River Restoration in Denmark

30 years of experience and what have we achieved?

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Outline

- Background
- River restoration in Denmark
- Examples of effects
- Conclusions
- Reflections on the past studies and methods
- The future

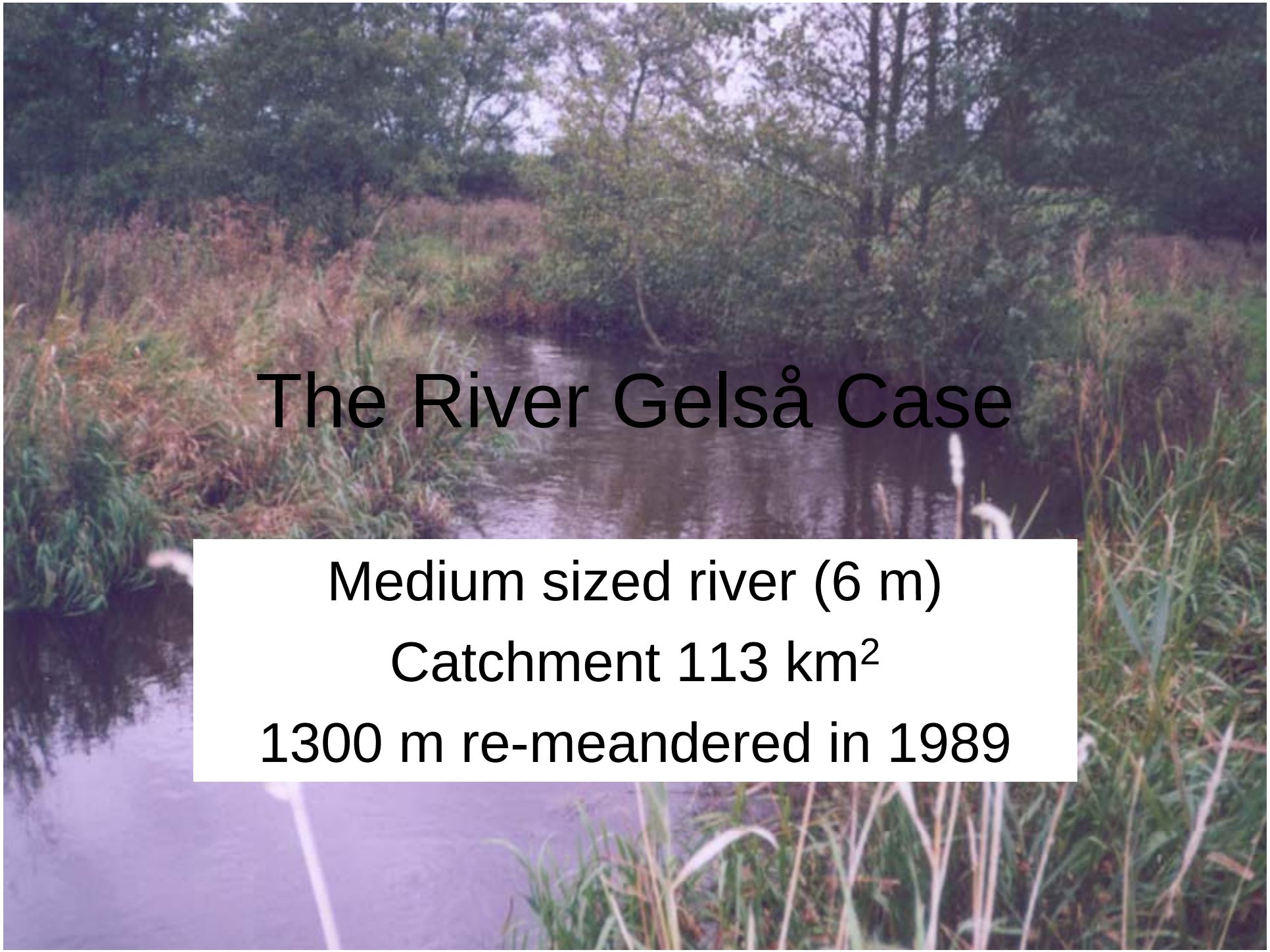
Channelisation and dredging

30 years of experience

- More than 2000 restoration projects in all parts of the country – from small brooks to rivers
- Majority of projects are aimed at re-establishing connectivity in river systems and spawning areas
- Re-meandering is widely used and 110 projects are of this type
- Consultants, engineers and municipalities (counties) and Government Agencies have developed the administrative, legislative technical and engineering skills to plan, implement and carry out the restoration work

Effects studies

- A limited number of projects have included systematic effect studies
- Most projects are evaluated through routine monitoring of either macroinvertebrate or trout communities
- In general there has been resistance towards systematic ecological evaluation → pseudo scientific documentation of the effects
- Effects are rarely documented if projects fail! →
- How are we going to learn anything if nothing gets reported on the failures?



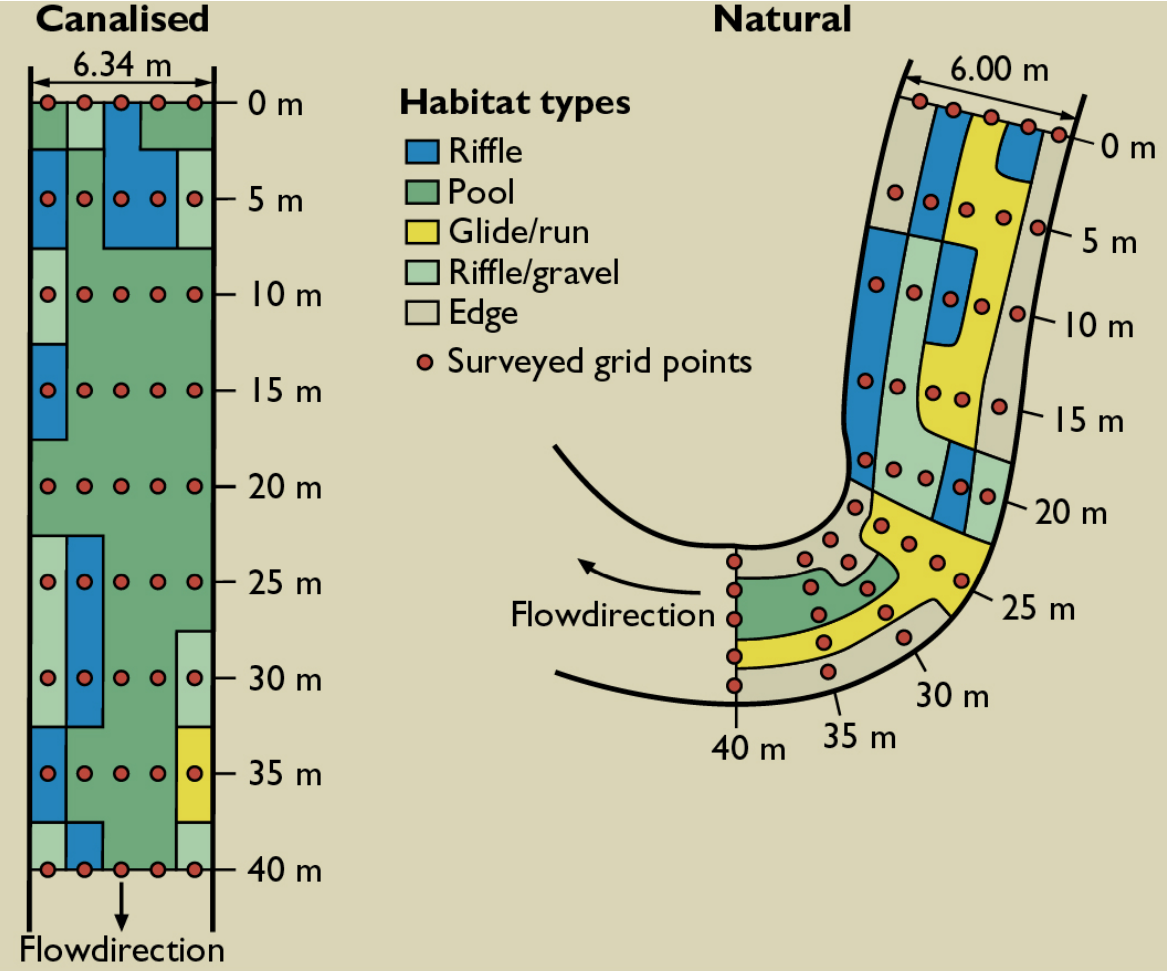
The River Gelså Case

Medium sized river (6 m)

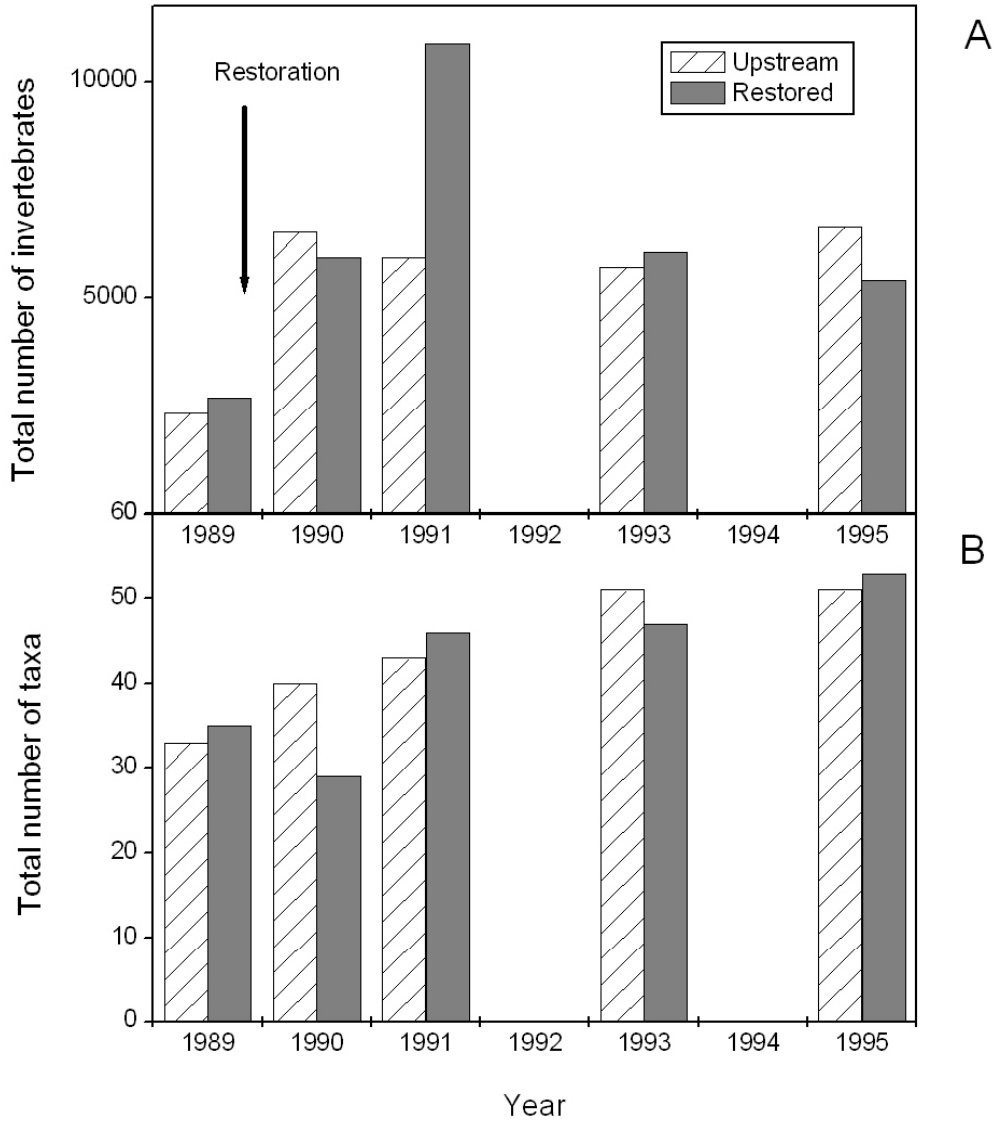
Catchment 113 km^2

1300 m re-meandered in 1989

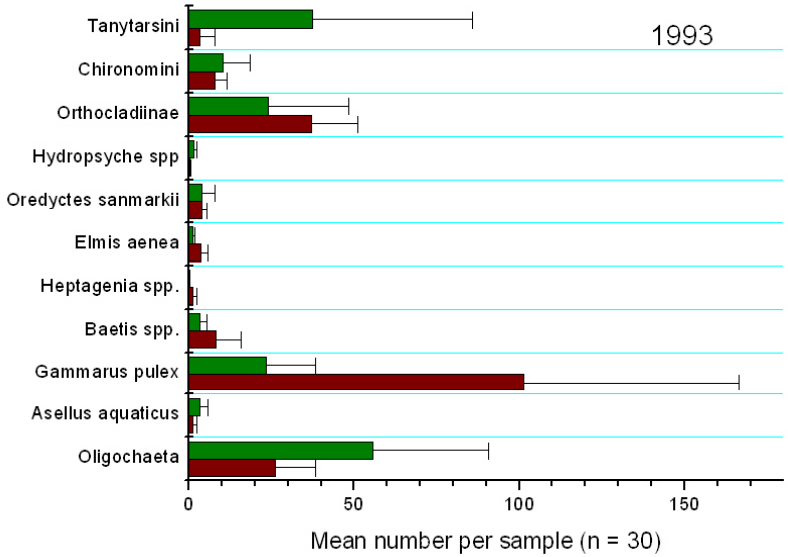
Habitat restoration

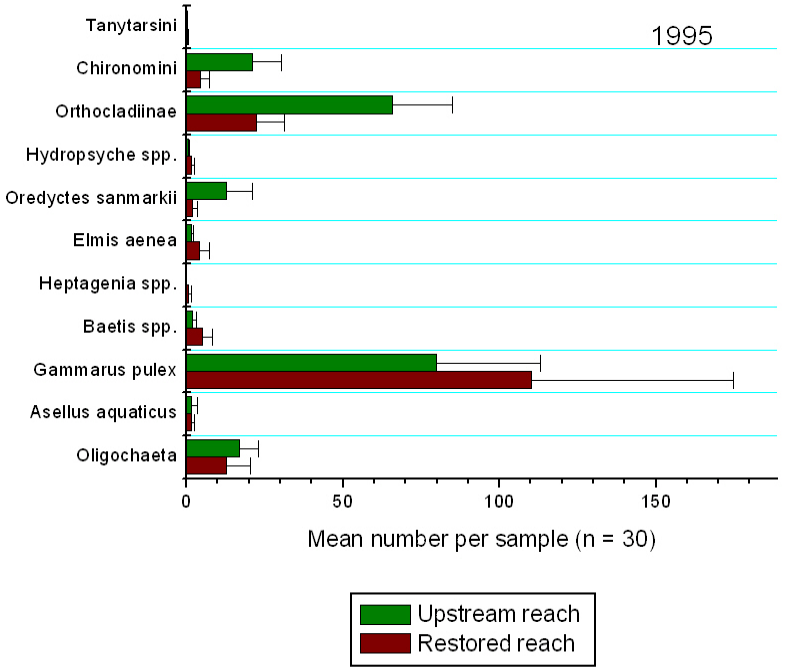


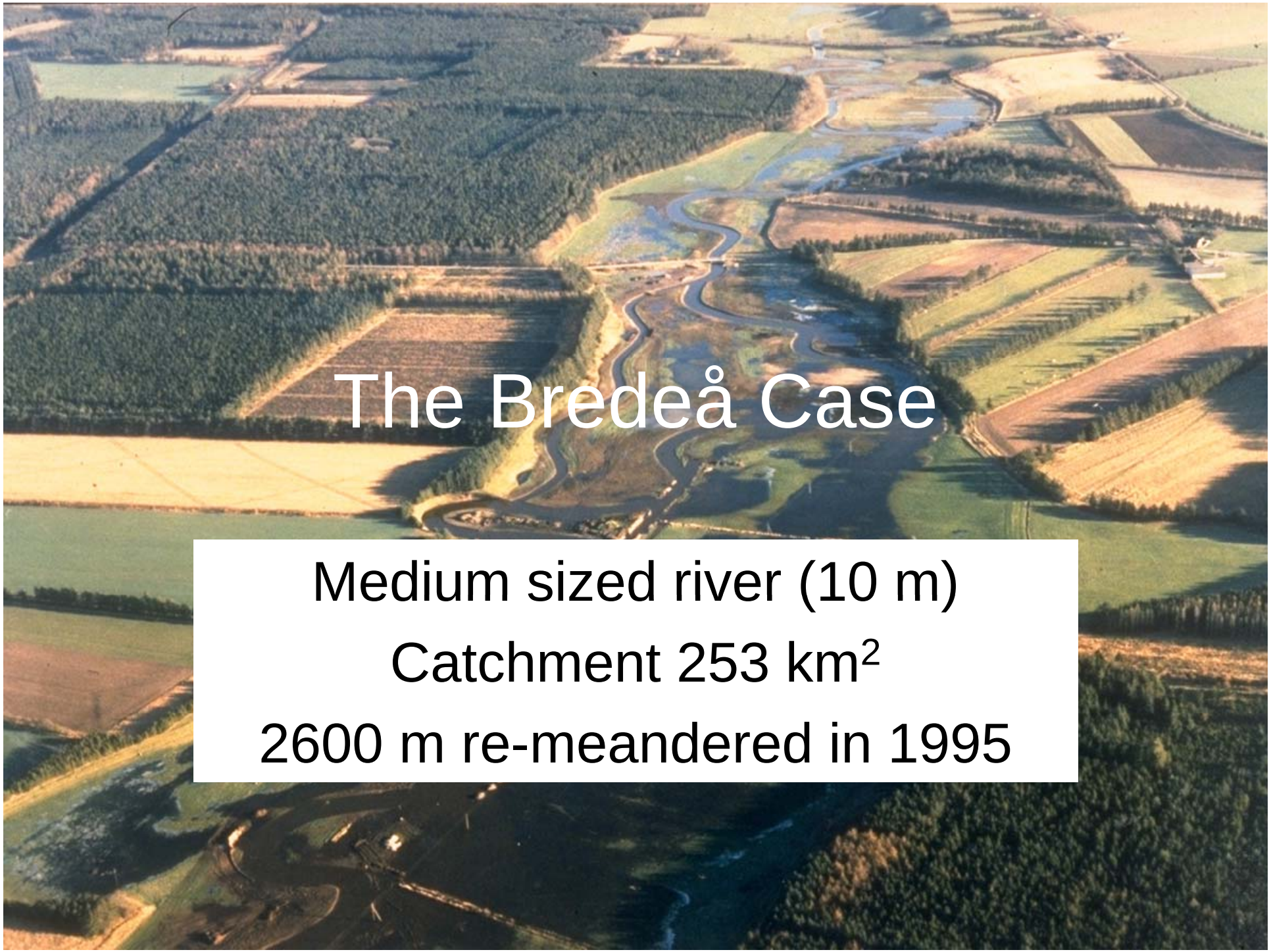
Macroinvertebrate communities responded quickly



Macroinvertebrate species







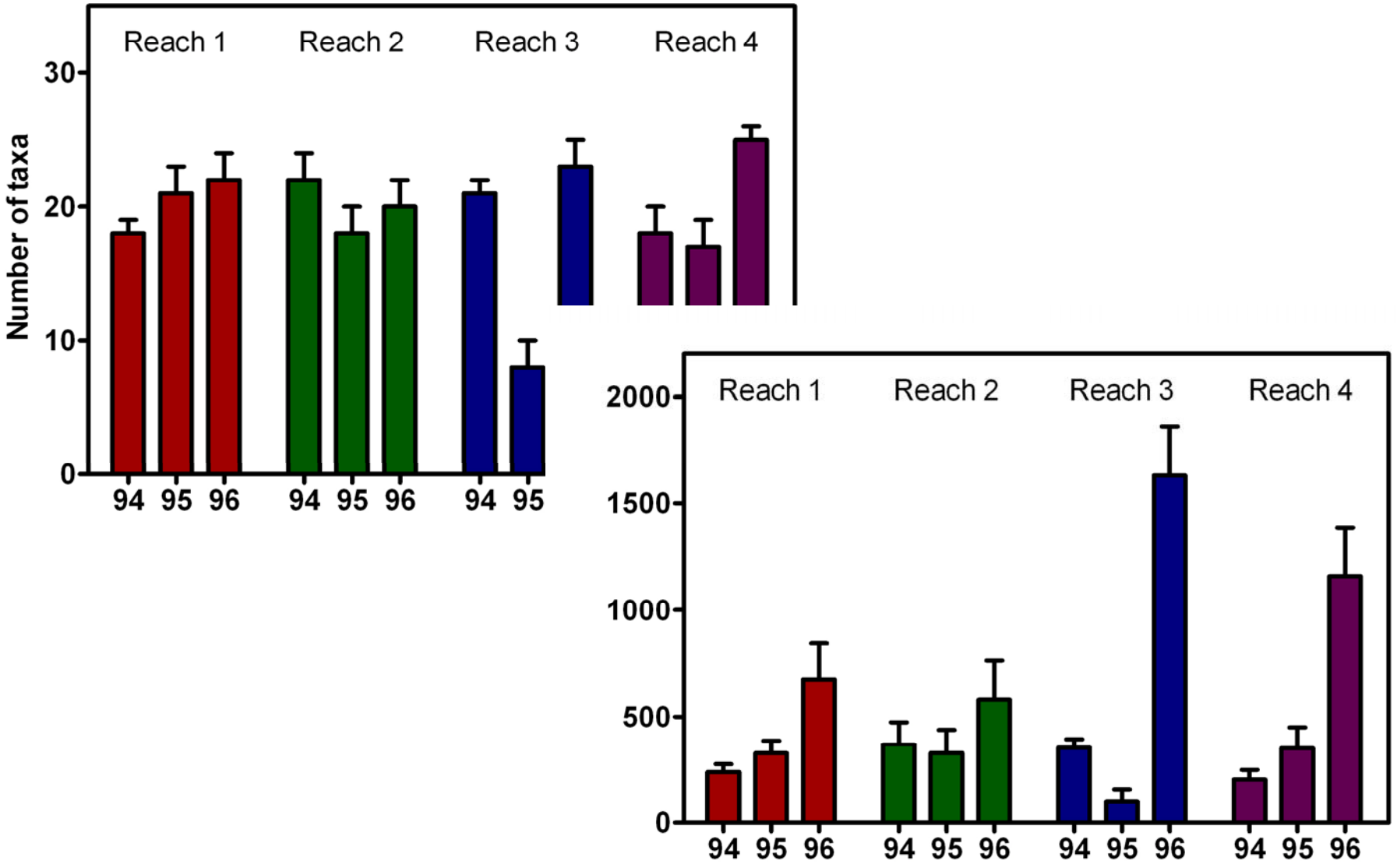
The Bredeå Case

Medium sized river (10 m)

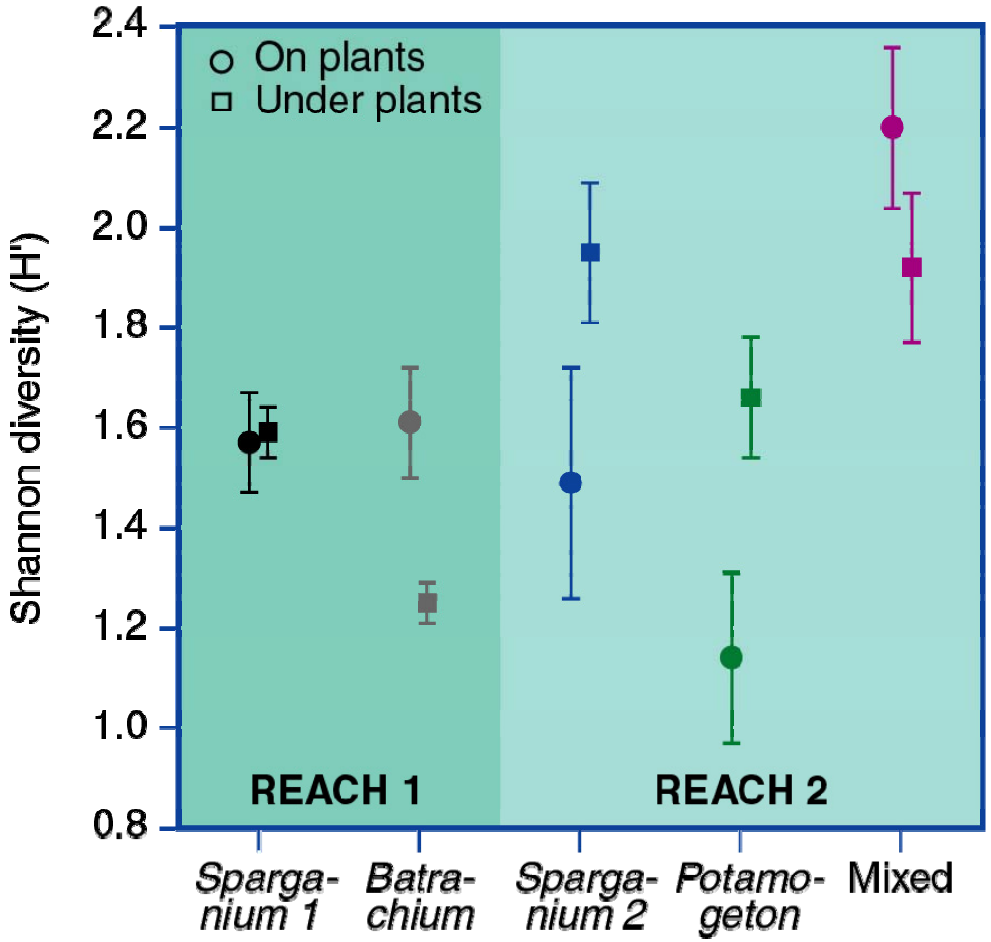
Catchment 253 km^2

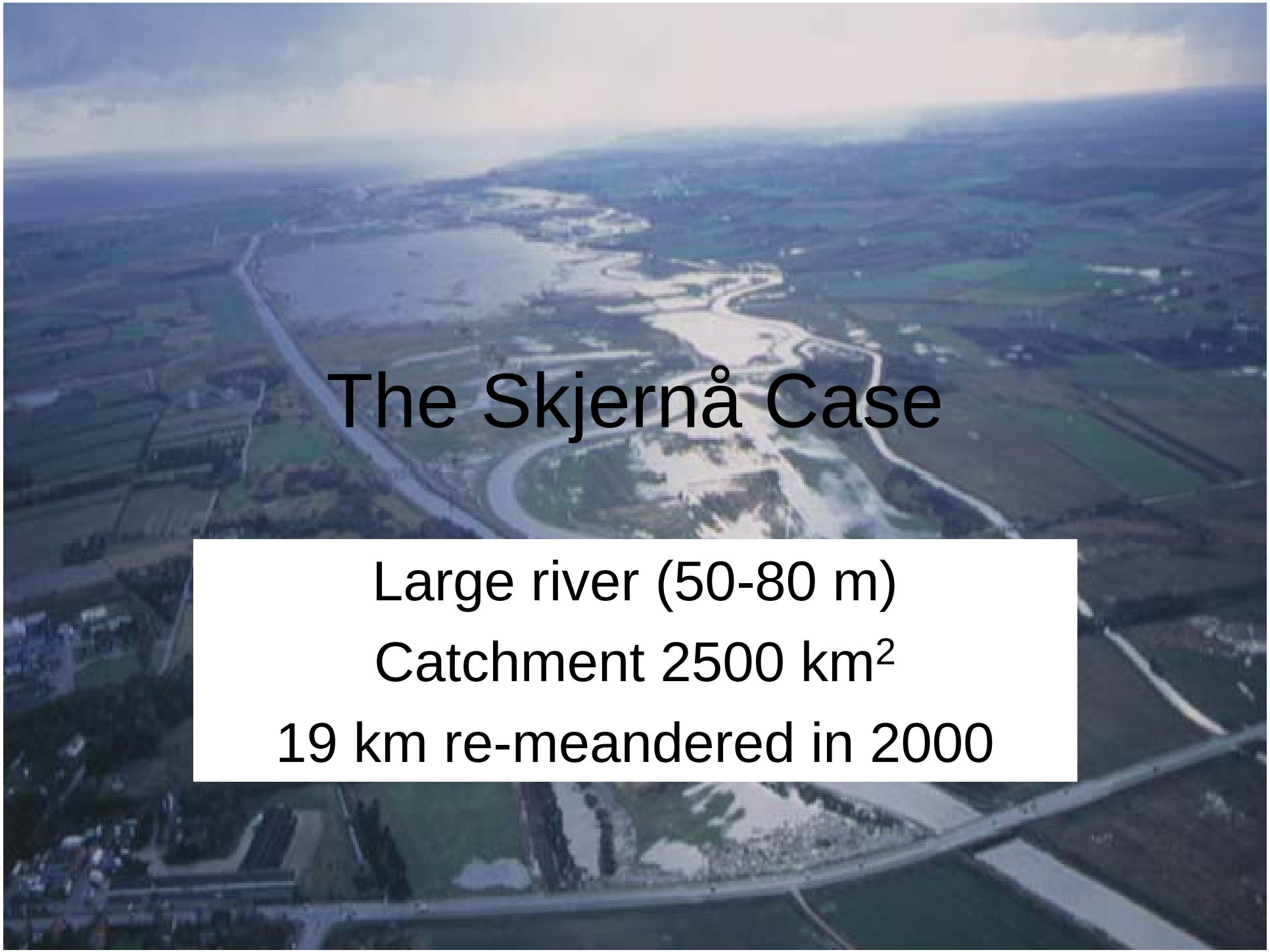
2600 m re-meandered in 1995

Taxonomic abundances remain unaffected, but densities respond



The importance of the plants





The Skjernå Case

Large river (50-80 m)

Catchment 2500 km^2

19 km re-meandered in 2000

Community structure changes

	Before (2000)	After (2003)
Taxa	14.7	19.7
Abundance	761	335
Shannon diversity H’	0.43	0.62
EPT taxa	6.8	10.4
EPT abundance	14.9	19.2

Main results

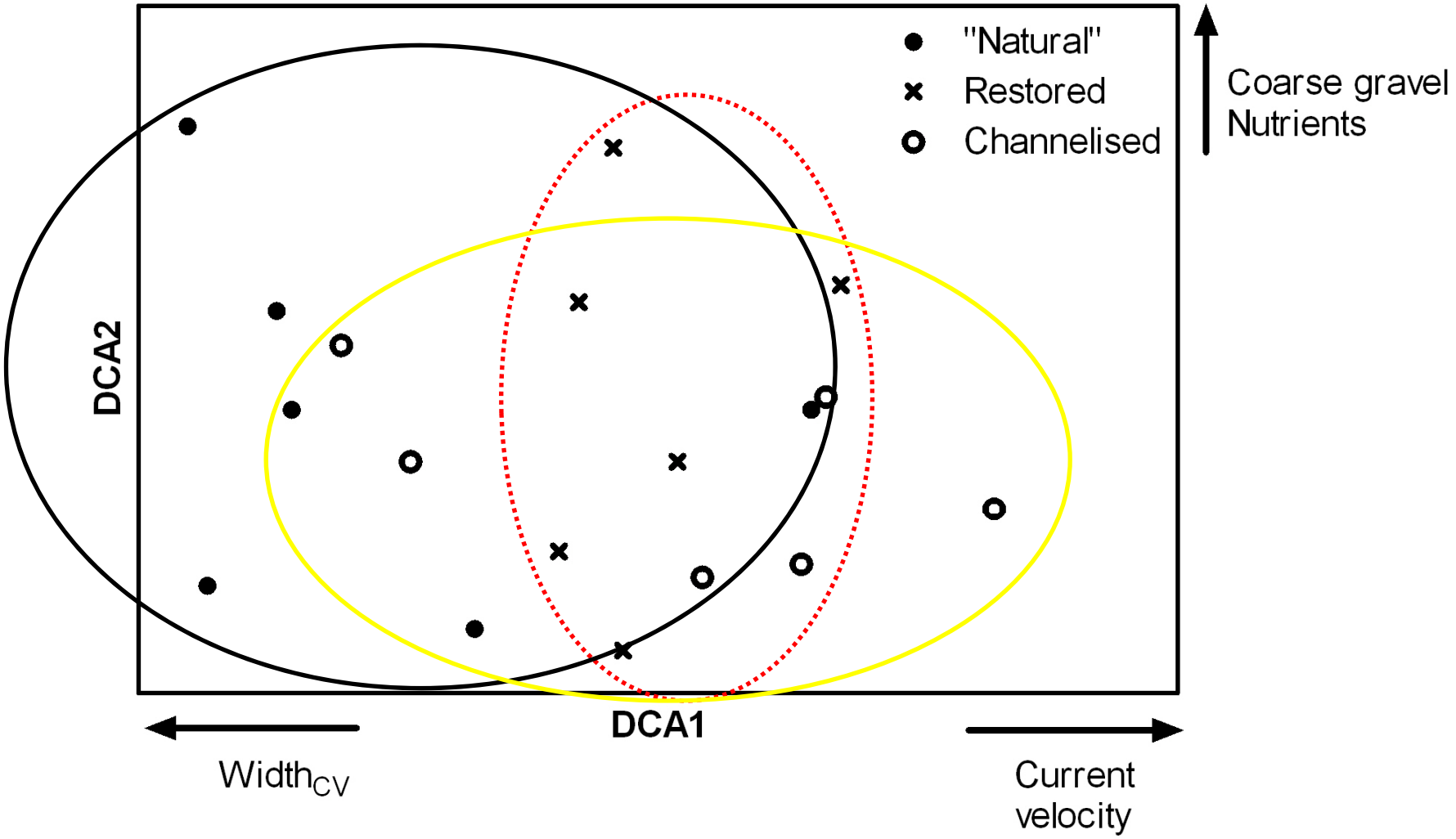
- Plants colonised the reaches quickly
- Spawning gravel and stones were placed in riffles creating a new habitat not available in the channelised river
- Several rare species colonised during the first 2 years
- Evenness decreased significantly – a more robust community was established
- Similarity analyses indicate a community shift on the restored reaches – a “gravel community” colonised the restored river

10 years after

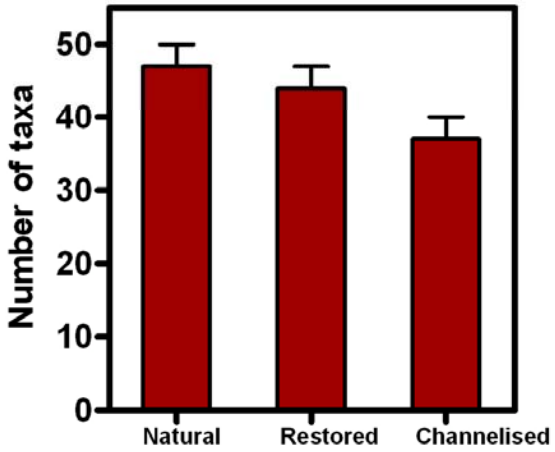
A comparative study of 18 streams in Denmark

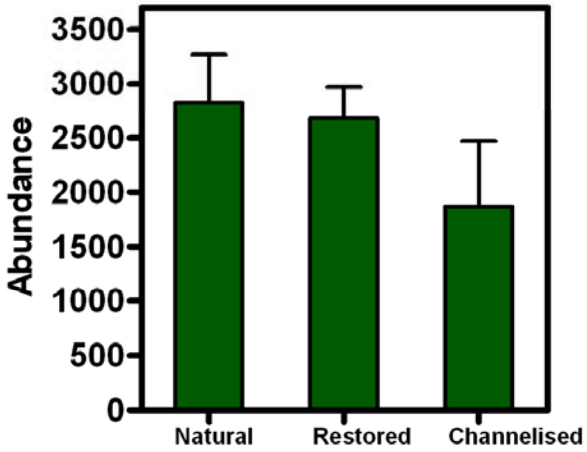
6 “natural”, 6 restored and 6 channelised

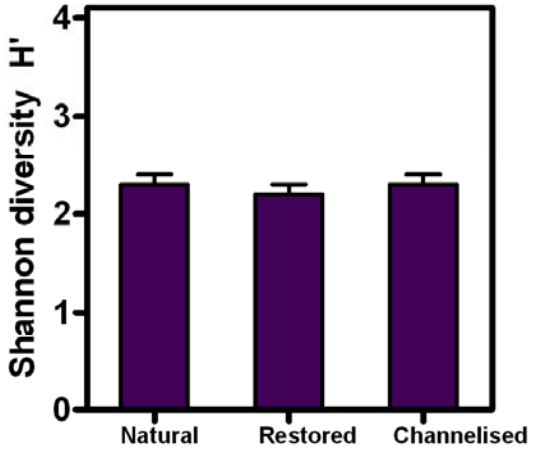
Macorinvertebrate communities

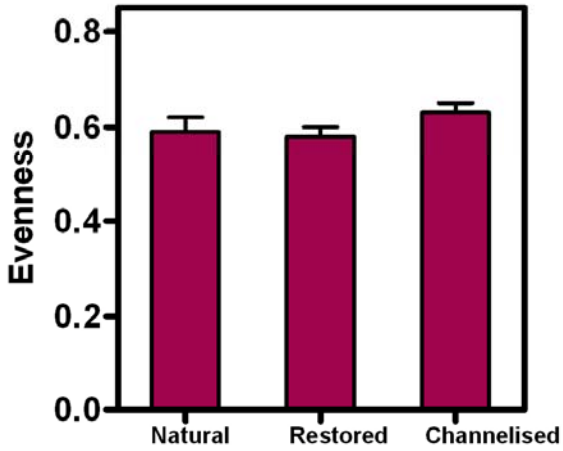


Community structure





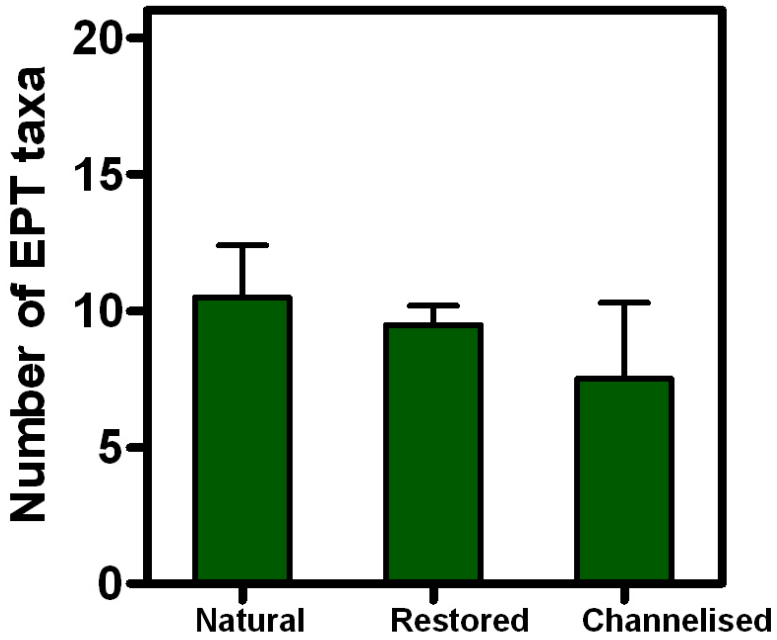


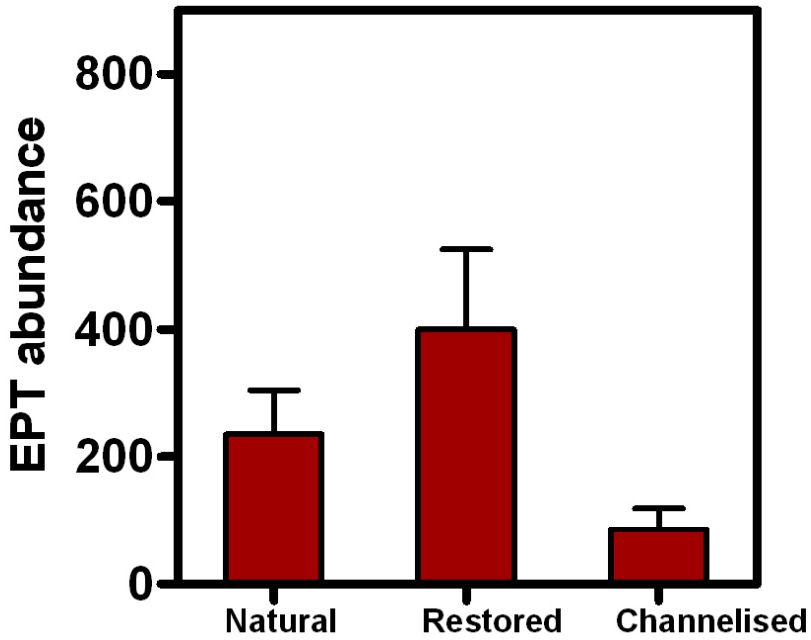


Physical habitats

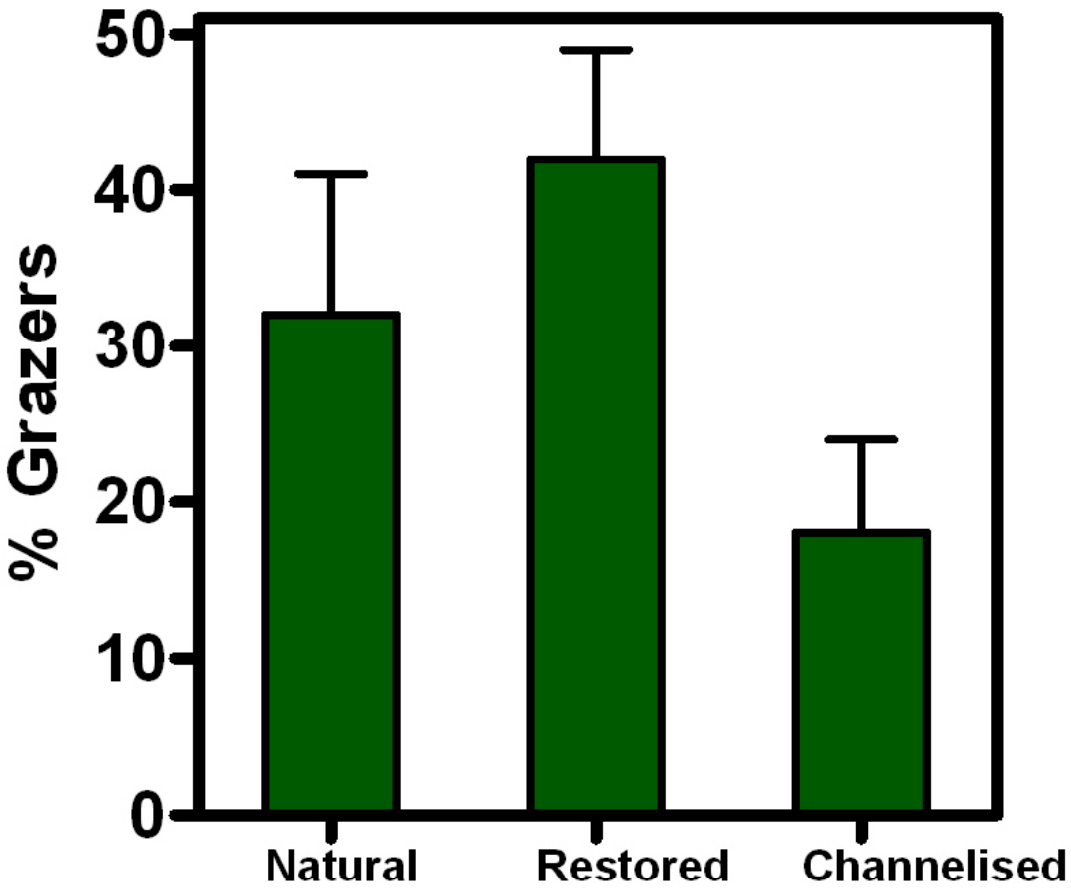
	Natural	Restored	Channelised
$Width_{CV}$ (%)	**17 ± 3**	**11 ± 2**	7 ± 1
Velocity (ms^{-1})	0.34 ± 0.02	0.30 ± 0.02	**0.26 ± 0.02**
Stones (%)	3 ± 1	**22 ± 7**	0 ± 0
Gravel (%)	16 ± 7	**33 ± 6**	7 ± 5
Sand (%)	77 ± 6	**39 ± 2**	75 ± 9

EPT taxa response in riffles





Functional response



Results from the ecological effect studies

- Restored streams are generally in a better condition compared to channelised rivers
- Too much emphasis on spawning gravel – we probably overcompensate resulting in non-natural conditions
- Initial reduction in number of taxa and especially density of plants and animals.
- Recovery very different between projects, reflecting placement in river continuum, climatic conditions during the restoration period and site specific conditions such as hydrology, hydraulics, geomorphology and ecological dispersal potential.

Experiences

Negative

- No systematic biological / geomorphological evaluation of the projects
- Isolated projects – carried out at the reach scale
- Publication of experiences and results (if any) usually in “grey literature” – no scientific evaluation and communication
- We’ve lost a golden opportunity to gain valuable information on ecosystem functioning and recovery

Positive

- Connectivity has been restored to a certain degree in many systems
- Habitats have been positively affected
- Implementation experience is advanced
- Awareness of the possibilities has been raised to the political level as well as in the society in general

Restoration or re-habilitation?

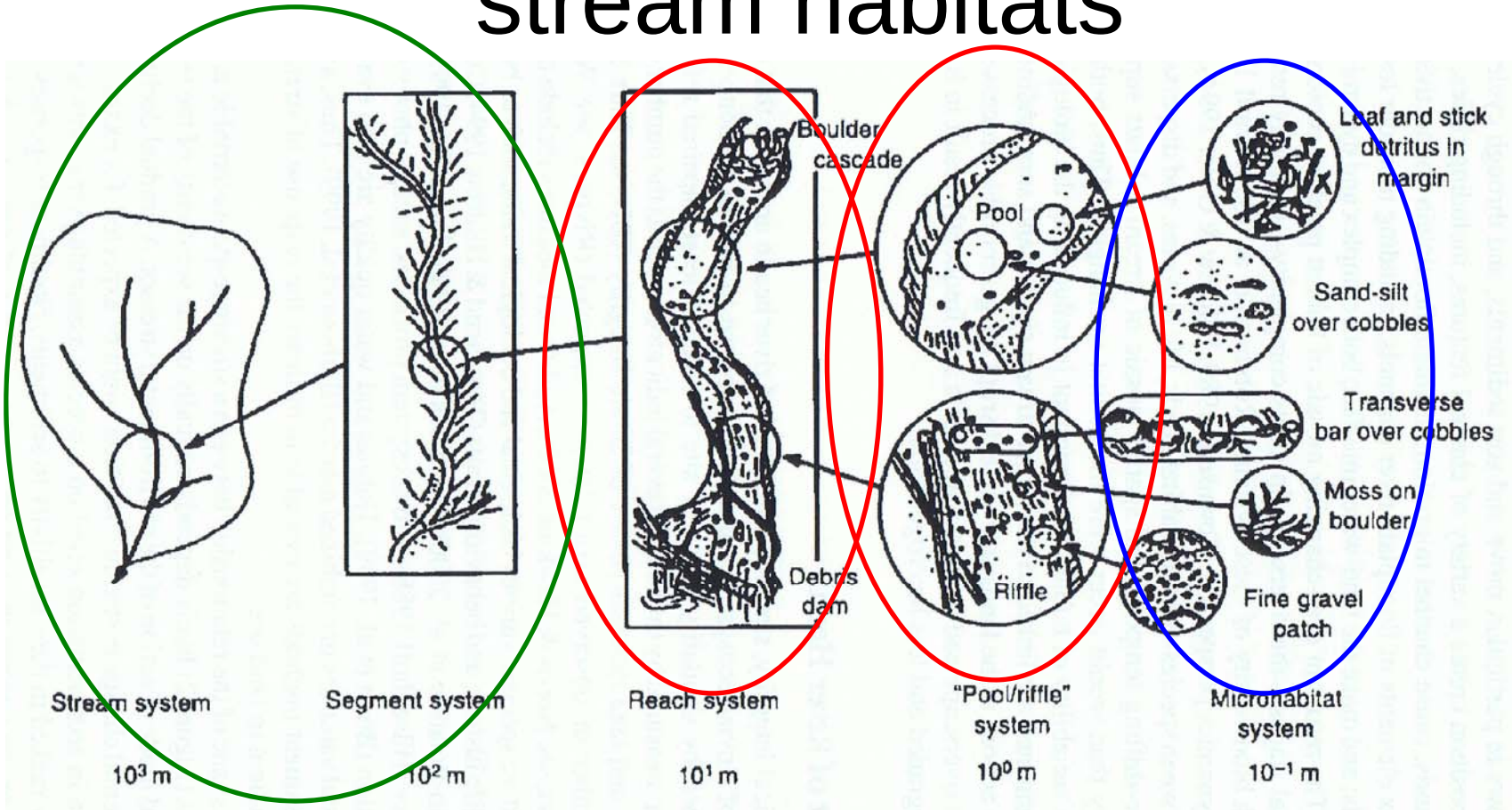
- Restoration is an unrealistic goal in Denmark or any lowland country where agriculture and drainage and diffuse pollution (eutrophication) is affecting the river ecosystems

- We thus rehabilitate most rivers rather than restoring them to some previous pristine state

- This has to be reflected in our restoration goals

From: Bent Lauge Madsen

The hierarchical organisation of stream habitats



…and assume these have no effect

We expect this develop

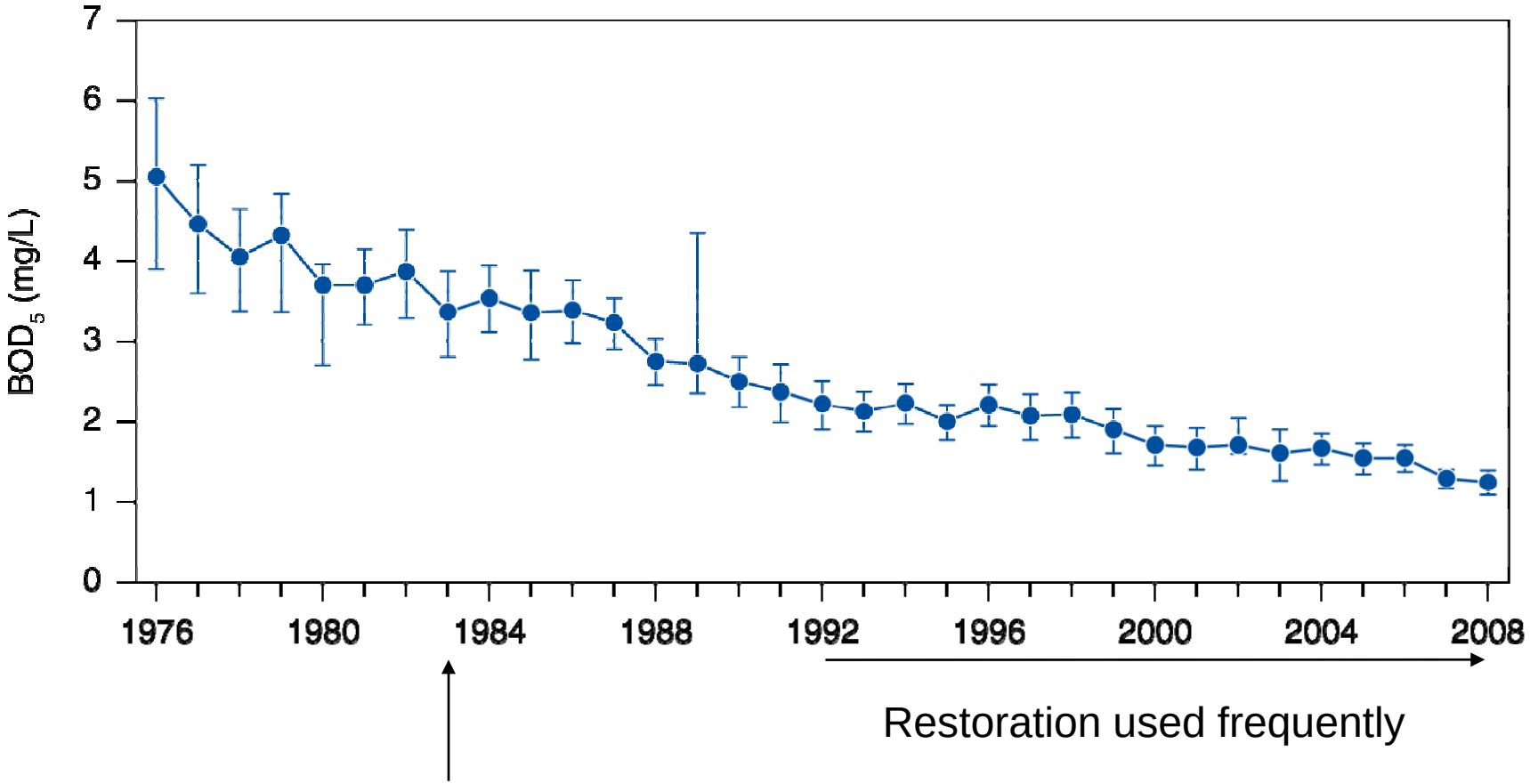
From: Frissell et al., 1986

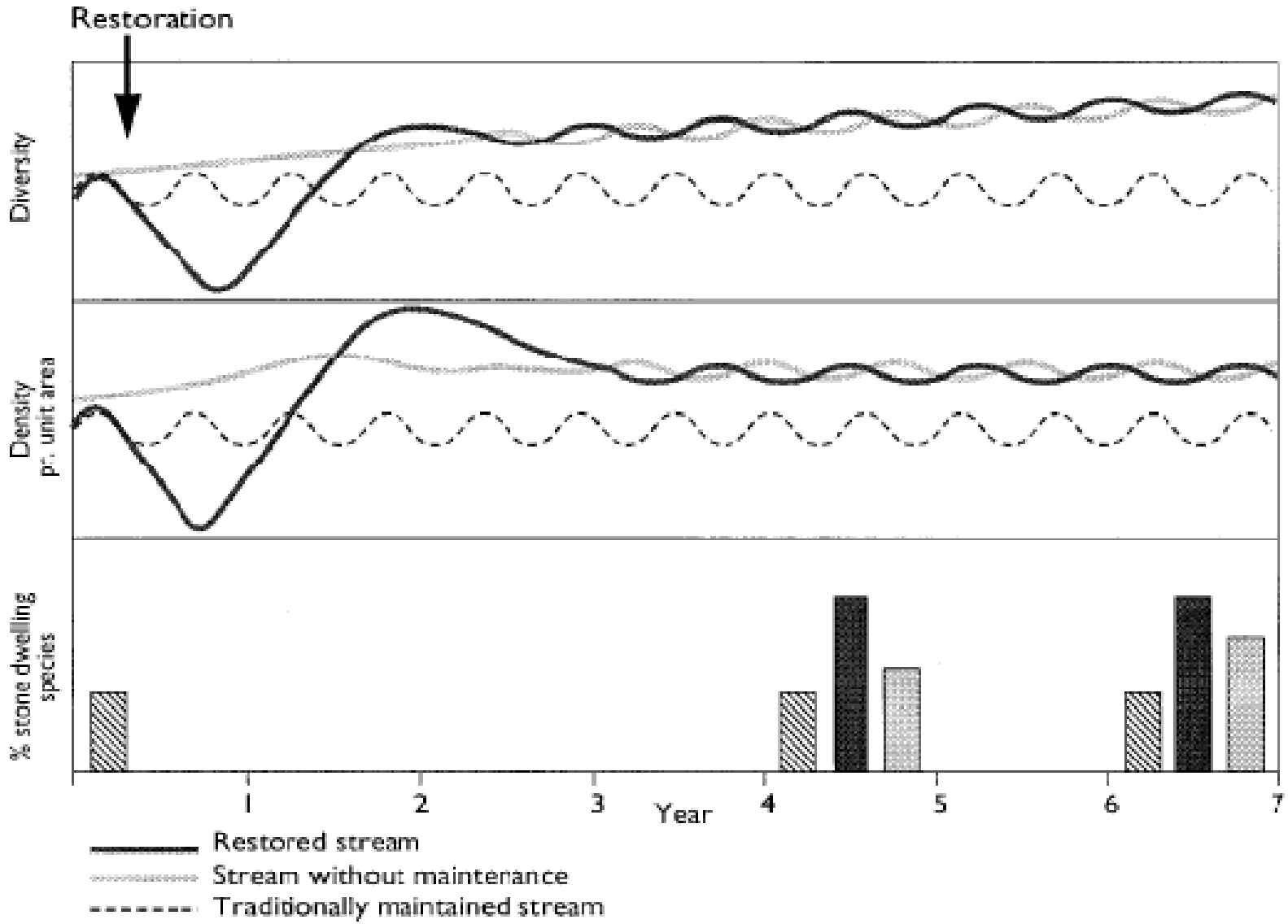
Why is it difficult to document any effects of restoration?

1. Covariation in anthropogenic and natural gradients in the landscape
2. Multiple scale dependent mechanisms
3. Non linear response in the physical and biological system
4. Difficulties of separating present-day from historical influences

Allan JD, 2004. Annu. Rev. Evol. Syst, 35: 257-284

Restoration or water quality improvements?




Restoration
Diversity
Density pr. unit area
% stone dwelling species
1
2
3
4
5
6
7
Year
Restored stream
Stream without maintenance
Traditionally maintained stream

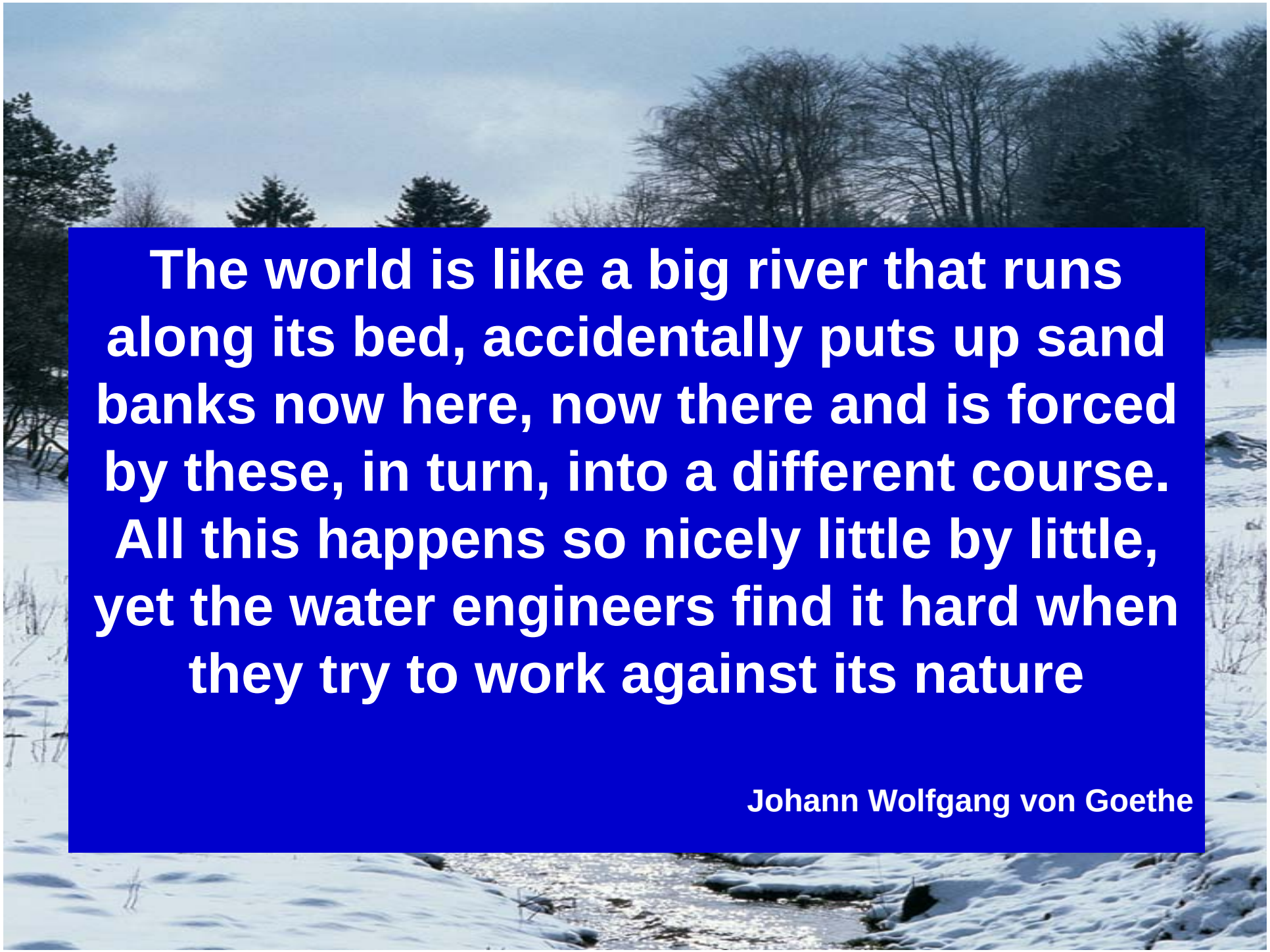
Recommendations for future projects

- Start with restoring water quality and river connectivity
- Include the river valley, if possible. Work with the entire “Riverscape” – this will increase the number of rehabilitated ecological processes.
- Remember to restore refuge areas and terrestrial habitats
- Reduce input of fine sediments to the river if possible
- Hydrology plays an essential part in the river ecosystem
- Restore systems – not reaches!
- Start restoring from upstream in your catchment – the headwaters - and move downstream
- Identify the number of stressors affecting the river and set realistic restoration target with this in mind
- Monitor a selection of your restoration projects using targeted indicators
- Monitor ecosystem functioning…focus on processes instead of structure
- Start monitoring after the first couple of years (to avoid disturbance from construction) and continue for a longer period (colonisation takes time)

Water Framework Directive challenges

- River restoration or re-habilitation is one of the tools that can be used to reach good ecological status
- Politicians will need bullet-proof documentation in order to use money on re-habilitating rivers

- The scientific / administrative system face the following challenges:
  - We can only deliver to certain degree
  - We need to combine the data already collected in post appraisal studies
  - We must focus on collecting new (or dust off old) data to document the positive (and negative) effects


The world is like a big river that runs along its bed, accidentally puts up sand banks now here, now there and is forced by these, in turn, into a different course. All this happens so nicely little by little, yet the water engineers find it hard when they try to work against its nature
Johann Wolfgang von Goethe


THANK YOU FOR YOUR ATTENTION