Riparian Restoration

INTERVENTION CATEGORY: RESTORATION

DESCRIPTION

Riparian restoration is defined as the restoration of natural habitat that acts as an interface between land and water along the banks of a river, stream, or lake. It is also referred to as *riparian buffers*. Riparian restoration seeks to re-establish riparian functions and related physical, chemical and biological linkages between terrestrial and aquatic *ecosystems*. It comprises revegetation of riparian zones, which can be achieved through both an *active* and a *passive* approach. In the first case, vegetation is actively planted to achieve successful establishment of native riparian species, and any invasive species considered harmful are removed. In the second case, human-induced disturbances are reduced or hydrologic processes are restored to create the boundary conditions required for riparian vegetation, e.g., by reducing grazing pressure or restoring natural flood dynamics. Often, active and passive approaches are combined.[1]

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WATER SECURITY CHALLENGES (WSCs) ADDRESSED

TYPE		IMPACT	MAGNITUTE	DEPTH OF EVIDENCE BASE
Water availability	Groundwater recharge	Increased mean annual groundwater recharge	★☆☆	★★☆
	Dry season flows	Maintained dry season flows	★☆☆	★★☆
Disaster risk	Flood risk	Reduced peak discharge	★★☆	★★☆
Water quality	Erosion and sedimentation	Reduced on-site erosion and sediment yields	★★★	★★★
	Nutrients and pollutants	Reduced in-stream nutrient and pollutant concentrations	★★★	★★★

Restoring hydrological processes is a primary objective of riparian restoration measures. More specifically, moderation of extreme events and water purification are typical aims.[2] Reported impacts on WSCs include increased infiltration, groundwater recharge[3] and water storage, though the impact on catchment scale is relatively small due to the limited surface area of the buffer strips[4]. Mitigation of peak flows leads to reduced risks of flooding of downstream areas. The potential for riparian restoration to reduce riverbank erosion is particularly high, as steeply sloped areas with sparse vegetation regain stability through the introduction of riparian grass and tree buffer strips with well-developed root systems. These root systems, as well as organic surface layers and understory vegetation, also act as physical and biological filters for runoff water and sediment that often contain nutrients and other agrochemicals.[2, 5] Vegetated buffer strips retain much of the sediment eroded elsewhere in the catchment, preventing it from reaching streams.[4]

OTHER BENEFITS

WHAT?	HOW?
Water temperature control	Provision of shade which reduces thermal pollution.[6]
Provisional ecosystem services	Provision of food, fiber, timber, medicinal resources, etc.[7]
Carbon sequestration	Rapid accumulation of carbon in riparian biomass.[8]
Habitats/ biodiversity	Increased habitat (connectivity) and enhancement of both terrestrial and aquatic biodiversity.[9] Riparian areas are often particularly important corridors for terrestrial biodiversity.
Recreation and tourism	Increased aesthetic value and more pleasant environment (e.g., by providing shade).[7]
Spiritual value	Restoration of the natural situation that is often socially or culturally embedded in local communities.[7]

LINKAGES TO CLIMATE CHANGE

Mitigation: Though spatial extents are typically small, carbon sequestration is an important co-benefit of riparian restoration.

Adaptation: Intensification of hydrological extremes is projected in many areas worldwide as a consequence of climate change. Riparian restoration projects contribute to mitigation of these extremes by reducing peak discharges and enhancing groundwater recharge and baseflow.

DESIGN-ENABLING CONDITIONS AND TYPICAL CONSTRAINTS

- Buffer effectiveness is approximately proportional to width.[4]
- There is no clear upper limit for slope of riparian lands suitable for forest buffers, but steeper slopes might require wider buffers to be effective.[4]
- Plant species and stock types selected for restoration efforts must be appropriate for the site characteristics and its hydrological dynamics.[9]
- If applicable, landowners need to be engaged early in the process and willing to collaborate[10]. The typical shape of a riparian buffer area (long and narrow) means that potentially many stakeholders need to be on board.
- Designing riparian restoration requires a certain understanding of future hydrological conditions, which are often highly uncertain.[11]
- Maintenance needs, depending on context[12]:
  - Management of weeds and removal of invasive species
  - Inspection after major storm events
  - Replant/reseed any areas where plants have died or been washed away by flood waters

RELATION TO GREY INFRASTRUCTURE

INFRASTRUCTURE?	SERVICE PROVIDED BY GREY SOLUTIONS	TYPE OF RELATION
Water treatment infrastructure (chlorination, coagulation, flocculation, sedimentation, filtration) [21, 22]	Water supply	Complementary
Alluvial dykes and dams[23]	River flood management	Alternative
Improved drainage systems, engineered flood protection[21]	Stormwater management	Complementary, Alternative
Retaining walls, terraces[23]	Preventing erosion and sedimentation/siltation of e.g., (hydropower) reservoirs	Complementary, Alternative

COMMON RISKS AND TRADE-OFFS

Practical cases report a (partial) failure of riparian restoration projects due to:

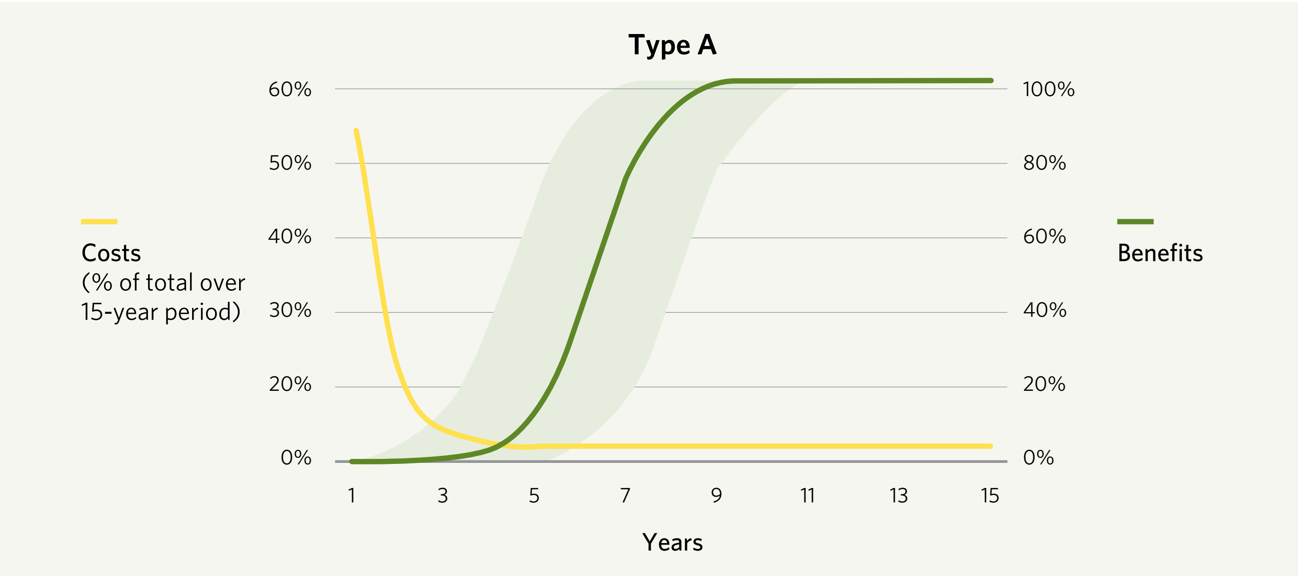
- Occurrence of weeds[13]
- Generation of woody debris, damaging vulnerable downstream infrastructure such as bridges[14]. Potentially this debris also interferes with navigation.

MONITORING OPPORTUNITIES

- Status of the riparian vegetation can be monitored with satellite imagery, aerial photos and ground-truthing by field surveys[14, 15]. Given the typically narrow spatial extents, high resolution imagery (<30m pixel size) is required.
- Impacts on water quantity (dry season) can be monitored by measuring streamflow at downstream sites.
- Impacts on water quality can be monitored locally by measuring concentrations of relevant parameters (e.g., nutrients or sediments)

IMPLEMENTATION COSTS AND TIMING OF BENEFITS

Riparian restoration projects typically come with relatively high **capital costs**, related to land acquisition, preparation (e.g,. slope stabilization), and planting of vegetation. **Recurring costs** comprise maintenance, monitoring of effectiveness, and land rent (if applicable). Additional costs that can be relevant are foregone income associated with land that cannot be harvested for forestry or agricultural purposes. For Oregon, USA, a synthesis compiled in 2010[16] reports total costs of $10,000–$15,000/acre for riparian restoration projects in urban areas, and around $ 5,000/acre in rural environments, over a 15-year period. On average, installation costs were estimated to be twice as high as total recurring costs during this period, which is a typical investment horizon considered in NbS projects[17]. **Benefits** of riparian restoration will accrue relatively soon after implementation, and will quickly increase while native vegetation is restored.



Riparian restoration in Pennsylvania—before and after (source: EPA)

EXAMPLES

Riparian restoration projects are relatively widespread and can be effectively implemented in many regions around the world. Some examples:

Thur and Töss Rivers, Switzerland[18]

Brief description: Sections of the rivers Thur and Töss in Switzerland were restored between 2000 and 2003. Restoration measures undertaken in the river Thur are mainly passive. In the river Töss, a combination of passive and active measures was used. Costs of restoration were estimated at around 3 to 4 million CHF per km of river.

Lessons learnt:

- No previous study found such a strong improvement in social welfare and as high B/C ratios. Possible explanations are the high purchasing power in Switzerland and the strong environmental consciousness of the population
- An increase in ecological benefits can lead to reduced recreational benefits and vice versa, thus it can be difficult to optimize benefits in both categories simultaneously. It can be necessary to set priorities involving trade-offs

Alderson Creek, Canada[19]

Brief description: Alderson Creek is a small stream located in British Columbia, Canada. The creek and riparian corridor are substantially degraded, with sinking stream banks, siltation of the watercourse, loss of native riparian vegetation, and loss of fish habitat. A project (total costs: USD 163,000) is being implemented that primarily involves installing land drainage and protecting and enhancing the riparian buffer area along the creek.

Lessons learnt:

- Largest benefits result from improvement of cropland productivity, improved water supply & regulation (flood mitigation, carbon storage) and outdoor recreation
- Net benefit increases with buffer width, up to a certain maximum

Sarapuí River, Brazil[20]

Brief description: Sarapuí River watershed is a particular case of an agricultural watershed close to very high-density urban areas like Sorocaba and Sao Paulo. The study uses simulation modeling to evaluate the role of riparian forest restoration on water quality in tropical agricultural watersheds.

Lessons learnt:

- Riparian restoration can decrease sediment, nitrogen and phosphorus loads to local streams. Riparian restoration is therefore important to improve water quality in agricultural watersheds.
- Management practices in specific sites need to be evaluated as a part of a watershed system perspective.

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