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Balanced sediment budget and morphodynamics as precondition for habitat quality

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Mid-Term Conference
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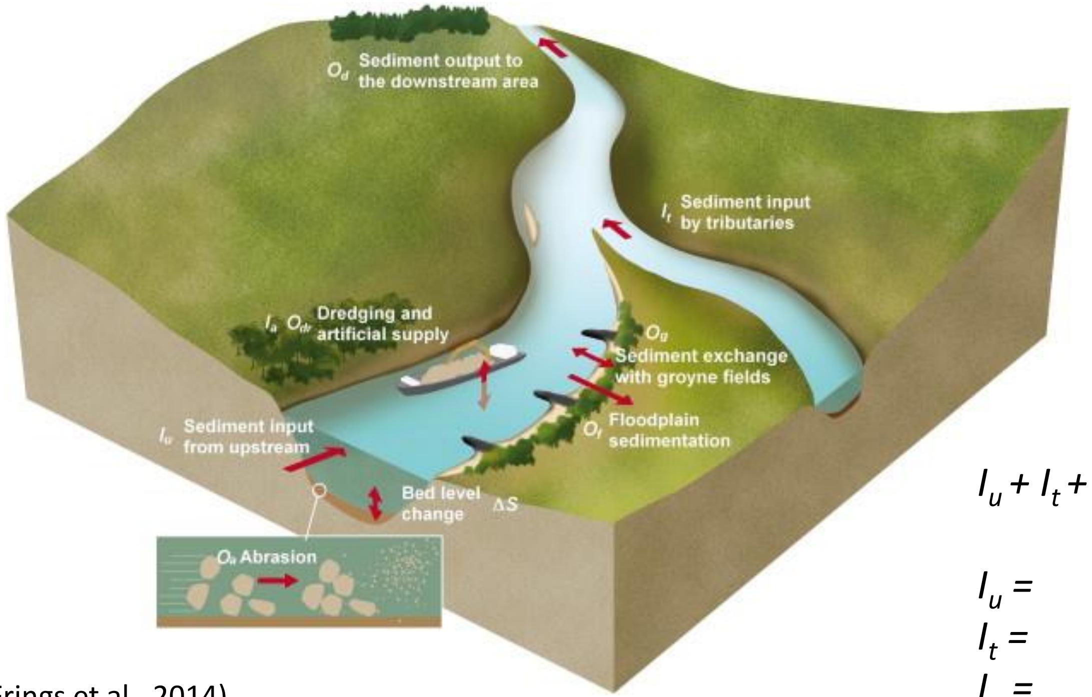
Sediment balance



(Frings et al., 2014)

$$I_u + I_t + I_a - O_d - O_{dr} - O_{fgp} - O_a = \Delta S$$

I_u = sediment input from upstream
I_t = sediment input from tributaries
I_a = artifical sediment input
O_d = sediment output downstream
O_{dr} = dredging
O_{fgp} = sedimentation on floodplains
O_a = abrasion
ΔS = bed level difference

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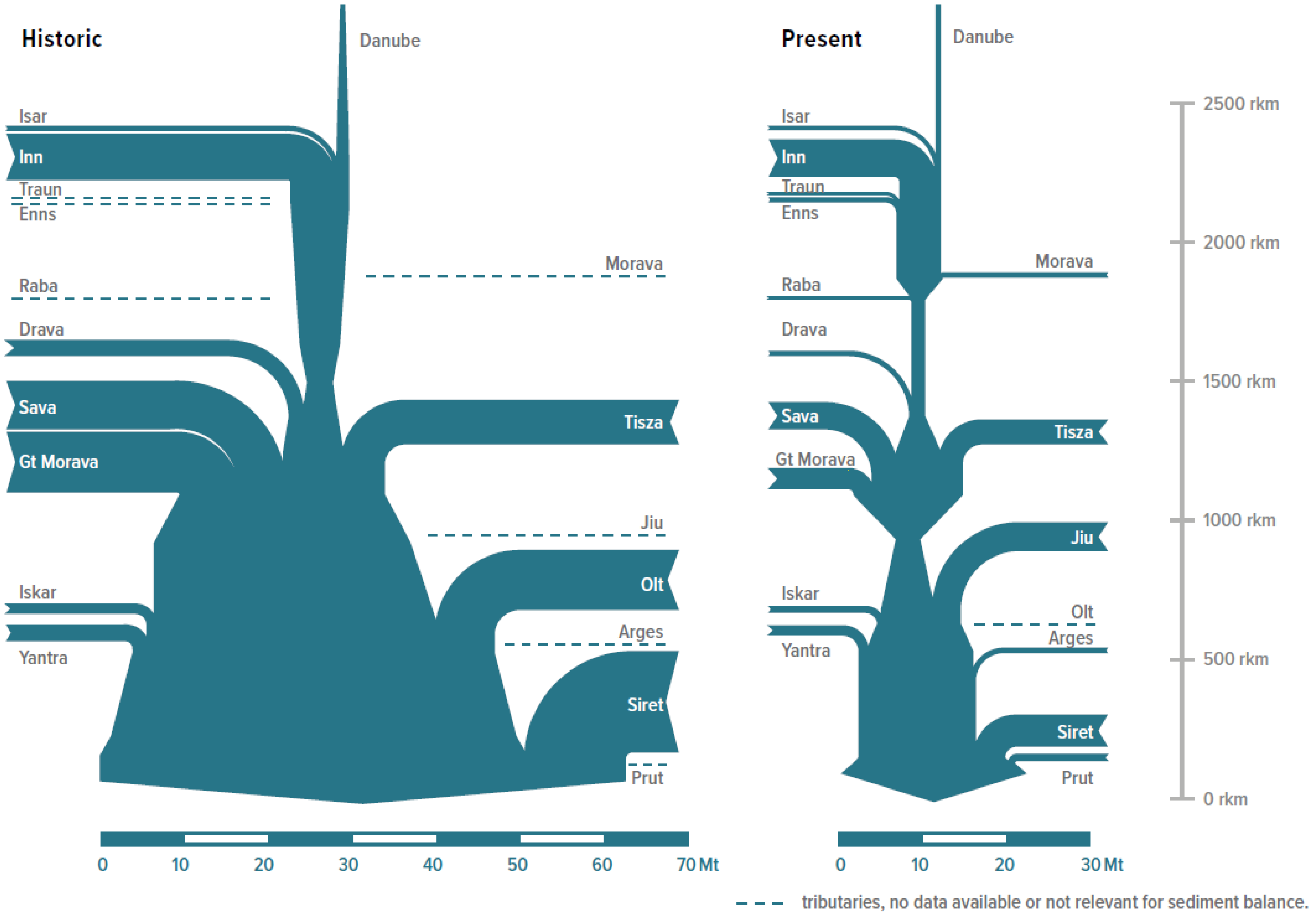
Suspended sediment balance



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Erosion / Sedimentation

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Morphological typology

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Surplus


Foto: ALPRESERV

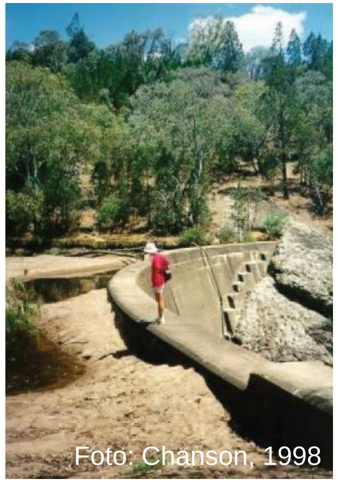
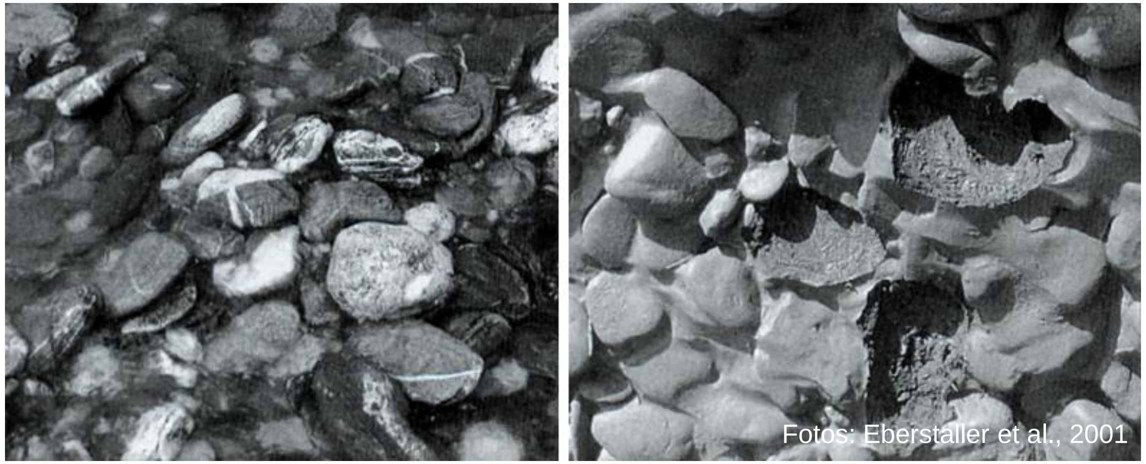


Foto: Chanson, 1998


Foto: Jacobsen, 2012

Foto: IWHW


Fotos: Eberstaller et al., 2001

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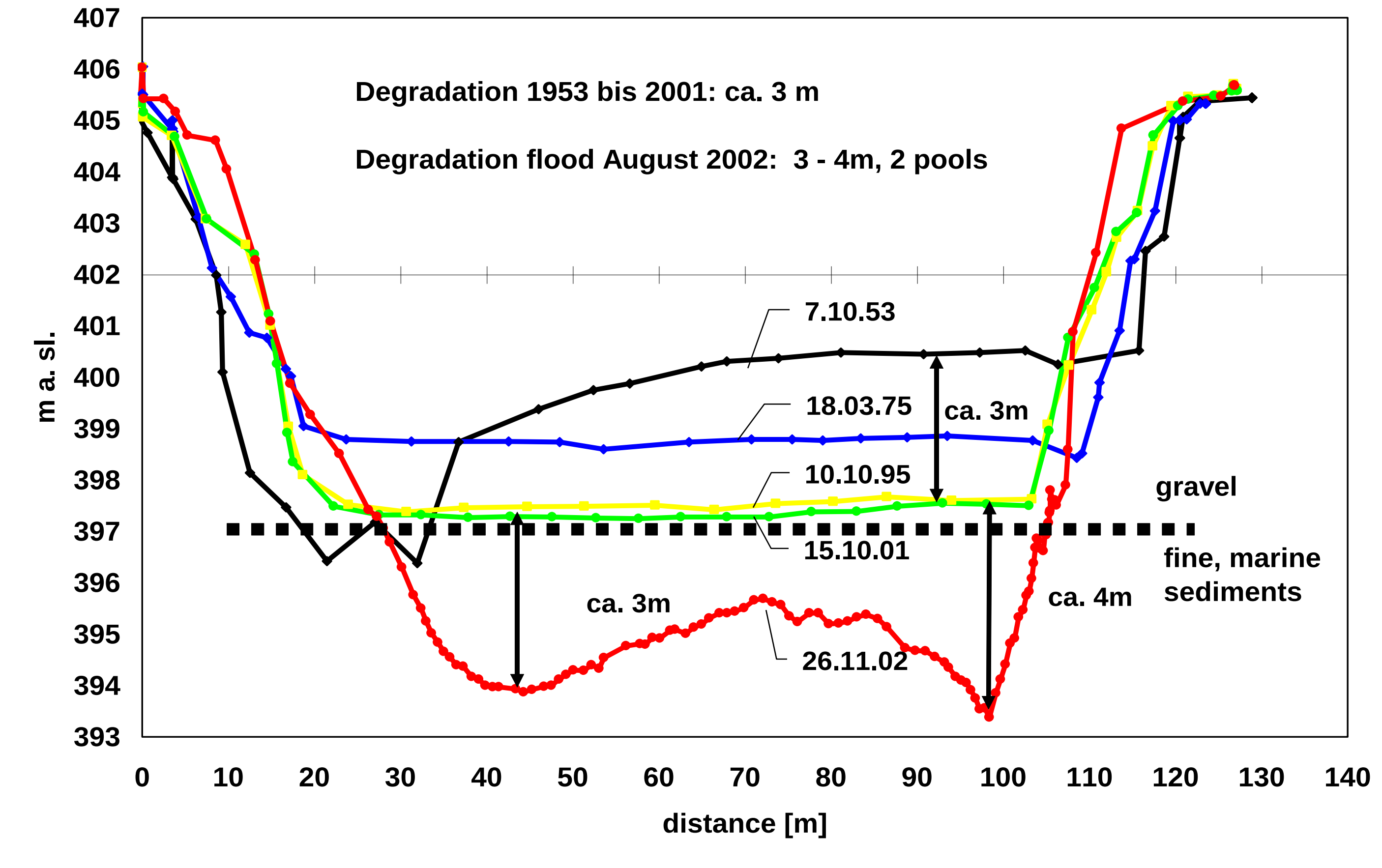
Deficit



12)

(Hengl, 2004)

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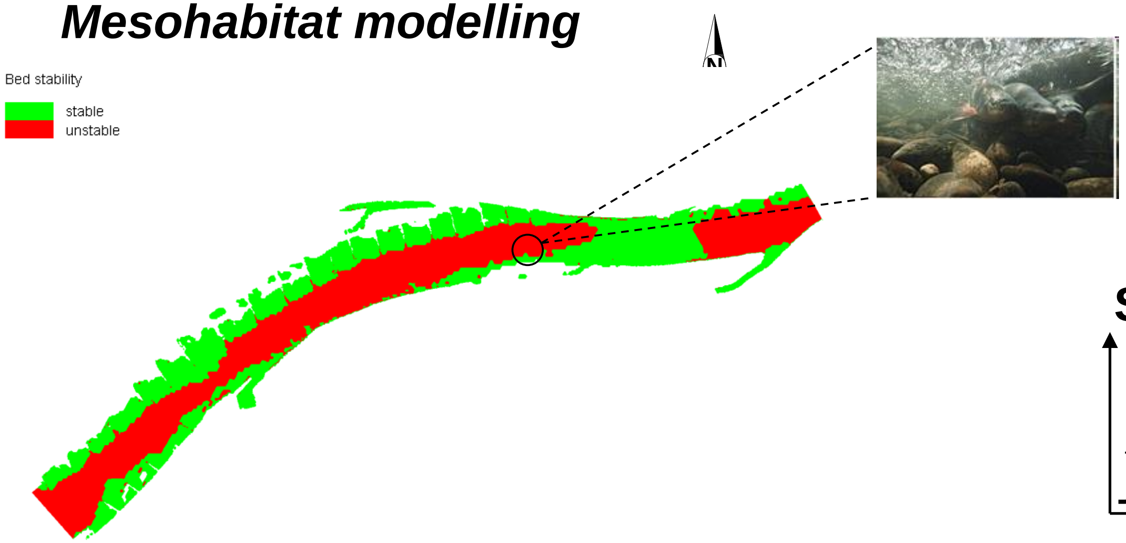
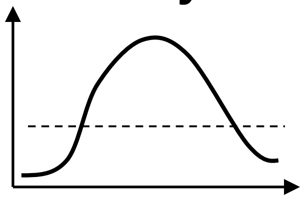
Sediments and fish

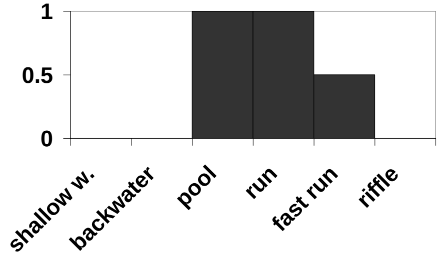
Mesohabitat modelling



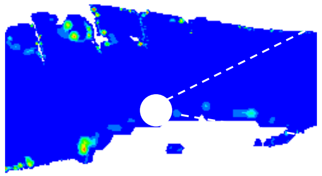
Stability



Mesohabitat modelling



Microhabitat modelling



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Hauer & Habersack

Spawning & juvenile status Nase

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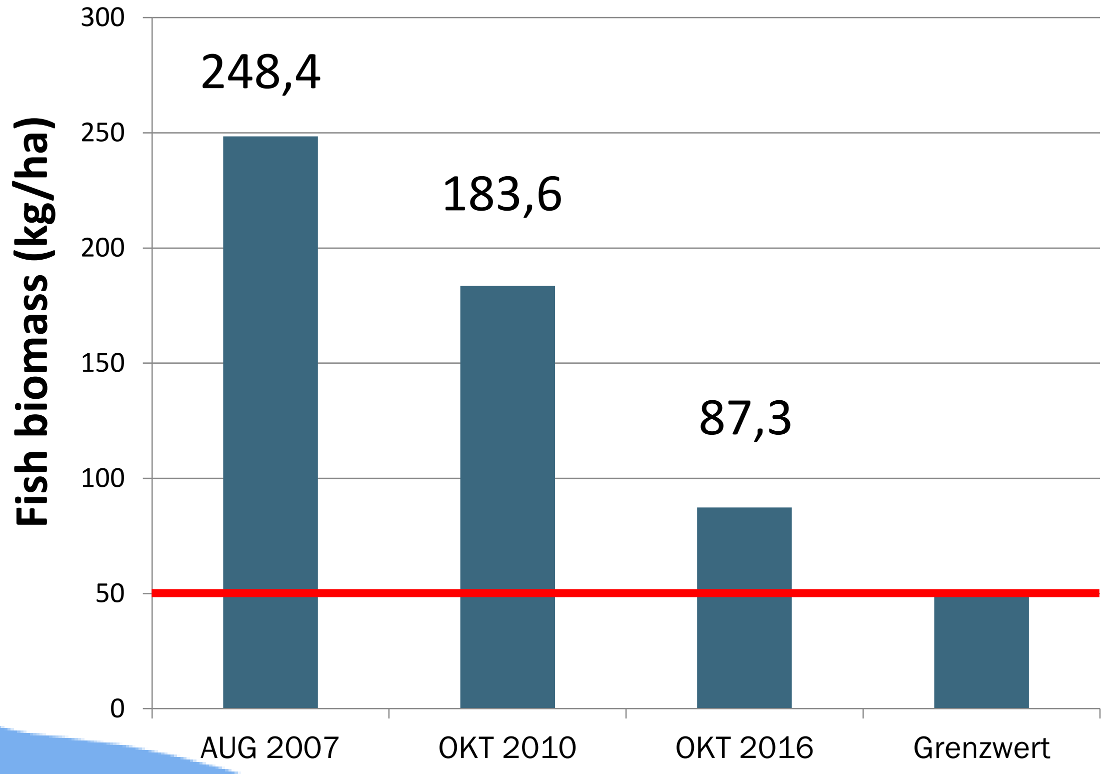
Hauer, Unfer, 2014

Need for action – Water framework directive
Fish as indicator of good ecological status

BQE fish at the monitoring site Hainburg; fish biomass in kg/ha



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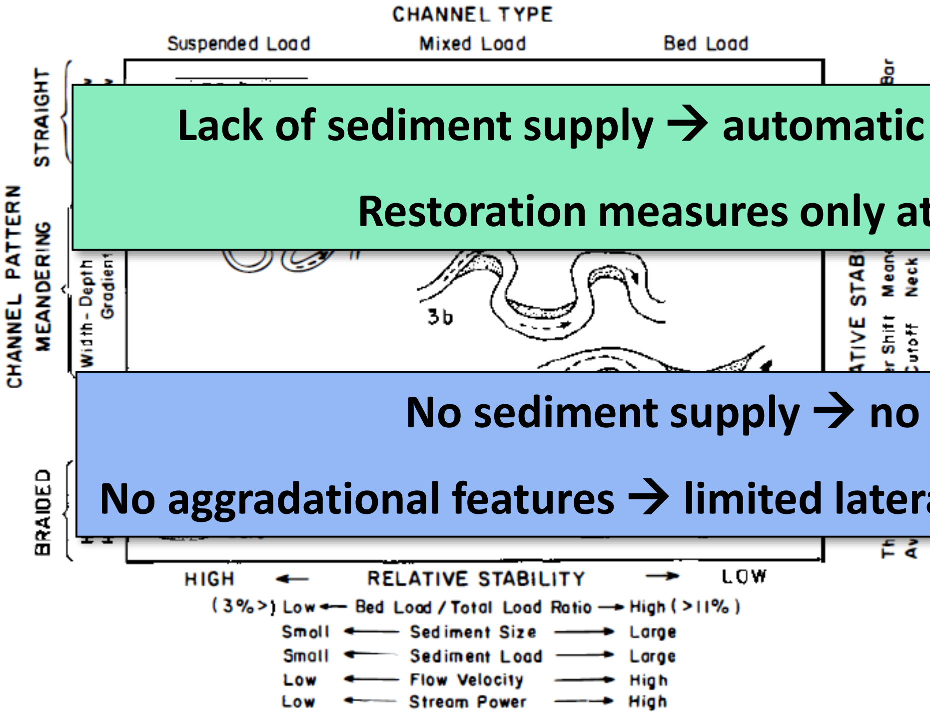
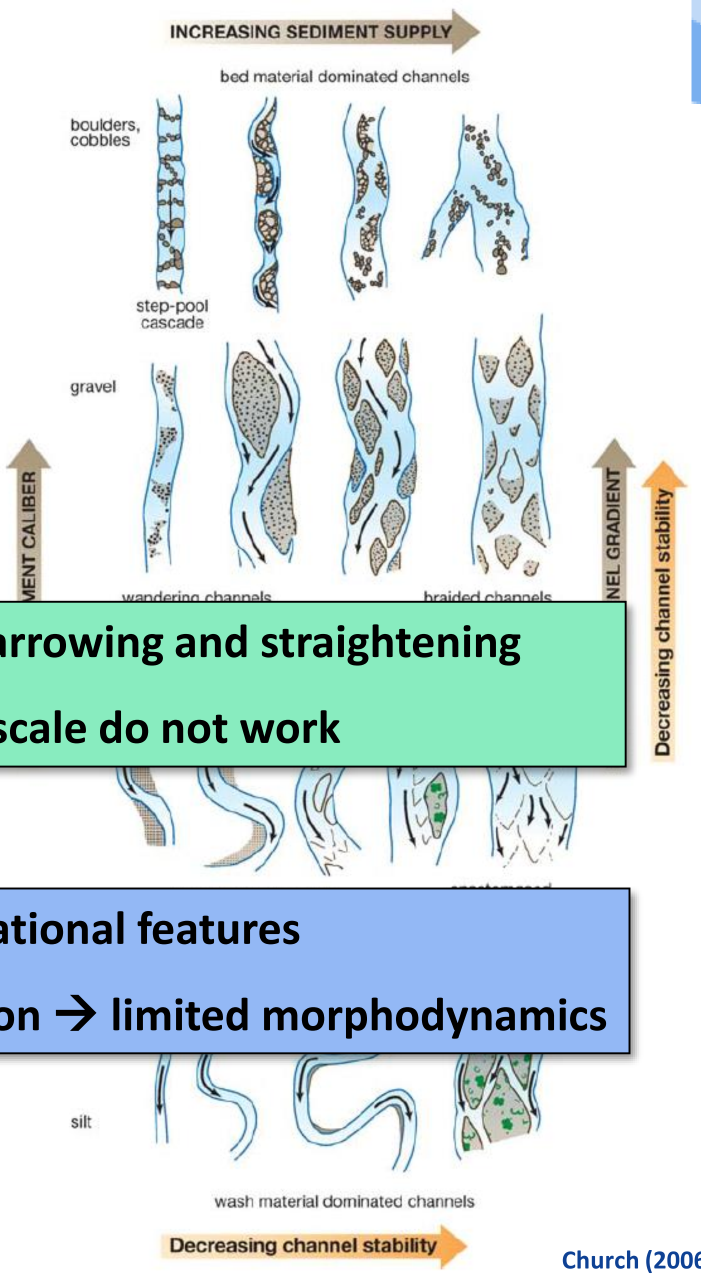
50 kg/ha threshold value for good ecological status according to EU - WFD

Relevance of sediment supply for the hydromorphological condition



Schumm (1985)



Church (2006)

Lack of sediment supply → automatic river narrowing and straightening

Restoration measures only at reach scale do not work

No sediment supply → no aggradational features

No aggradational features → limited lateral erosion → limited morphodynamics

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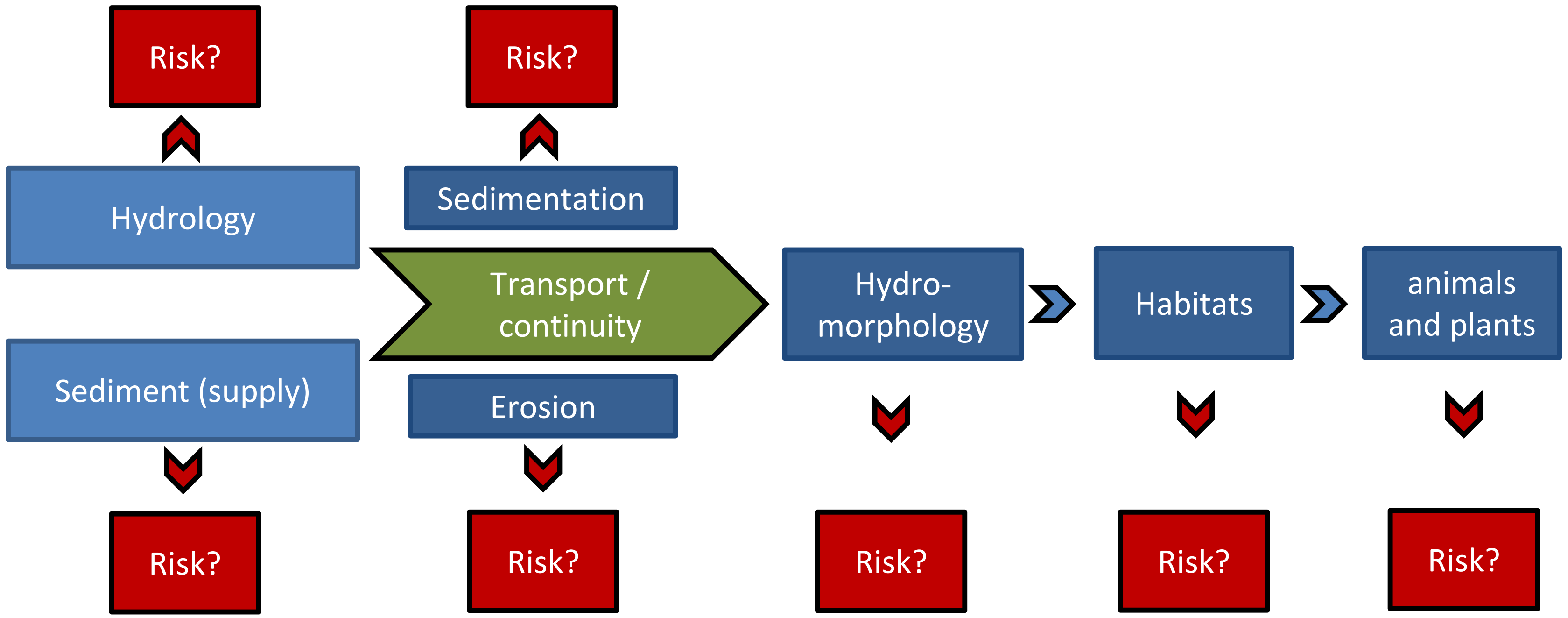
Risk analysis – process based

Understanding systematic relationships and their impact on different users



→ Risk can occur at several points along a causal chain
→ Sediments are rather in the beginning of this causal chain

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Risk analysis

Sediment deficit

- **Abiotic** → e.g. gravel is missing
  - → **Biotic** → e.g. no spawning places – no reproduction – reduction of biomass and reduction of species – risk of failing good ecological status
  - → e.g. river bed erosion
    - → e.g. instability of bank protection – increased flood risk
    - → e.g. lowering of the groundwater table – risk for drinking water supply

Sediment surplus

- **Abiotic**
  - → e.g. Surplus of fine material → **Biotic** → e.g. overlays / masks gravel – no spawning gravel – no or reduced reproduction – loss of biomass and species – risk of failing good ecological status
  - → e.g. River bed aggradation
    - → e.g. reduction of the wetted area – increased flood risk
    - → e.g. reduction of fairway depth and width – bottleneck for navigation

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Risk analysis

Parameters

- **Channel width change in regulated rivers** compared to reference state
- **Change of river bed or water surface slope**
- **Erosion rate**
- **Gravel layer (river bed break through)** in combination with erosion rate
- **Sediment continuity at structures** (suspended sediments and bedload)
- **Capacity-Supply-Ratio (bedload)**
- **Bedload transport capacity**
- **Decrease / Increase in suspended sediment concentration or load** compared to reference state
- Change of **characteristic grain sizes of the bed material**
- **Bed armouring**

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Erosion rate

Erosion rate	1 = very low erosion (0%)	high
	2 = low erosion (0-15%)	good
	3 = moderate erosion (15-30%)	moderate
	4 = strong erosion (30-60%)	bad
	5 = very strong alterations (>60%)	poor

Example

%	%	cm/a	cm/a
	0		-0.25
0	15	-0.25	-0.66
15	30	-0.66	-1.08
30	60	-1.08	-1.90
>60		-1.90	

-3 max erosion rate per year

input
calculated

- **Percentage of the high to poor classes is fixed.**
- **The maximum erosion rate sets the corresponding absolute values in cm/a.**
- **Erosion of -0.25 cm/a is tolerated: Capture measurement uncertainty and river dynamics**

Transversal structures

Sediment continuity	1 = no structures or structure has no effect on sediment transport	high
	2 = no effect on suspended sediment; only frequency of bedload is affected	good
	3 = partially permeable for bedload; suspended sediments only frequency affected	moderate
	4 = impermeable for bedload; suspended sediments can partially pass through	low
	5 = general barrier for all sediments	poor

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Bedload

Capacity – supply ratio (CSR = Supply / Capacity – 1)	1 = very low alterations (-10 - 10%)	high
	2 = low alterations (<-15% / >15%)	good
	3 = moderate alterations (<-25% / >25%)	moderate
	4 = strong alterations (<-35% / >35%)	bad
	5 = very strong alterations (<-45% / >45%)	poor

Bedload transport capacity ($\tau = \tau_{present} / \tau_{ref} - 1$)	1 = very low alterations (-5 - 5%)	high
	2 = low alterations (<-10% / >10%)	good
	3 = moderate alterations (<-15% / >15%)	moderate
	4 = strong alterations (<-20% / >20%)	bad
	5 = very strong alterations (<-30% / >25%)	poor

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Suspended sediments

Suspended sediment concentration / load (decrease) ($SSC_{\_change} = 1 – SSC_{present} / SSC_{ref}$)	1 = very low alterations (0 - 10%)	high
	2 = low alterations (10 - 20%)	good
	3 = moderate alterations (20 - 35%)	moderate
	4 = strong alterations (35 - 50%)	bad
	5 = very strong alterations (>50%)	poor

Suspended sediment concentration / load (increase) ($SSC_{\_change} = SSC_{present} / SSC_{ref} - 1$)	1 = very low alterations (0 - 20%)	high
	2 = low alterations (20 - 50%)	good
	3 = moderate alterations (50 - 75%)	moderate
	4 = strong alterations (75 - 100%)	bad
	5 = very strong alterations (>100%)	poor

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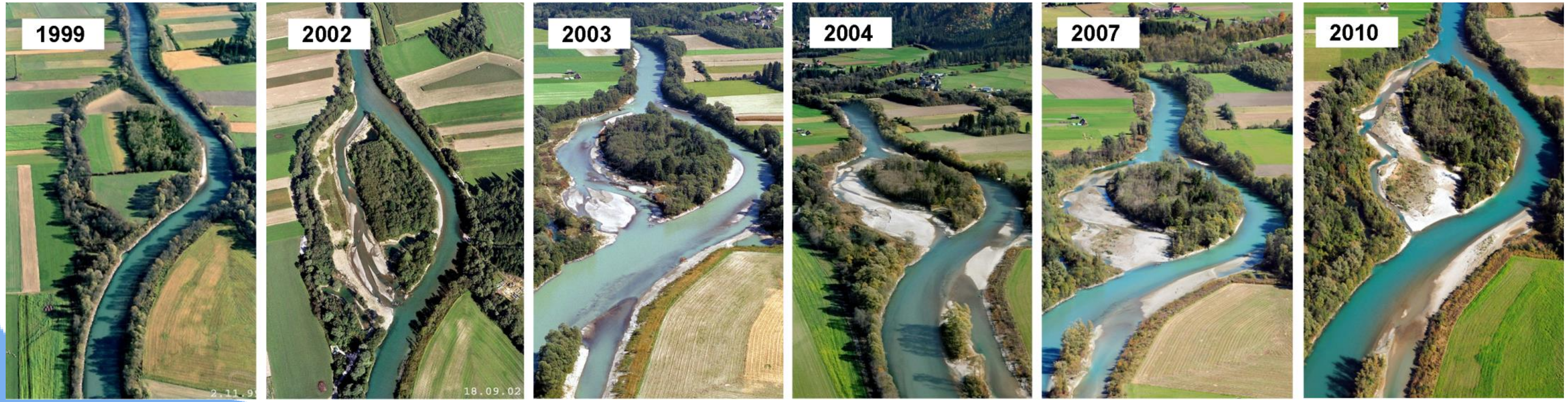
River bed widening

Mai 2018



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Klösch und Habersack, 2018

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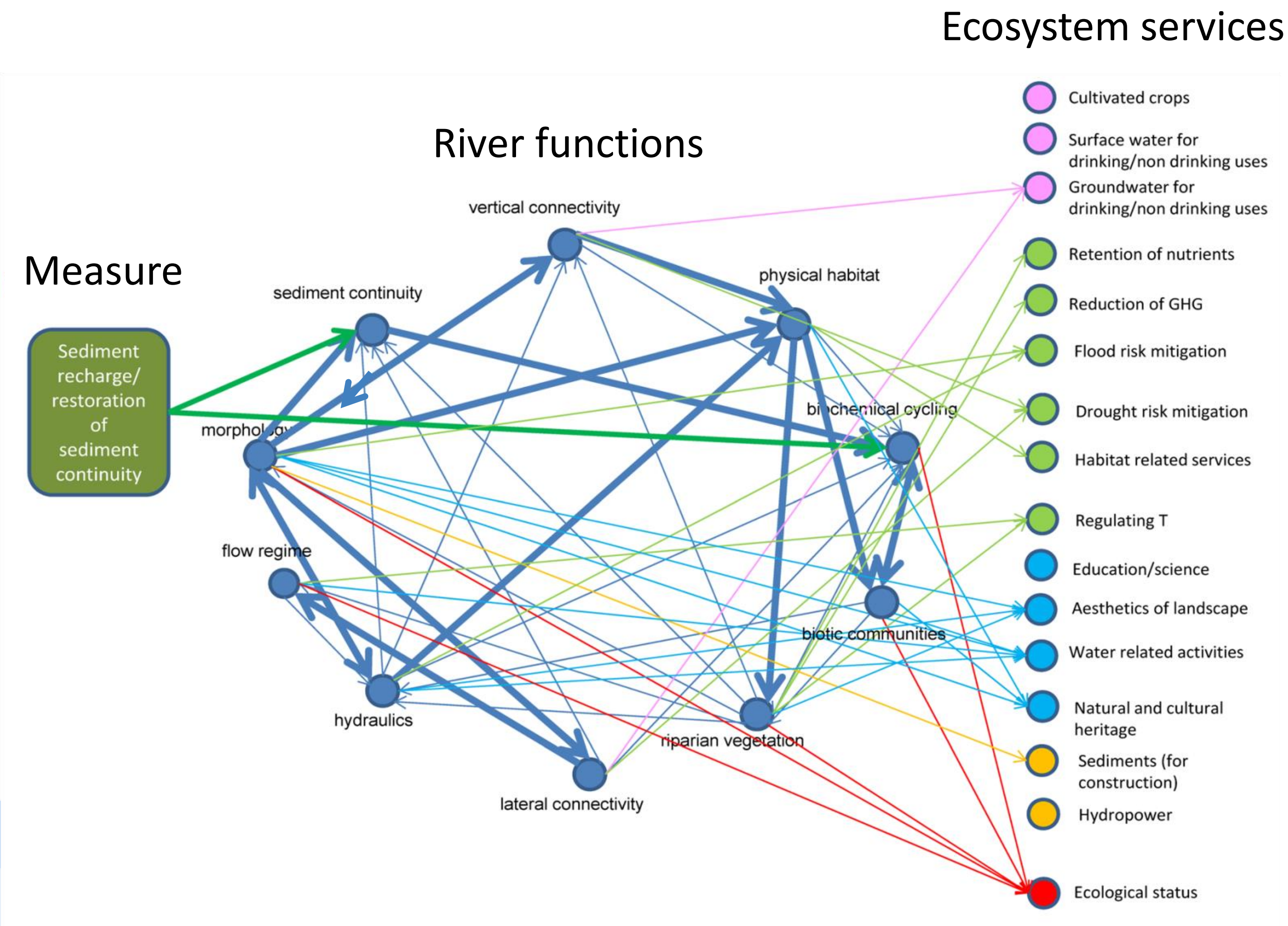
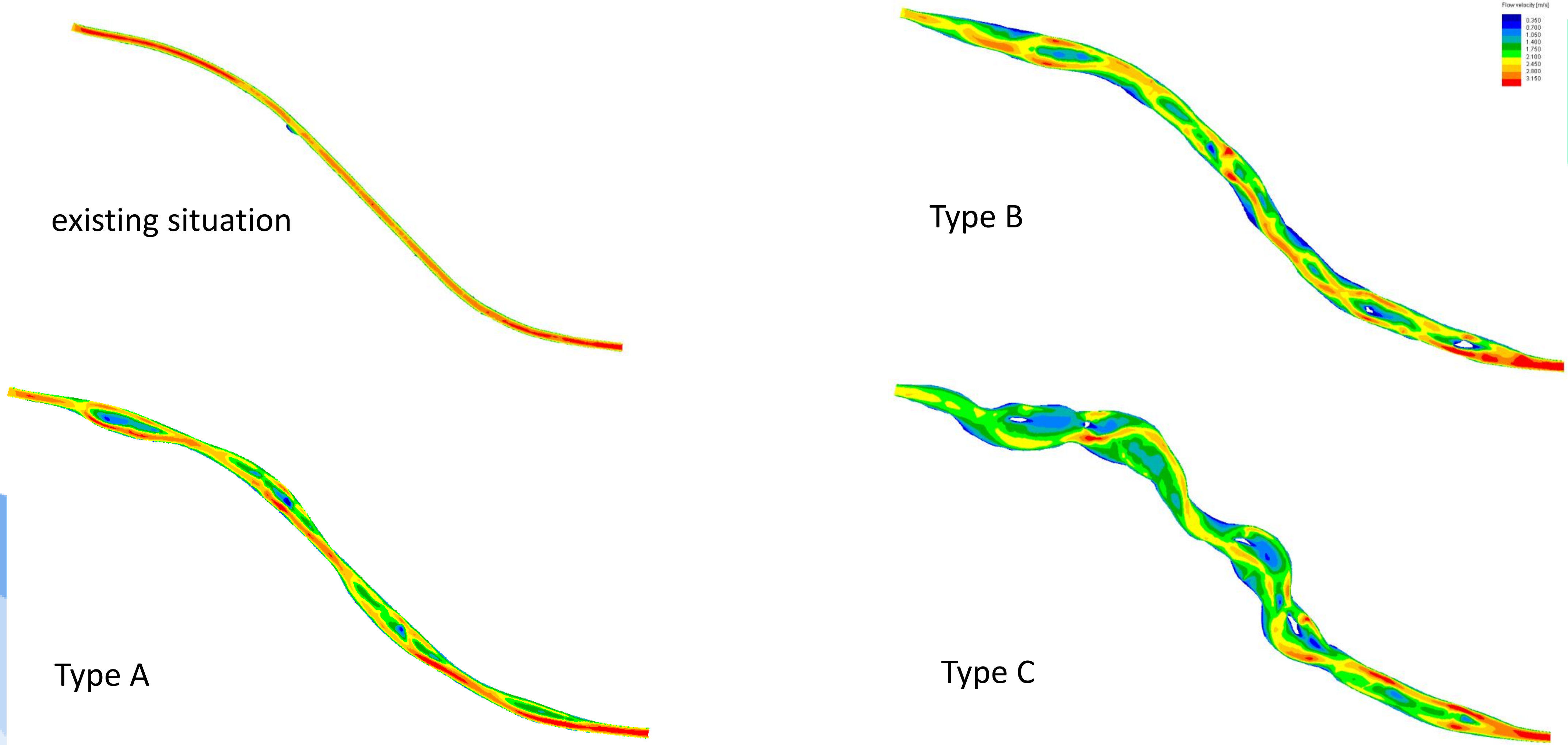
HyMo CARES

Interaction of measures, river functions and ecosystem services



Vision for Border Mura – flow velocities simulated with a 3D numerical model



Conclusions

- A sediment balance is needed to sustain river functions that serve habitat quality and ecosystem services
- In reality most rivers show a disbalance between erosion, transport, sedimentation and remobilisation
- There is a hierachical sequence from catchment based sediment balance to river morphodynamics to habitat diversity to the ecological status
- It will be important to evaluate the risk of failing a good ecological status because of disbalance of sediments, river bed level changes and habitat deterioration
- In most rivers urgent measures are needed to restore sediment balance, stop river bed erosion in free flowing sections, improve river and habitat dynamics

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Many thanks for your attention!

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