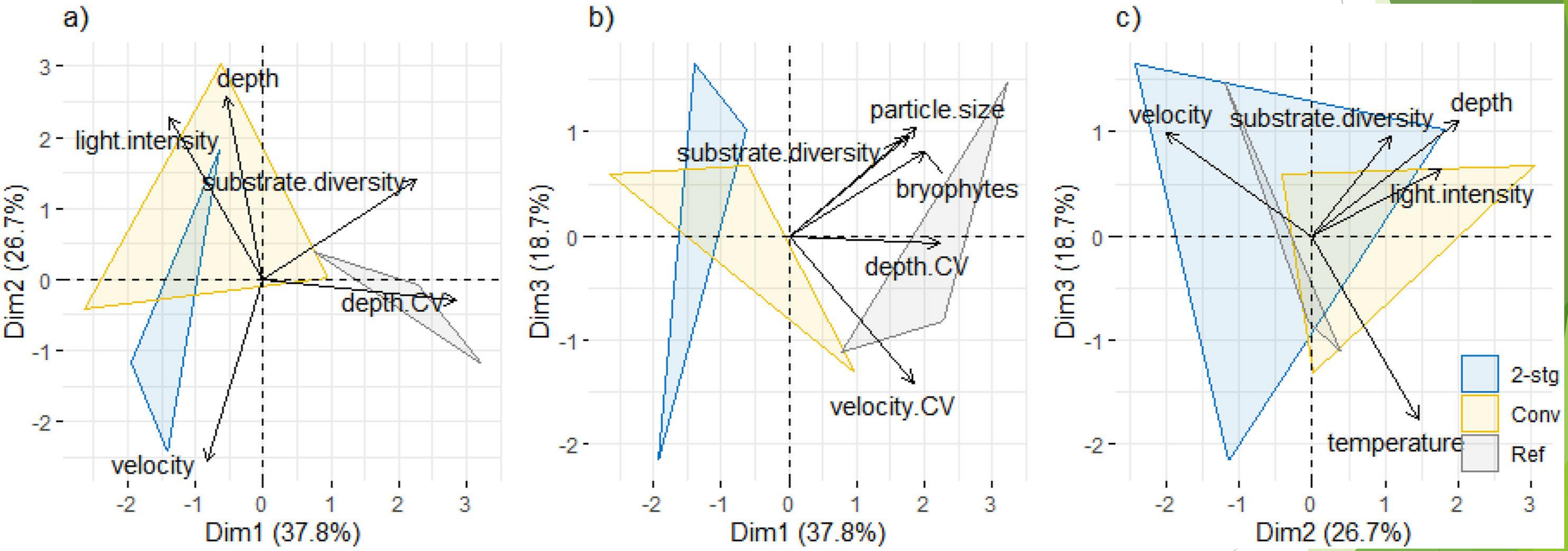


→ riparian plant and invertebrate communities benefited from the TSC design

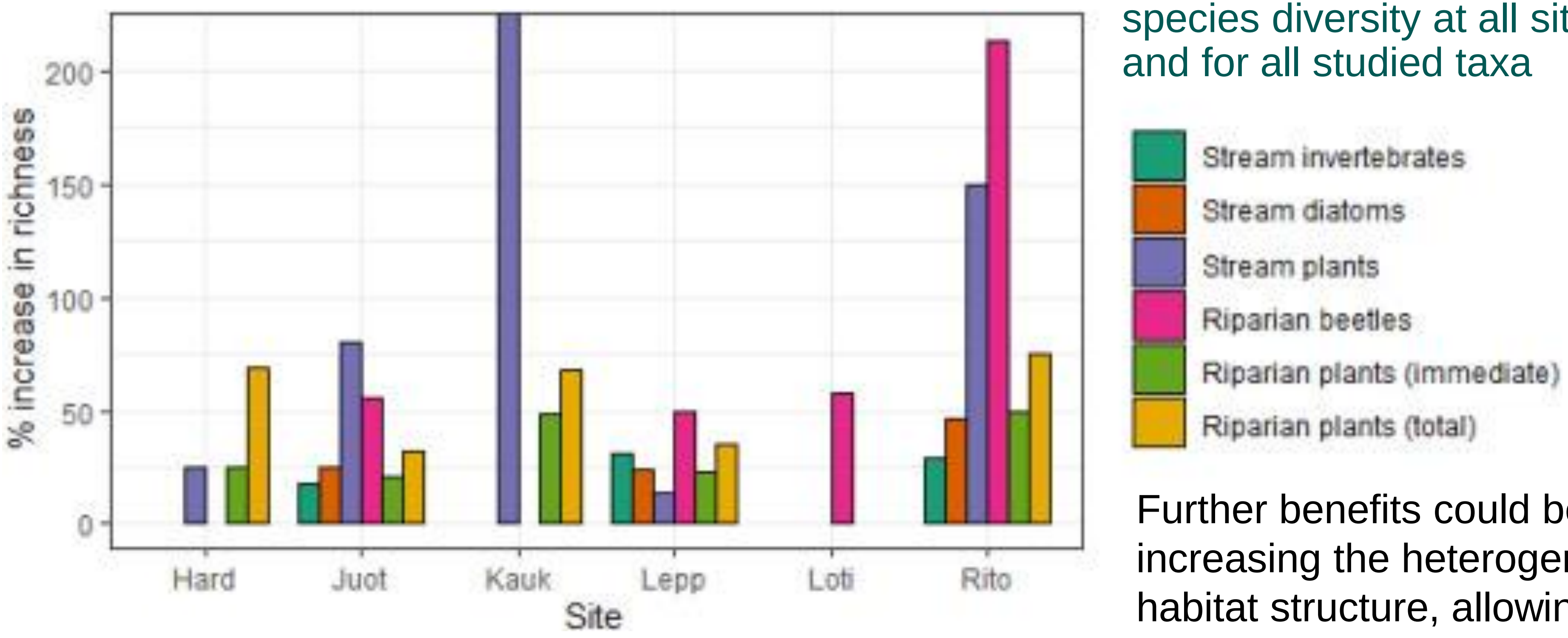


(Huttunen et al. 2024, Two-stage channels can enhance local biodiversity in agricultural landscapes. Journal of Environmental

Connections between hydraulics, morphology and channel type



Two-stage channel design enhanced regional species diversity (gamma diversity)



At each catchment the increase in local richness due to inclusion of two-stage channels was calculated by comparing the combined taxa richness across adjacent sections of conventional and two-stage sections to species richness in a conventional ditch alone.

- TSCs enhanced regional species diversity at all sites and for all studied taxa

Further benefits could be achieved by increasing the heterogeneity of in-stream habitat structure, allowing more woody vegetation, and with additional efforts to decrease nutrient and sediment loads -> requires combining technical and ecological expertise

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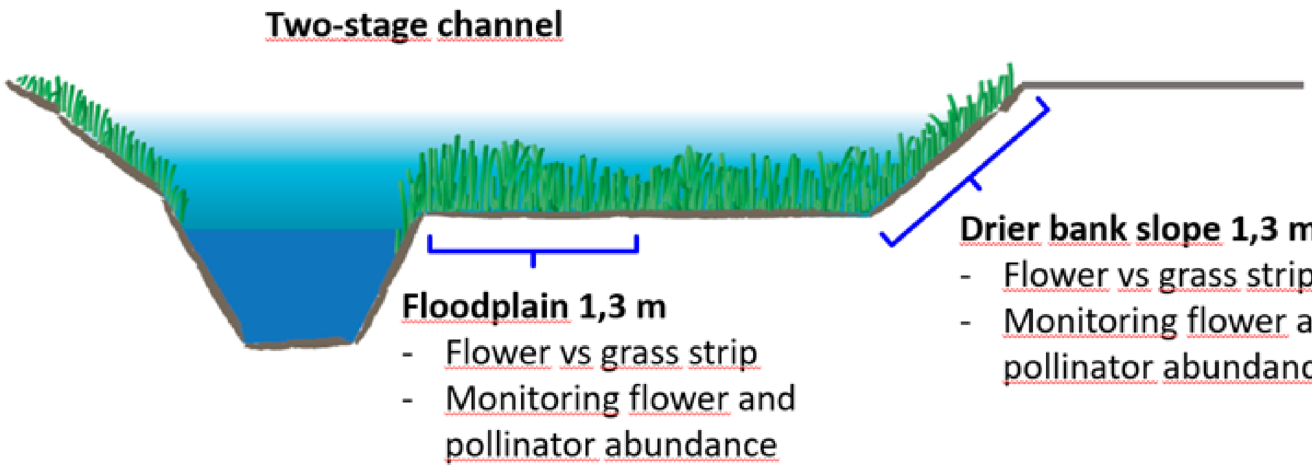
(Huttunen et al. 2024, https://doi.org/10.1016/j.jenvman.2024.120620)

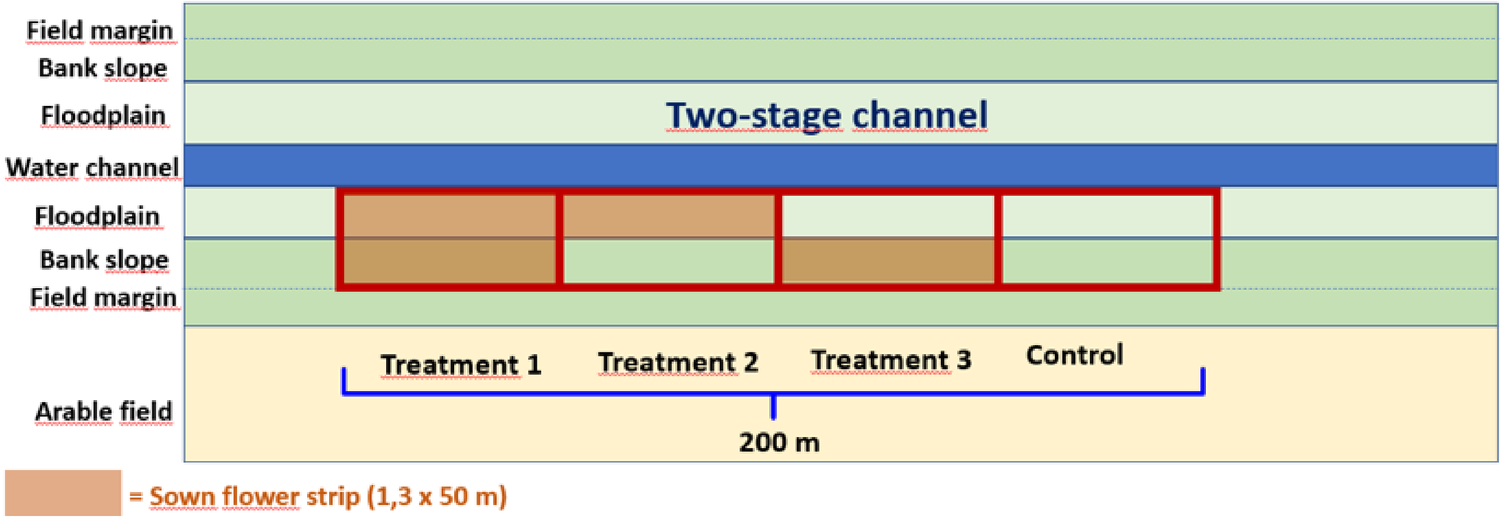
Three-year flower strip experiment along two-stage channel

- 50 m long sown flower strips
  - Different seed mixtures on floodplain vs drier bank
- Monitoring flowering plant and pollinator abundance for three years

Experimental design (5 x 4 = 20 replicates)

- 10 flower- vs. 10 grass strips on both floodplain and bank





(Kuussaari et al., submitted)



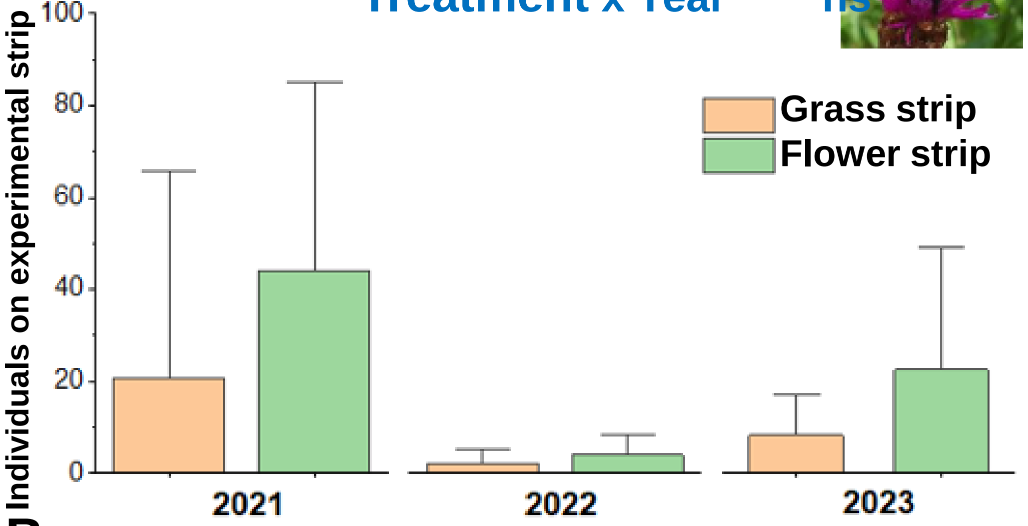



Sown flower strips increased pollinator abundance

- Sowing flower strips was successful on channel banks but not on floodplain
- Pollinators more abundant on flower strips
- Unsown, good nectar sources established naturally along the channel
- Seed mixtures should include both annual and perennial flowers

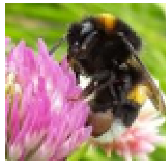
Bees, bank

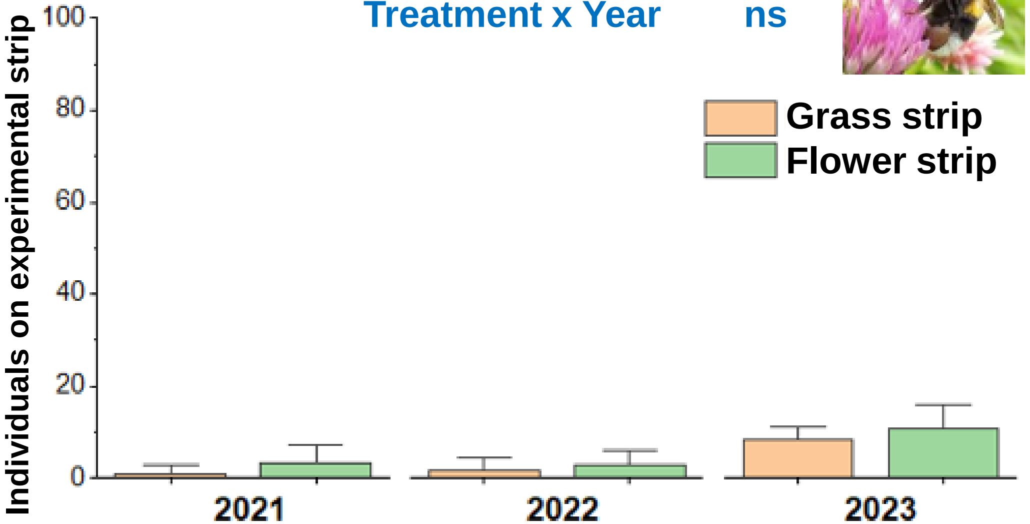
Treatment ***
Year ***
Treatment x Year ns



Bees, floodplain

Treatment *
Year ***
Treatment x Year ns





(Kuussaari et al., Valumavesi-BD)

Natural sciences and engineering supported by economical, policy, governance, and legal considerations

Implementations of NbS influenced by factors beyond engineering and natural sciences

- Costs: immediate vs long-term, relevant categories
- Benefits: also societal & ecosystem services, compared to costs and other measures (additional)
- Regulations and policies: e.g. CAP, WFD, Baltic Sea Action Plan, Water Law
- Financing: agri-environmental subsidies, national funds for restoration, ecological compensation, stakeholders’ willingness to pay (~20…60 e/y)
- Governance: levels, information exchange, guidance to practitioners, bureaucracy
- Capacity: design tools, guidelines, science-practice knowledge exchange, co-creation
- Bottlenecks in any of these

Cost-benefit assessments considering technical, water quality and ecological benefits: NbS vs grey alternative

two-stage channels are cost-effective in streams/rivers having high biodiversity values, or where conventional dredging has resulted in instability or the need for frequent re-dredging

Variable	Units/Unit cost	Conventional dredging	Two-stage channel design
Project life	years	60	
Channel length	km	14.8	
Maintenance interval	years	20	50
Maintenance costs	€5/€2.5 per meter	-222 000	-44 000
Construction costs	€0/€21.6 per meter	0	-314 000
Adjacent land price	€ 0/ €3.6 per m	0	-53 000
Lost crop value	€ 0/ € 268 per km	0	-223 000
Environmental benefits for biodiversity	€50 per *Unio crassus* mussel	0	594 000
Environmental benefits for water quality	€ 249 per phosphorus kg retained on the floodplain	0	951 000
Net costs in 60 years	€	-222 000	910 000
Equivalent annual cost (EAC)	€ per year	-1 200	7 400

Two-stage channels compared to the grey alternative (conventional dredging):

Large initial contruction cost, but lower maintenance costs

Costs related to lost field area because of non-integration to CAP-AES

Additional monetary environmental benefits related to water quality and biodiversity

Environmental benefits larger than costs considering the whole lifecycle and targeting to optimal locations

(Västilä et al. 2021, Agricultural Water Management Using Two-Stage Channels: Performance and Policy Recommendations Based on Northern European Experiences. https://doi.org/10.3390/su13169349)

Developing financing models (example for EU's Common Agricultural Policy)

Associated Cost Factor	Costs (€) of Conventional Dredging	Costs (€) of Two-Stage Channel (TSC) Design	Notes
Maintenance costs	−15,000	−3000	
Construction costs	-	−21,200	
Adjacent land value	-	−3600	
Lost crop value	-	−2800	Lost crop value computed assuming the proposed CAP-AES reform (3 m of TSC width replaces the required edge-of-field buffer strips; Figures 5 and 6)
Total costs	−15,000	−30,600	
Difference in total costs	−15,600		

Benefits	Rationale for paying	Payment (€)	Notes
Well-functioning drainage and flood mitigation	Farmers pay the costs for ensuring drainage and flow conveyance, equaling the estimated costs of conventional dredging	−15,000	The total cost partitioning can be realized through public funding covering 74% of TSC construction costs
Improved water quality and biodiversity	Public funding covers the difference in total costs as the additional benefits are collective [1]	−15,600	

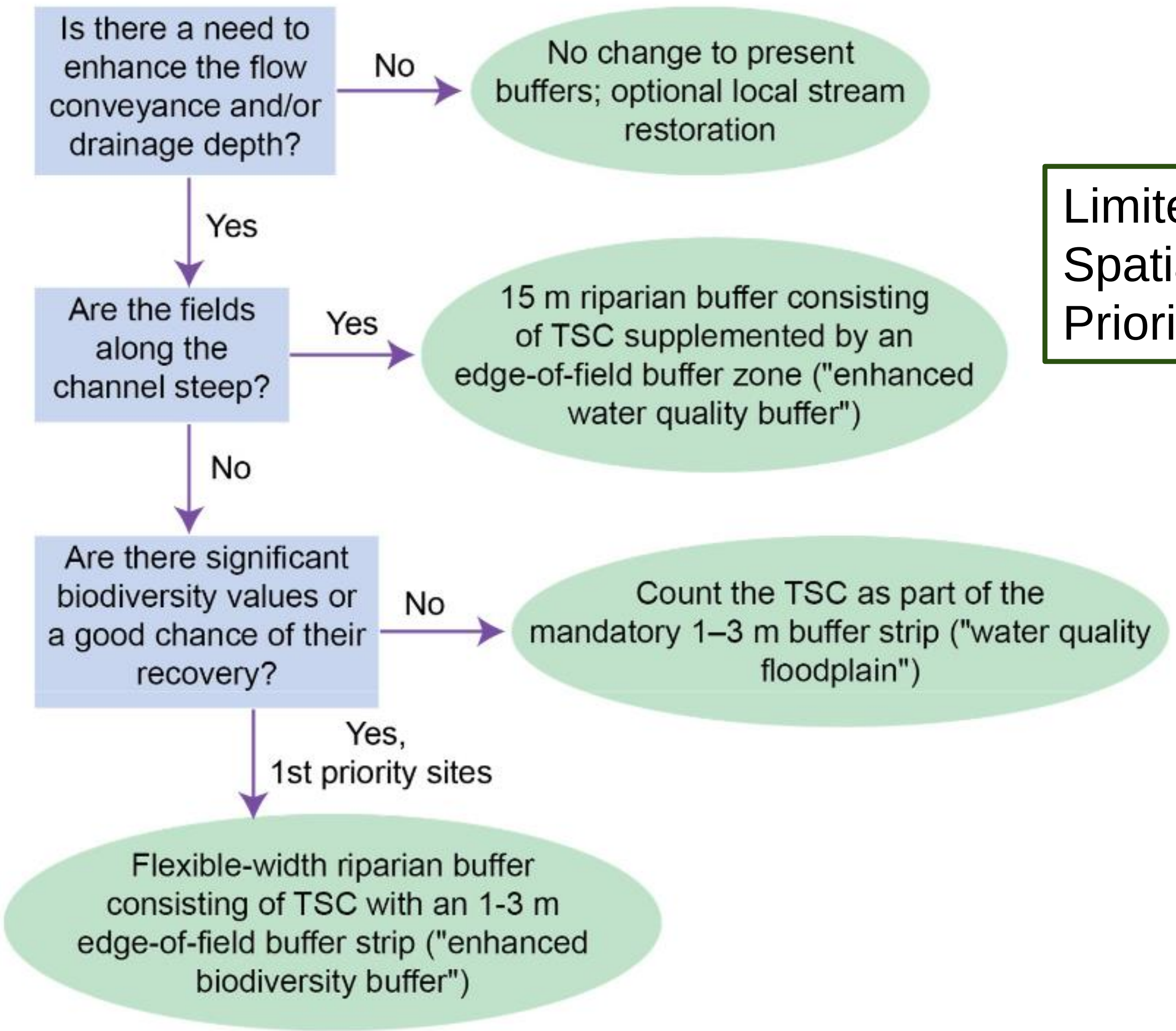
[1] Additional private funding can be arranged through developing mechanisms for ecological compensation (biodiversity offsetting) or for stakeholder participation according to their willingness to pay.

For **mitigating the costs caused by lost field area**: count TSC floodplains as vegetated buffer/subsidizable field area in the new CAP 2023-2027

For mitigating the higher construction costs: **an €/channel meter public compensation**

(Västilä et al. 2021, https://doi.org/10.3390/su13169349)

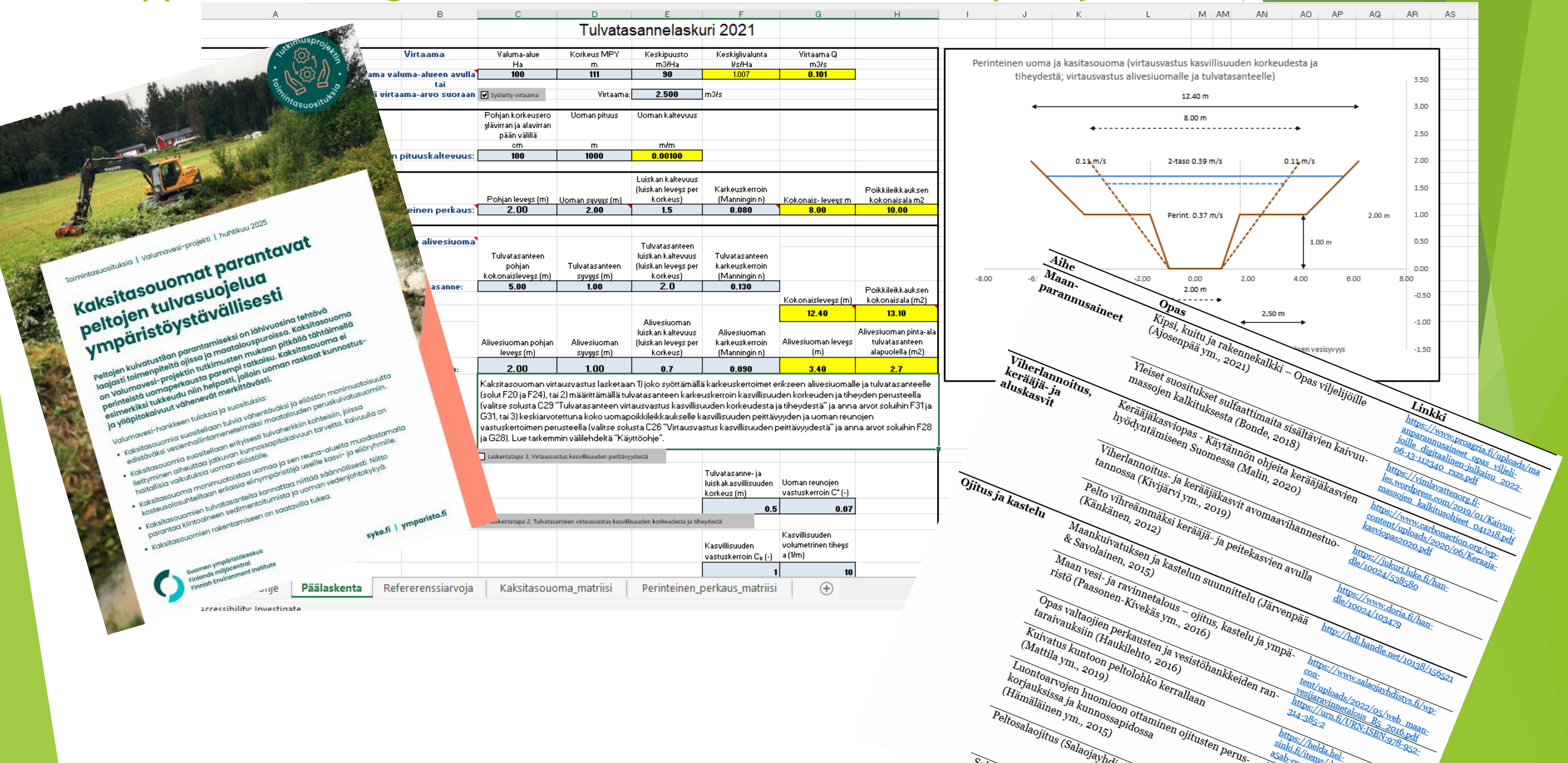
Providing decision/policy support: case vegetated buffers



Limited funds
Spatial targeting for optimizing performance
Priority sites

(Västilä et al. 2021, https://doi.org/10.3390/su13169349)

Support for designers, authorities, land owners & policy makers



Recent & ongoing developments to mainstream "wet NbS" & Natural Flood Management

- TSCs much more widely applied in Finland since ~2020, but still marginal compared to conventional methods
- TSCs included in CAP in Finland since 2023: but only ditches, not streams & rivers… + financing level insufficient
- EU's BD strategy & Nature Restoration Law
  - Increase landscape features on agricultural land (to 10%): wet NbS, woody vege
  - 3 billion new trees by 2030 (also on riparian areas?)
  - Laferia project to identify the key factors that can promote the reintroduction of LFs & develop strategies to overcome barriers
- EU Missions to Restore our Ocean and Waters and Adapt to Climate Change
  - Integrating catchment-scale NbS, CES & BfS with lake restoration (FutureLakes)
  - Blueprint for lake protection and restoration

LAFERIA
Funded by the European Union
Grant Agreement 101181492

FUTURELAKES
For Nature, Climate and People
Funded by the European Union
Grant Agreement 101157743

Conclusions

- Vegetative parameterizations available e.g. through Delft3D FM
- Vegetated two-stage channels as NbS appear to have potential for multiple benefits, but R&D gaps remain
- Impact through bridging natural sciences to policy & economical analyses to changes in policy & financing & capacity