Riverine Landscape Diversity

and

Setting Restoration and Conservation Priorities

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Madrid, 23 October 2007

Unprecedented change in structure and function of ecosystems

-More land was converted to cropland in the 30 years after 1950 than in the 150 years between 1700 and 1850.

Cultivated Systems in 2000 cover 25% of Earth's terrestrial surface

(from MEA 2003)

(Defined as areas where at least 30% of the landscape is in croplands, shifting cultivation, confined livestock production, or freshwater aquaculture)

River Danube at Vienna (A)

1848 1888 1989

Mohilla & Michlmayr (1996). Donauatlas – Wien vier Jahrhunderte Kartenbild

Outline of the presentation

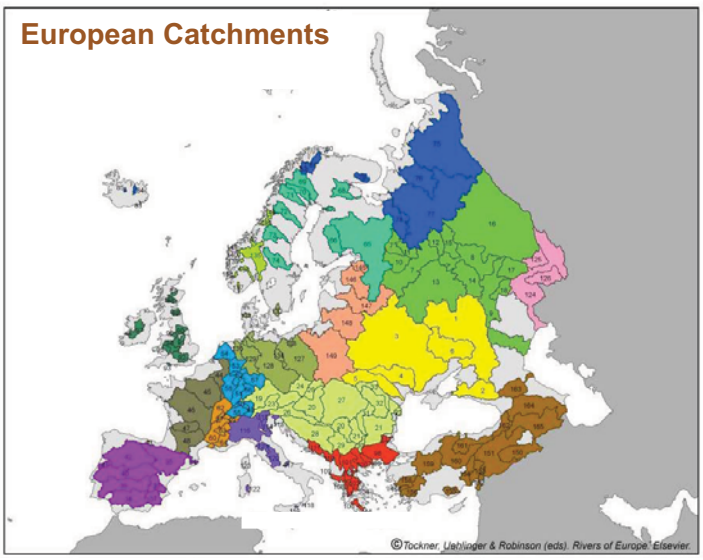
Setting restoration/conservation priorities at the European scale

Focus on keystone ecosystems and critical landscape elements

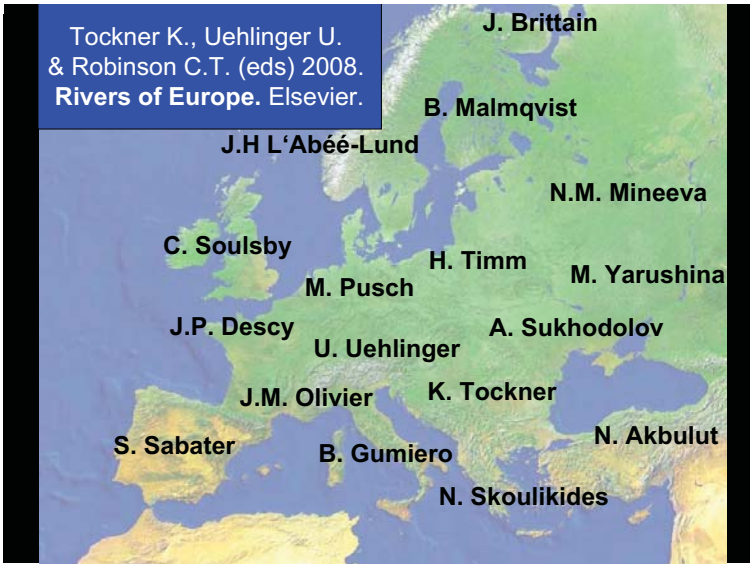
Integrating the Ecosystem Service Concept into Catchment Management

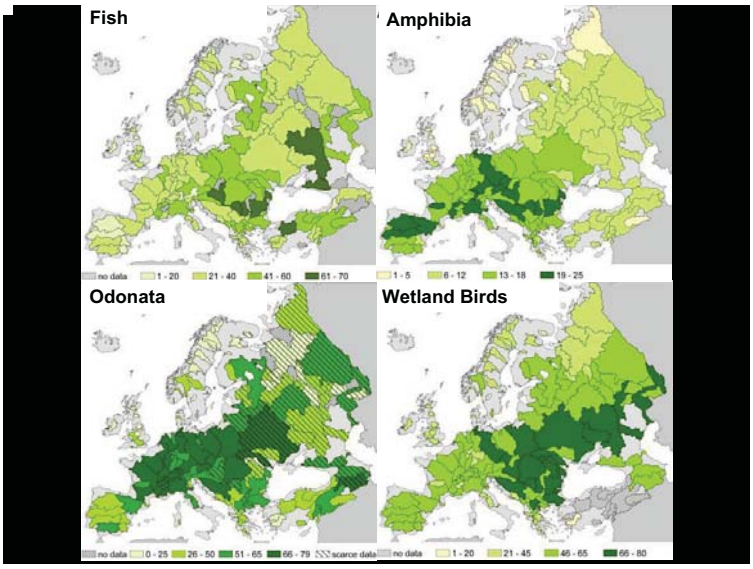
Conclusion and Prospect

European Catchments

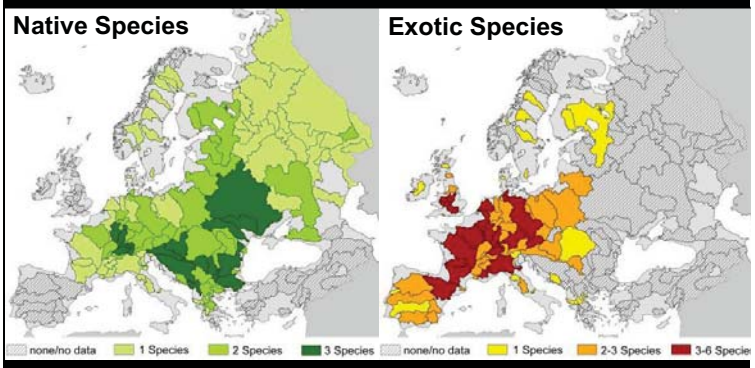


Tockner K., Uehlinger U. & Robinson C.T. (eds) 2008. **Rivers of Europe.** Elsevier.

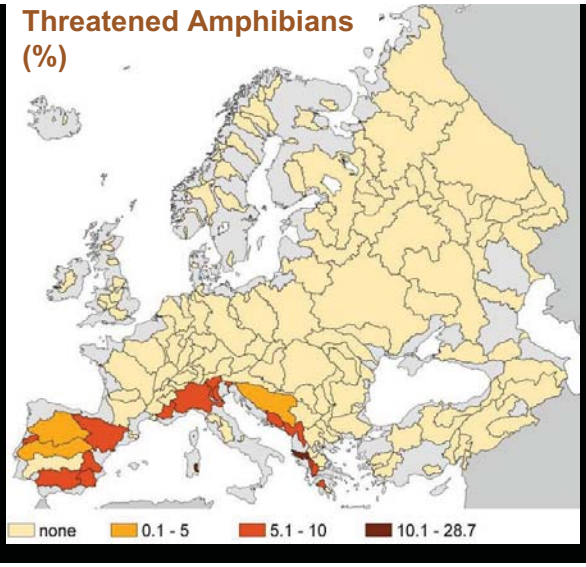




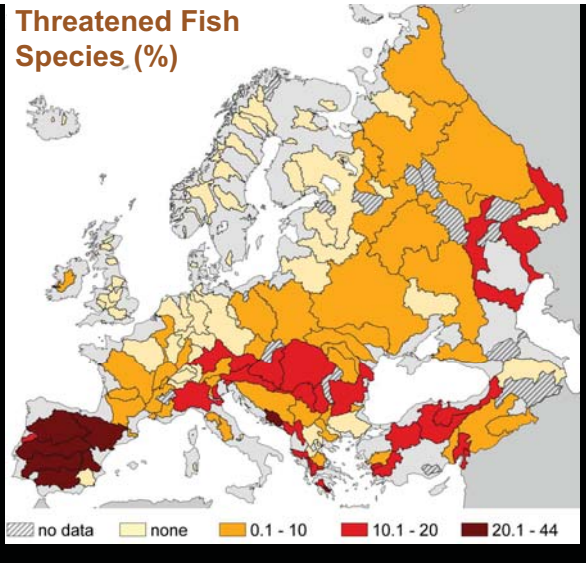
Example Crayfish



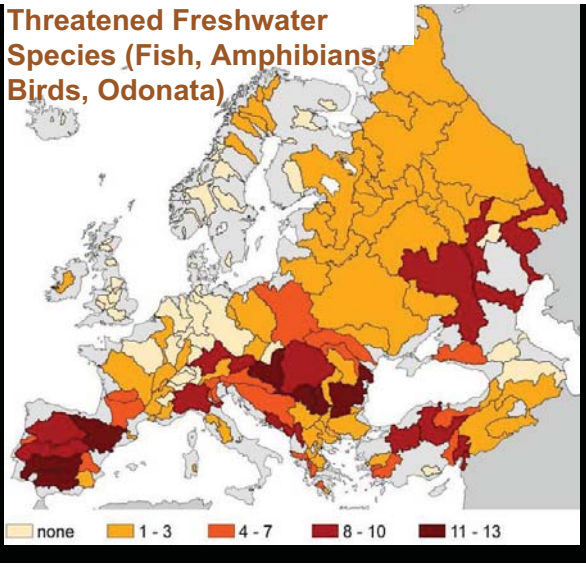
Threatened Amphibians (%)



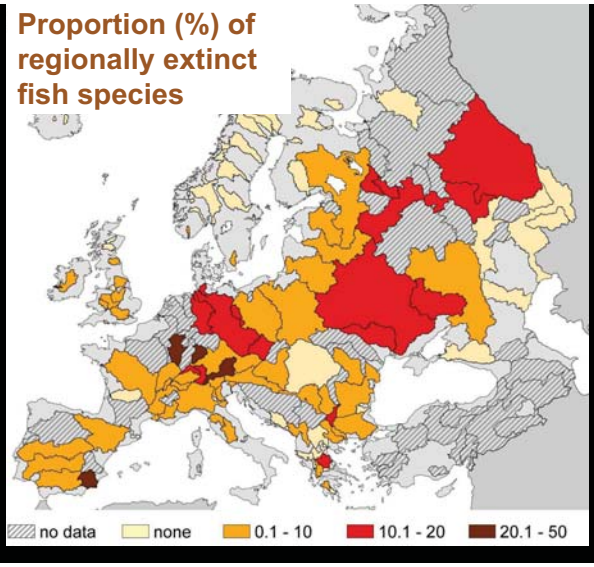
Threatened Fish Species (%)



Threatened Freshwater Species (Fish, Amphibians, Birds, Odonata)



Proportion (%) of regionally extinct fish species



Number of catchments, from which specific species disappeared

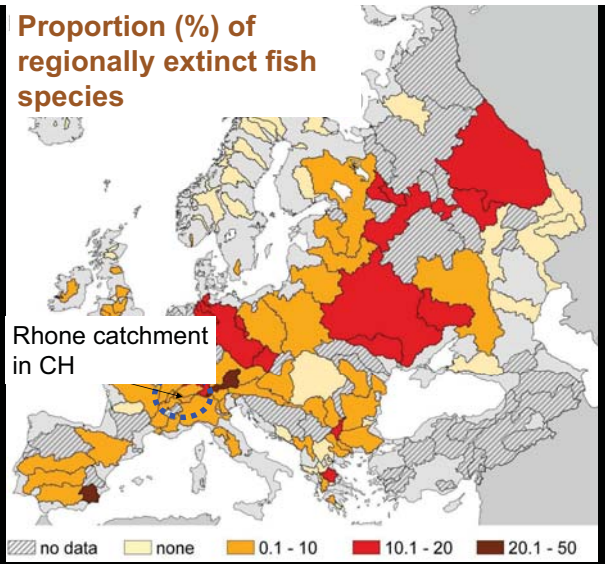
Acipenser sturio	27
Petromyzon marinus	9
Huso huso	9
Acipenser gueldenstaedtii	8
Acipenser stellatus	8
Alosa alosa	7
Salmo salar	7
Alosa fallax	6

(F. Peter *et al*. unpubl. data)

The salmon returns to the Elbe River
(www.smul.sachsen.de)

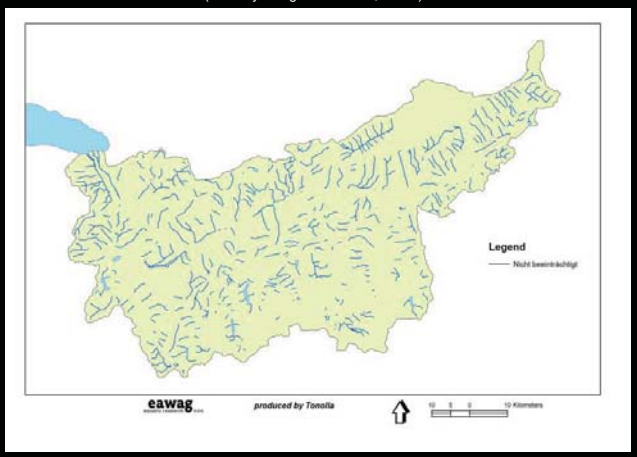
„The sturgeon should again swimm in the Odra River“
(National Geographic)

Proportion (%) of regionally extinct fish species

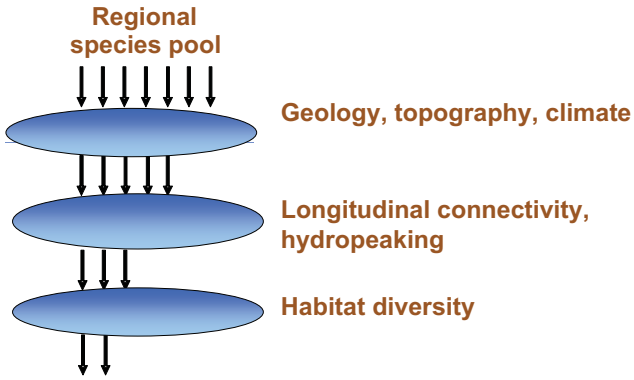


Example Upper Rhone (CH)

(data: Hydrological Atlas CH, BAFU)



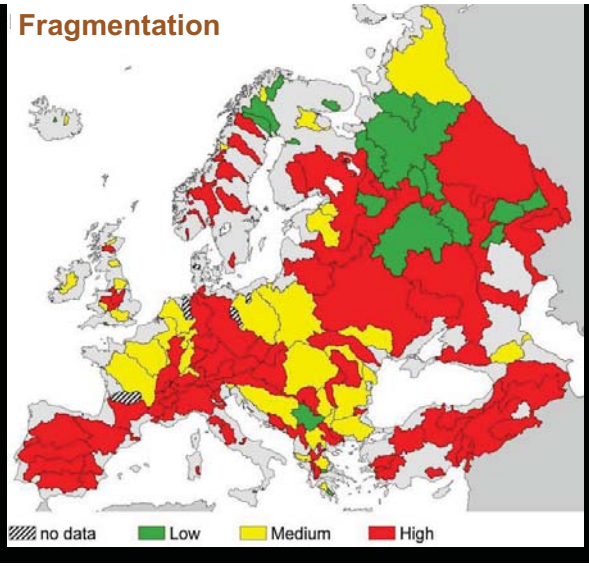
„Environmental Filter“ Concept



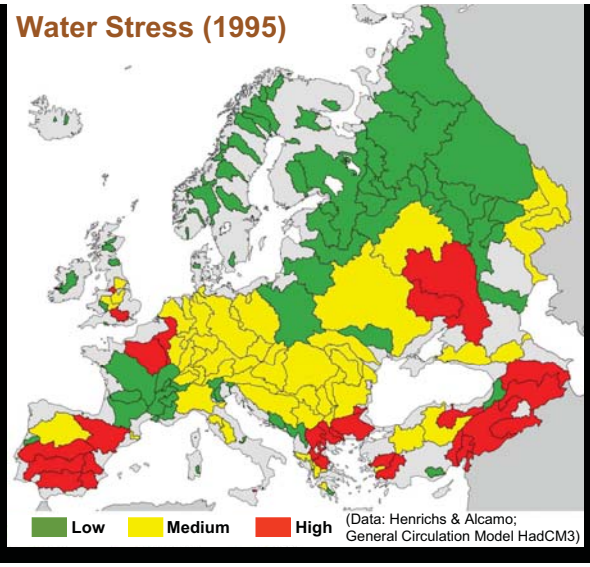
Human Catchment Pressure Index

- **Catchment Land Use:** Proportion (%) of developed land (cropland & urban area) in the catchment
- **Fragmentation:** Dams and flow regulation (after Nilsson *et al*. 2005)
- **Water Stress:** (Availability/withdrawal of water; 1995 and forecast 2070; HDMC3, after Henrichs & Alcamo 2001)
- **Biotic Pollution:** Proportion (%) of nonnative fish species

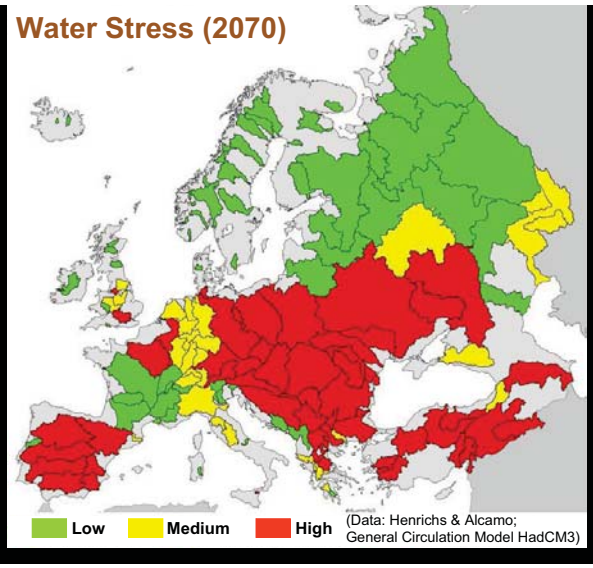
Fragmentation



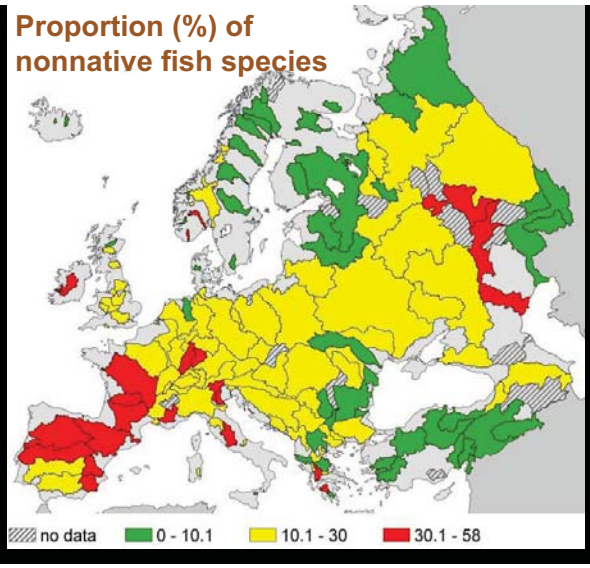
Water Stress (1995)

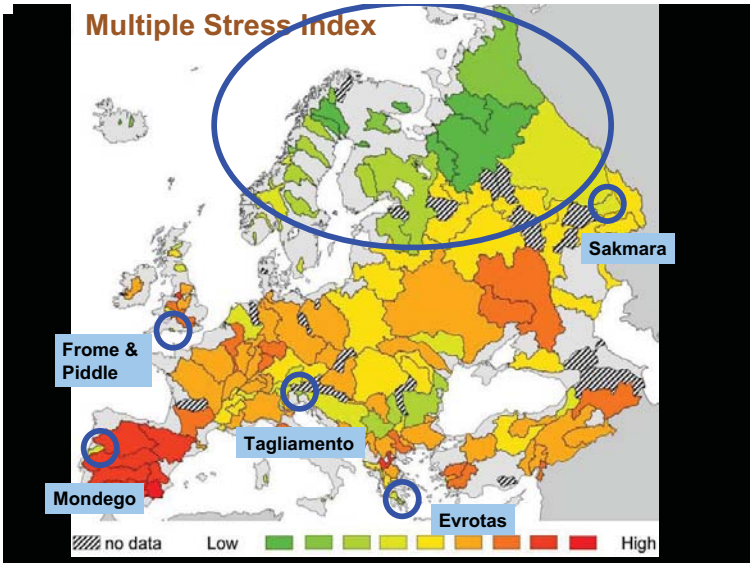


Water Stress (2070)



Proportion (%) of nonnative fish species



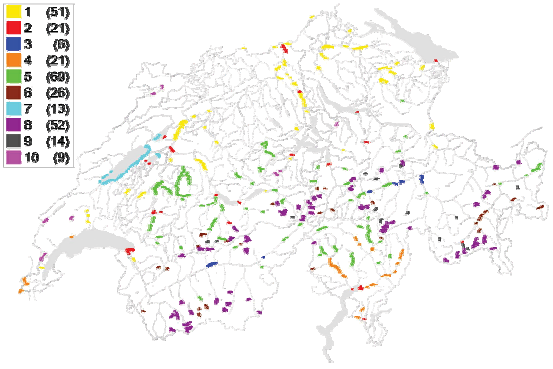


Conclusion

- Catchments of the Iberian Peninsula, the Western Balkans, and Anatolia are the most threatened systems (reactive approach)
- Near-natural catchments in central and eastern Europe require highest conservation priority (proactive approach)
- It would be necessary to establish a European Reference Catchment Network
- Focus on keystone ecosystems and landscape elements
- Integration of new aspects in conservation/ restoration: e.g. Ecosystem Service Concept

Focus: Keystone Ecosystems

Switzerland: Distribution of floodplains of national importance



(Source: Auenberatungsstelle)

Fauna of Switzerland

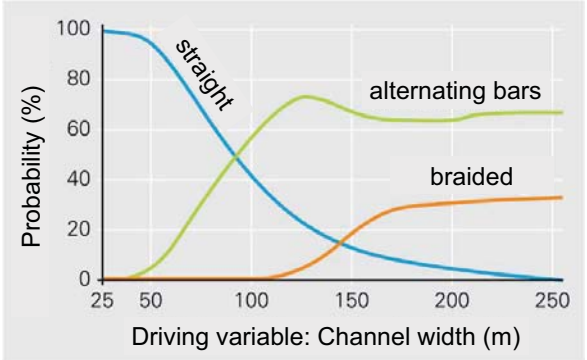
Exclusively in floodplains	10 %
Frequently in floodplains	40 %
Occasionally in floodplains	80 %
Total area of floodplains:	0.53 %

Thur (A = 1600 km²) Tagliamento (A = 2300 km²)

River Thur: A typical Swiss River

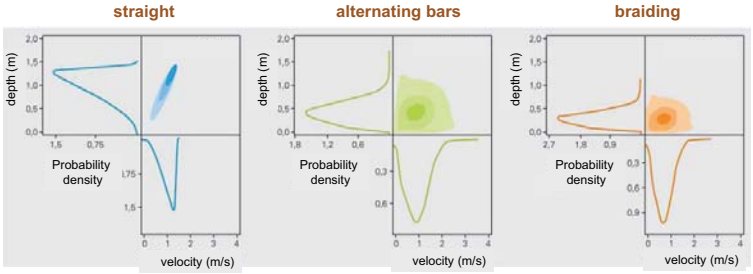
The largest restoration project in Switzerland!!

Morphological response to river widening (River Thur in CH)



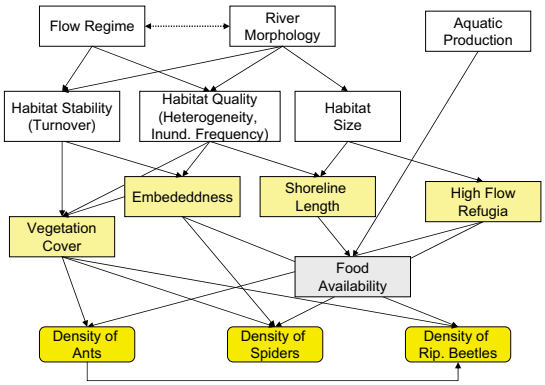
(Reichert *et al.* 2006; Schweitzer *et al.* 2006)

Predicted distribution of depth and velocity (River Thur in CH)

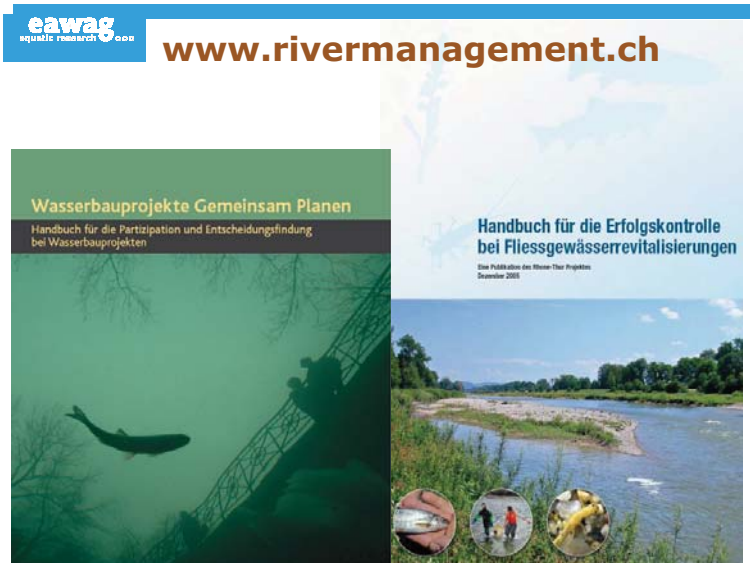


(Reichert *et al*. 2006; Schweitzer *et al*. 2006)

Predictive model for biota (e.g. terrestrial shoreline invertebrates)



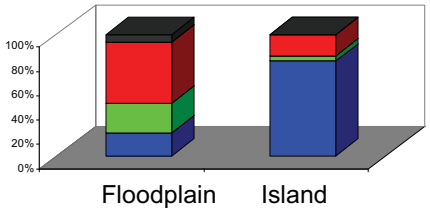
www.rivermanagement.ch



Islands: Key landscape elements along rivers

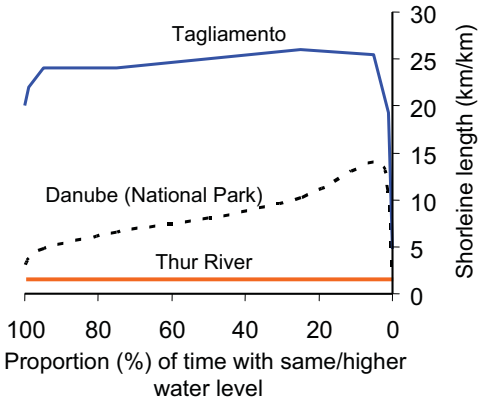
Study area: 12 European rivers (Varzuga to Ebro)
Total: 2771 islands
Islands per 100 km: 8 (Rhine) to 160 (Tagliamento)
Total ecotone length: 7200 km (island area: 1600 km^2)

Environmental condition:

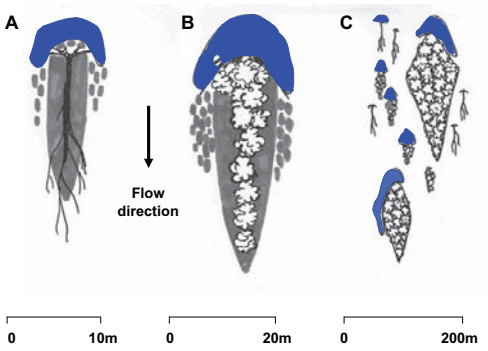


(Data: S. Boesch)

Shoreline length in three differently impacted Alpine rivers



Deposited large wood and islands create biocomplexity



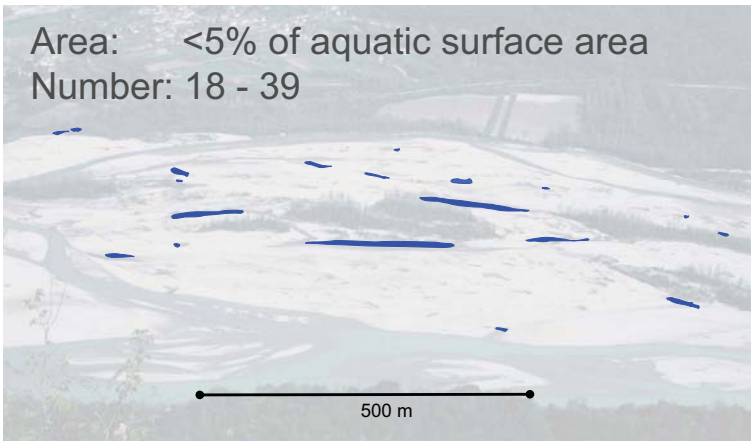
(Gurnell, Tockner, Edwards & Petts. 2005. Front Ecol Environ)

Island benefit along riparian corridors

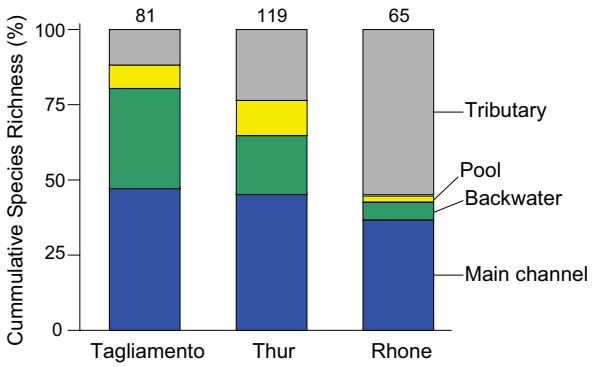
	Bar-braided	Island-braided
Large wood (t ha^{-1})	15-73	102-158
Channels (half-life expectancy; mo)	4.1	7.7
Aquatic habitat diversity (H')	1.6	2.0
Average number of ponds	7	22
Average shoreline length (km km^{-1})	13.7	20.9
Amphibian species richness	5	7
Carabid beetle species richness	34	47
Benthic invertebrates: α-diversity	30	27
Benthic invertebrates: β_2-diversity	10.5	21
Benthic invertebrates: γ-diversity	50	53

Island-braided floodplain

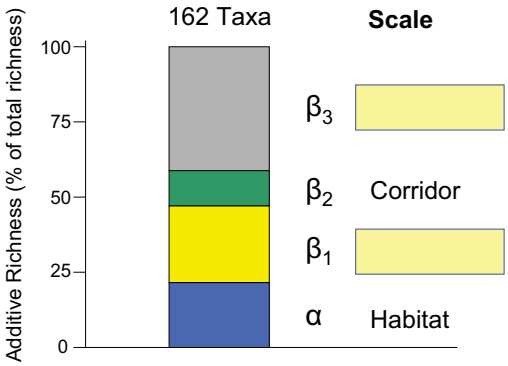
Lateral aquatic habitats



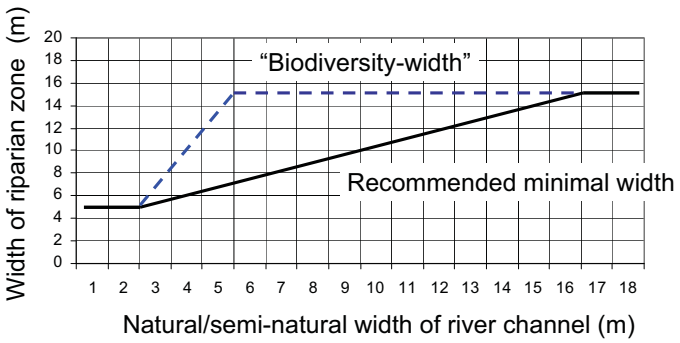
Cummulative species richness (EPT taxa)



Hierarchical partitioning of biodiversity



Riparian width as a function of the natural channel width



Estimation of the minimum required space for rivers and streams in Switzerland

	existing space	required space
Riparian area	1175 km^2	239 km^2
River channel	351 km^2	254 km^2
Total	1526 km^2	493 km^2

(from: Willi 2001)

New Swiss water law: Flood protection linked with river restoration

CH: Minimum additional river space: 500 km^2
Restoration need: ~20'000 km

Minimum width of a corridor to protect 90% of the riparian organisms

(mid-order streams, Spackman & Hughes 1995)

Herbs	8-16 m
Trees and shrub	12-32 m
Birds	119-170 m
N-Retention	5-15 m

Conclusion

- Ponds, backwaters, and tributary confluences contribute disproportionately to aquatic diversity
- Hierarchical partitioning of diversity helps identifing relevant scales
- Ponds and islands are among the first landscape elements that disappear due to human impacts

Challenges:

- Functional linkages among habitat types
- Aquatic-terrestrial interactions

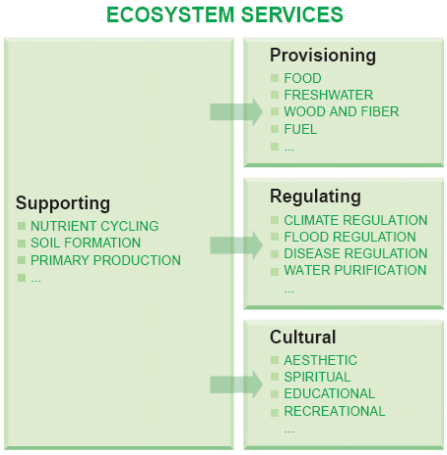
What are ecosystem goods and services?

Are the benefits people obtain either directly or indirectly from ecological systems.

(Millennium Ecosystem Assessment, 2003)

Ecosystem Services

The benefits people obtain from ecosystems



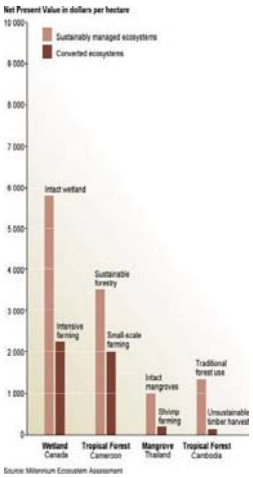
Values provided by flood plains

Function/service	US$ ha yr^{-1}
Recharge of groundwater/drinking water	7,600
Flood protection	7,240
Self purification capacity	1,659
Cultural benefit	1,761
Recreation	491
Habitat/Refugia	439
Climate regulation	265
Total	**19,580**

(Costanza et al. 1997)

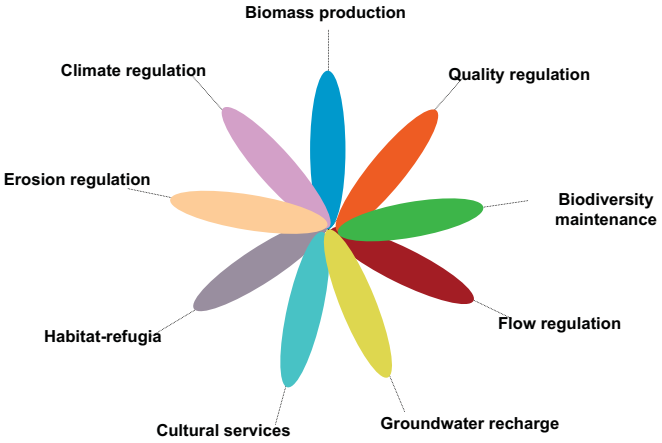
Degradation of ecosystem services often causes significant harm to human well-being

- The total economic value associated with managing ecosystems more sustainably is often higher than the value associated with conversion
- Conversion may still occur because private economic benefits are often greater for the converted system

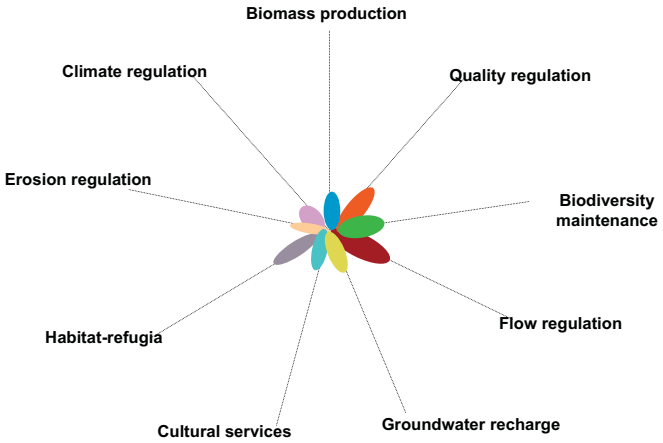


(from MEA 2003)

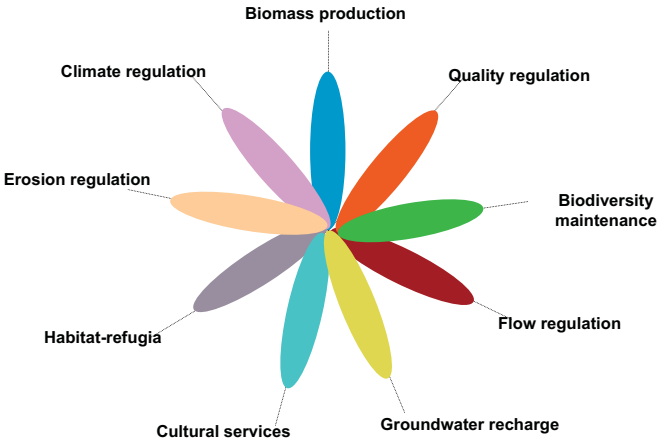
Multifunctional systems



Degraded systems



Multifunctional systems



Skjern River: 1987 – 2002
Denmark

The channelised lower reach of Skjern River.

✓ Re-establish a large coherent nature conservation area with good conditions of life for the fauna and flora connected with wetlands and riparian areas.

✓ The project comprises approximately 2,200 hectares (ha).

Approximate distribution of the different habitat types before and after restoration

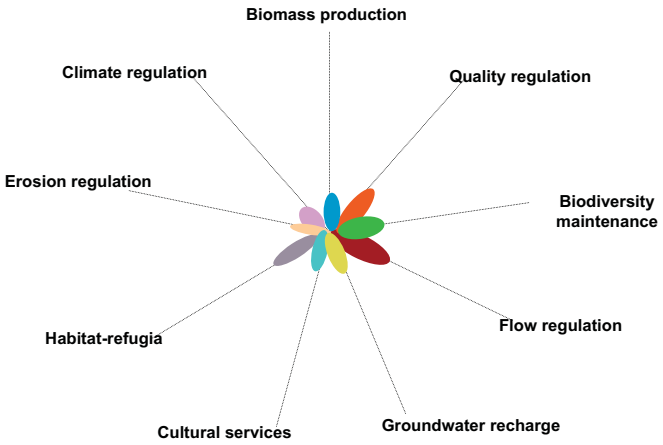
Nature type	Before restoration (%)	After restoration (%)
Cultivated land	77	0
Rivers and canals	7	6
Lakes	0	23
Woodland	3	3
Meadows	5	59
Swamp	7	9

The restored lower part of Skjern River and the estuary Ringkøbing Fjord delta

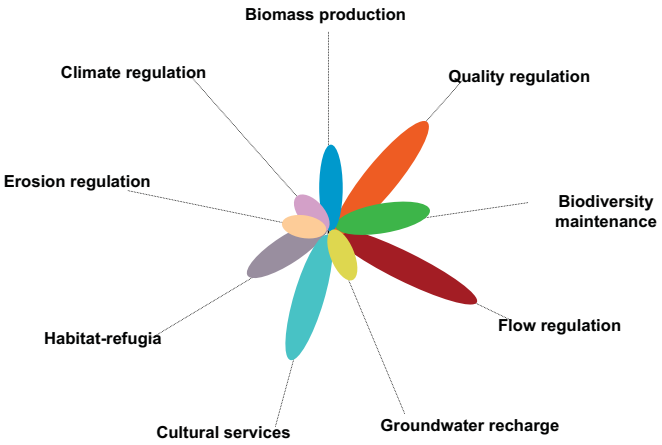
Cost-benefit analysis of the Skjern River

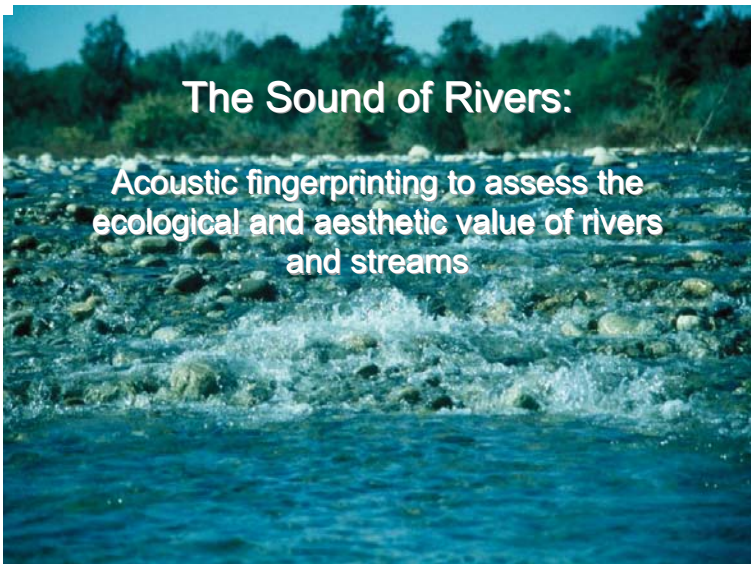
	Present values					
Time horizon	20 years, mio. DKK			Indefinite, mio. DKK		
Discount rate	3%	5%	7%	3%	5%	7%
Project costs	143.7	143.0	142.2	143.7	143.0	142.2
Operation and maintenance	12.9	13.3	14.0	17.0	14.9	14.7
Forgone land rent	44.8	36.4	32.3	101.4	63.0	46.1
Closing of fish farm	2.2	2.2	2.2	2.2	2.2	2.2
Total Costs	**203.6**	**194.9**	**190.7**	**264.3**	**223.1**	**205.2**
Termination of emission from fish farm	2.8	2.5	2.4	6.1	3.9	3.0
Saved pumping costs	6.0	5.1	4.5	12.1	7.4	5.4
Better land allocation	15.9	14.2	13.0	29.7	19.4	15.2
Reed production	4.6	3.6	2.9	10.1	5.0	3.0
Reduced flood risk	0.5	0.4	0.4	1.1	0.7	0.5
Reduction of nitrogen	20.3	17.0	14.5	35.8	23.7	18.5
Reduction of phosphorous	20.2	16.9	14.4	43.9	25.8	18.1
Reduction of ochre	18.6	17.7	16.9	40.5	27.0	21.3
Better hunting opportunities	7.0	5.9	5.0	15.3	9.0	6.3
Better angling opportunities	40.9	34.3	29.1	89.0	52.4	36.7
Outdoor recreation	55.2	46.3	39.3	120.1	70.7	49.6
Biodiversity, existence value	39.5	33.1	28.1	85.9	50.6	35.5
Total benefits	**231.5**	**197.0**	**170.5**	**489.6**	**295.6**	**213.1**
Welfare gain	**28**	**2**	**-20**	**225**	**73**	**8**

Degraded systems



Multifunctional systems - Skjern River



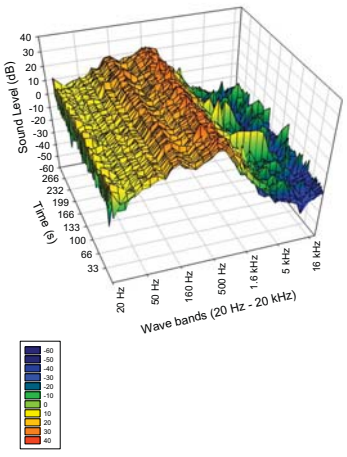


Project Goals

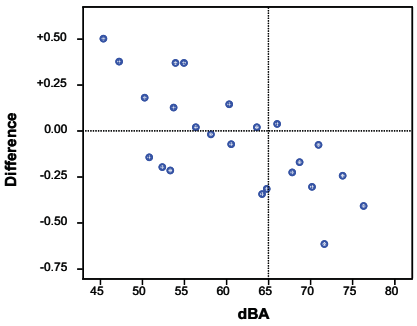
- To develop an acoustic fingerprinting technique for assessing the ecological integrity of rivers and streams
- To establish ‘sound‘ as a key component of public aesthetics (*cf* visual aspects)
- To identify the acoustic components that determine the aesthetic and ecological value of the sound
- **To quantify key ecosystem services provided by intact rivers and streams**

Experiments

Roughness: 1.33



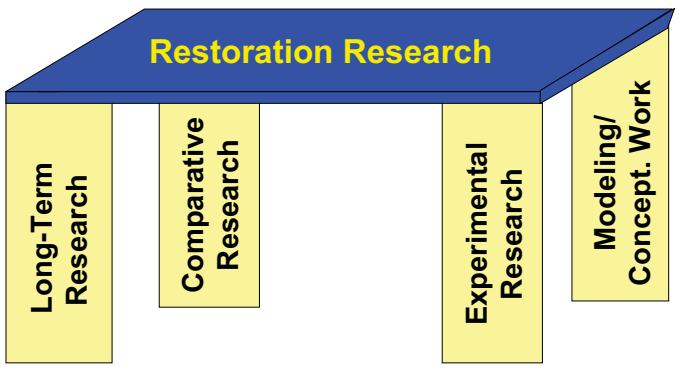
Pre-study: Aesthetic valuation (2006)



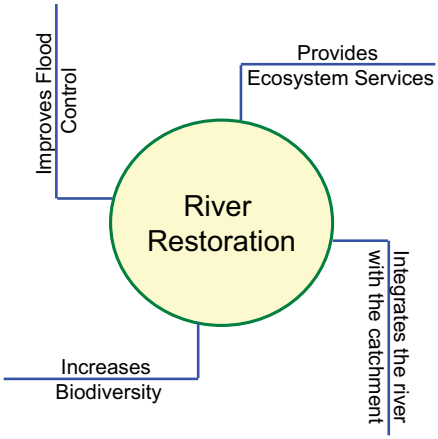
View downstream from Santa Teresa bridge Jan 1996.
(Are we in Denmark?)
Note: symmetrical meander bends, rock weirs and bank protection on outside meander bends

View downstream from Santa Teresa bridge, July 1997 (after washout in Feb 1996)

Need for sound scientific underpinning of restoration projects



Requires cooperation between ecology, engineering, and social sciences




Most important
however, is the
conservation of the
remaining natural
river ecosystems


THANK YOU!