River morphodynamics

Part 3.2: River restoration

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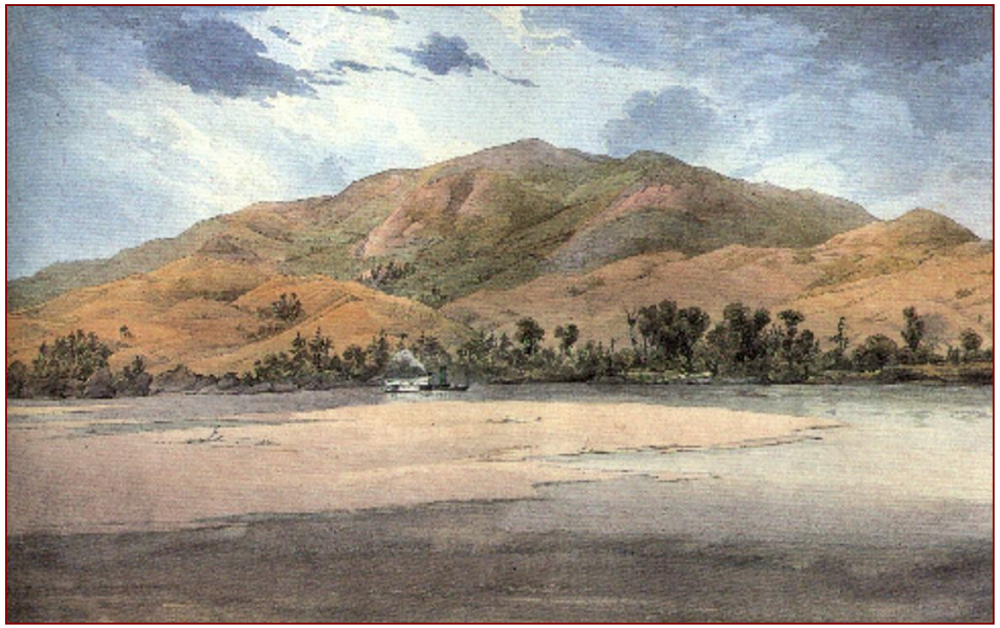
Introduction

River engineering is, in this case, the design of structures which restore a close-to-natural river landscape, recreating an environment able to support its ecosystem.

Structures are intended to reproduce a “pristine river”, thus a the wide use of natural materials such as wood and boulders is preferred.



Karl Bodmer’s America, 1832-1834 (Missouri River)

Karl Bodmer’s America, 1832-1834

Introduction

Actual rivers are like artificial (anthropized) environments modified with structures for:

- defence against flood → levees, straightening of the channel
- navigation (trade) → dredging to create/enlarge the navigation waterway
- water uses → different exploitation methods depending on the use (dams, diversions, etc.)
- land reclamation → the area close to rivers is very important (narrowing of the channel, levees, etc.)
- river regulation, river training → reshaping of the cross section

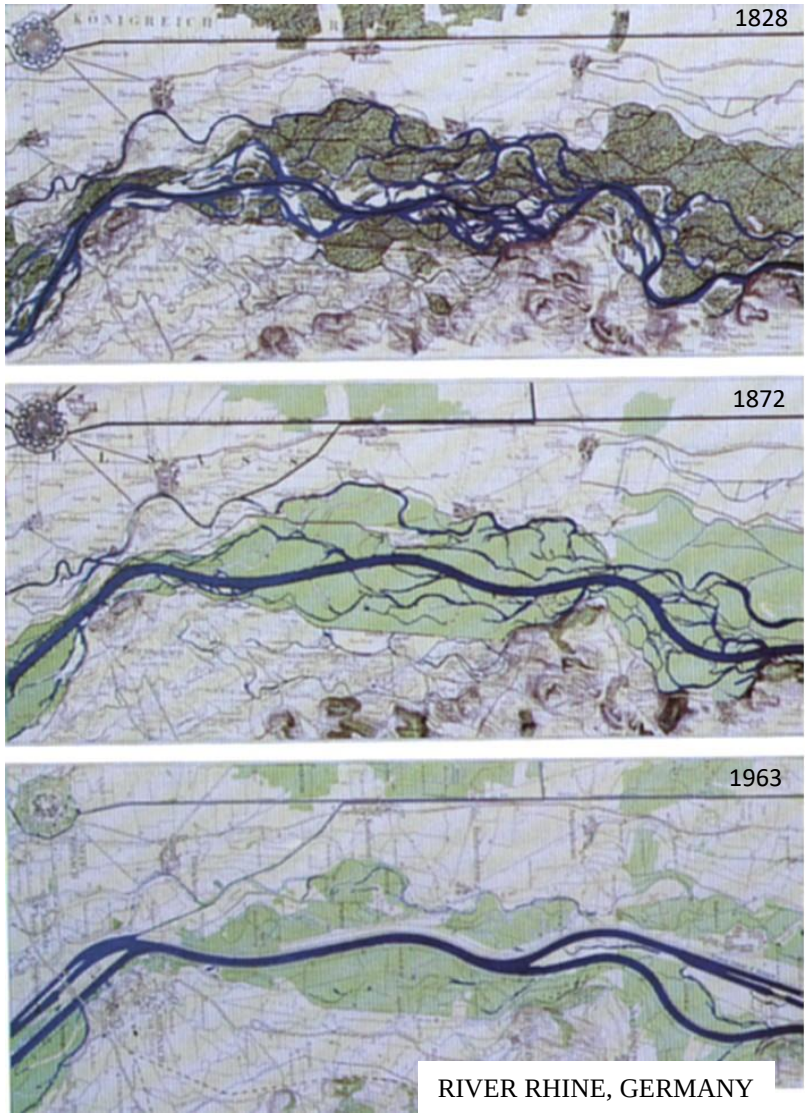
Danube river, lowland reach (source: https://www.latimes.com/travel/la-tr-cruise-news-20180924-story.html)

WFD and regulations

Most European rivers are anthropized environments

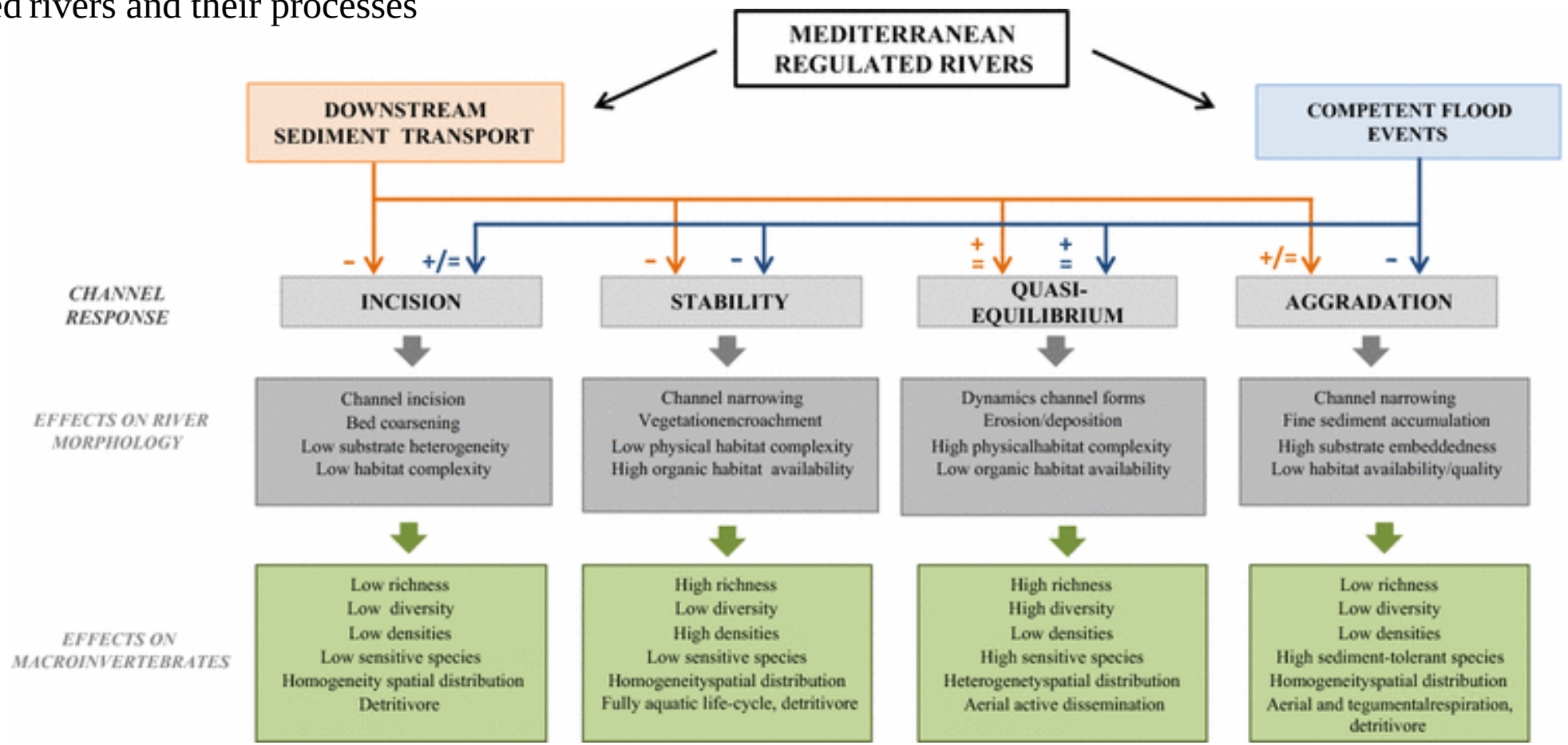
- deepening of the main channel
- obliteration of secondary channels
- decrease of the overall ecological status
- creation of new navigation channels
- decrease of the number of active channels

Rhine River straightened reach. http://bityl.pl/k3vGv



Regulated rivers

Regulated rivers and their processes

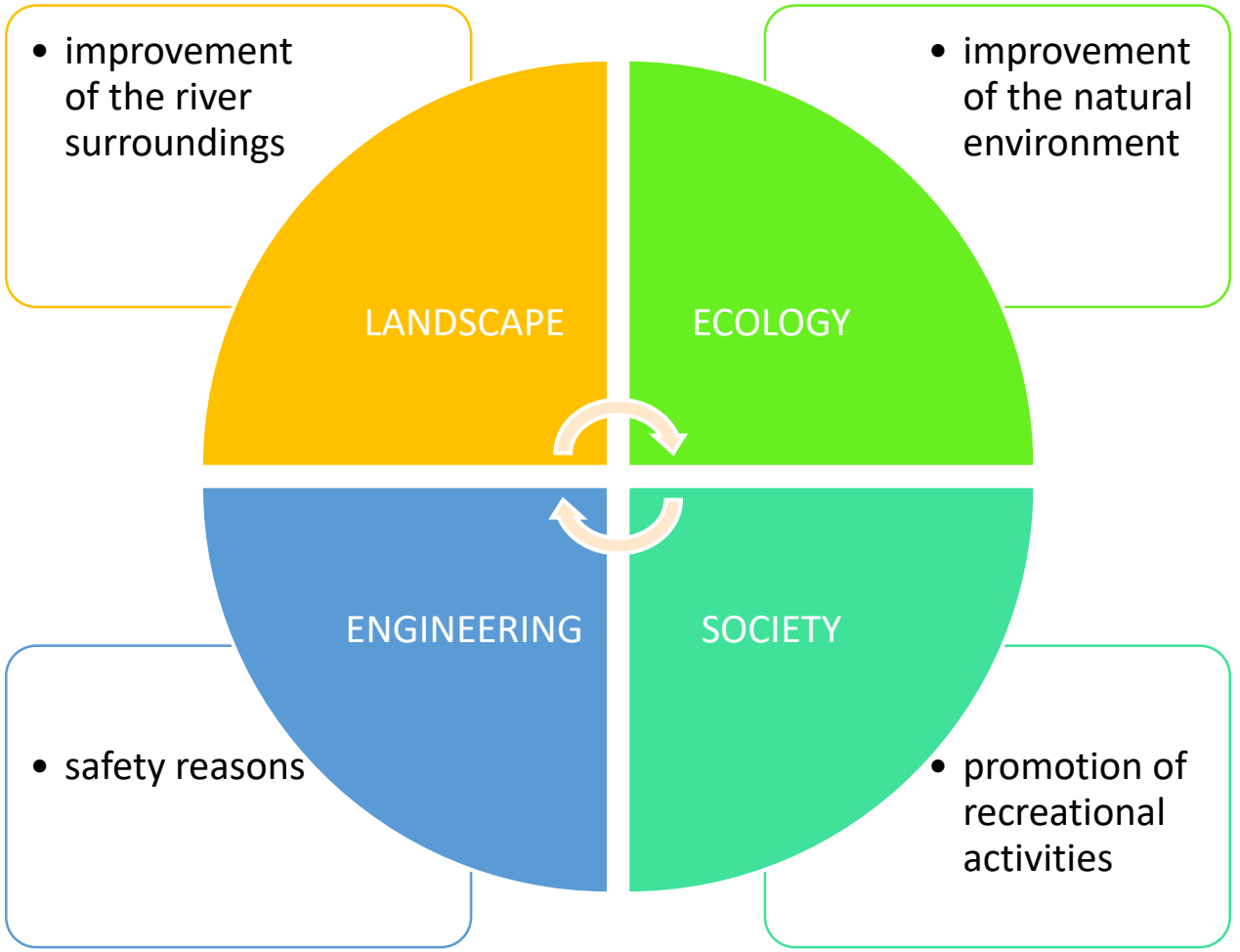


Lobera et al., Hydrobiologia 2017

Motivation for river restoration

River as complex system

Adapted from River restoration notes (Nones, 2018)



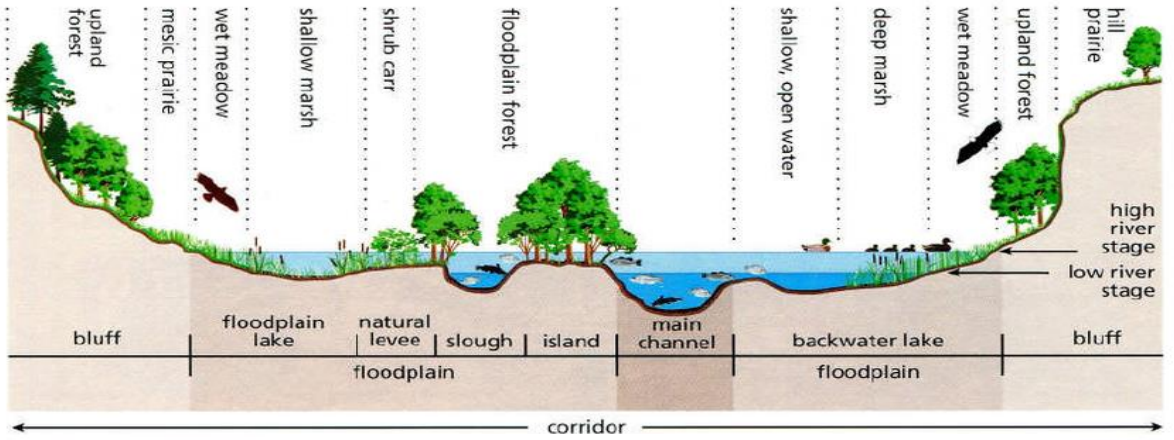
Landscape

- improvement of the landscape
- frequently aesthetic and ecological reasons are confused and even combined
- changing the landscape cannot be directly correlated to an improvement of the ecological status

Left: Enns short restored section. Right: Ruhr long restored section. Photo credit: Daniel Hering.

Ecology

- improvement of the overall ecological status of the river
- ecological corridor → connected system characterized by high ecological gradients (high biodiversity)
- biodiversity correlated to the hydrological variability and to the morphological structure, in all the directions
- free exchange of fluxes between stream, substrate and floodplains
- nature based solutions → more effective if applied to small-scale projects



Cross-section of a river corridor, from Milhous et al. (2012)

Society

- promotion of recreational activities and tourism
- many activities in competition, depending on the flow conditions (still or flowing water) and the period

→ dry: trekking, cycling, horse-riding, etc.

→ wet: bird watching, canoeing, aquatic activities, etc.

source: www.curbed.com/2017/8/3/16089352/city-rivers-swimming-safe

Engineering

- natural conditions are more stable than the anthropized ones (is it correct?)

  → vegetation should grow freely, as it protects the banks from the erosion

  → floodplains should be unobstructed to reduce flood waves (flow peak and lag)

Waal river (The Netherlands) plan for renaturation of a urban reach

source: www.slideshare.net/DutchEmbassyDC/room-for-the-river-presentation-2011

Actual vs natural conditions

Adapted from River restoration notes (Nones, 2018)

Scaricatore channel near Padova, Italy

ACTUAL SITUATION

- main channel fixed by means of longitudinal/transversal groynes
- few secondary channels
- floodplains and island covered by unique vegetation
- man-made structures along the floodplains

NATURAL CONDITIONS

- wandering main channel
- several and active secondary channels, well-connected with the main stream
- floodplains and islands frequently inundated
- well-distributed vegetation→high biodiversity

Kolyma river, Syberia

Natural conditions

- reduced discontinuities between the fluvial environment (low flow conditions) and the terrestrial area (floodplains)
- high ecological status → fulfillment of the Water Framework Directive
- reduced activities along the floodplains
- in-channel navigation possible only in the main channel

  → reduction of the associated benefits
- reduced hydraulic safety to flood

  → no control on vegetation growth fosters the production of floating debris

  → reduced efficiency of the floodplains in reducing the flood wave peaks

The Vistula river in Poland is among Europe's large rivers, and, though its core position, it has not been much affected by anthropic interventioins along its course

Nature-based structures

- secondary levees
- floodplains connected with the main channel through weirs to assure the continuity also during low flow conditions
- floodplains subdivided depending on the use:

  → dry (forest) and humid (ponds, secondary channels) areas

  → recreational (fishing, bird-watching) and sporting (cycling, horse-riding) activities
- re-opening of secondary channels and changing of the grainsize composition of the bed
- small localized works to maintain the main channel (navigation purposes)

Spree river, Cottbus (DE)

Working with nature

Example: restored reach of the Spree river:

→ re-opening of secondary channels

→ changing of the grainsize composition of the bed

→ small localized works to maintain the main channel

→ reactivation of humid areas for fishing

Secondary channels

Re-opening of secondary channels and oxbow lakes

- reshaping of the main channel
- weirs and new levees → problems related to sediment transport
- necessary to evaluate long-term effects driven by transient hydrology → flooding events

Restored reach of the Spree river near Cottbus (on the left before works in 2005 and on the right after restoration in 2015)

Large- versus small-scale

Adapted from River restoration notes (Nones, 2018)

SMALL-SCALE

- local effects
- low-cost
- easy to implement
- widely applied since years → “well”-studied

LARGE-SCALE

- effects at the reach-scale
- expensive
- very rare because of different authorities/parties involved