European Commission

NWRM

Natural Water Retention Measures

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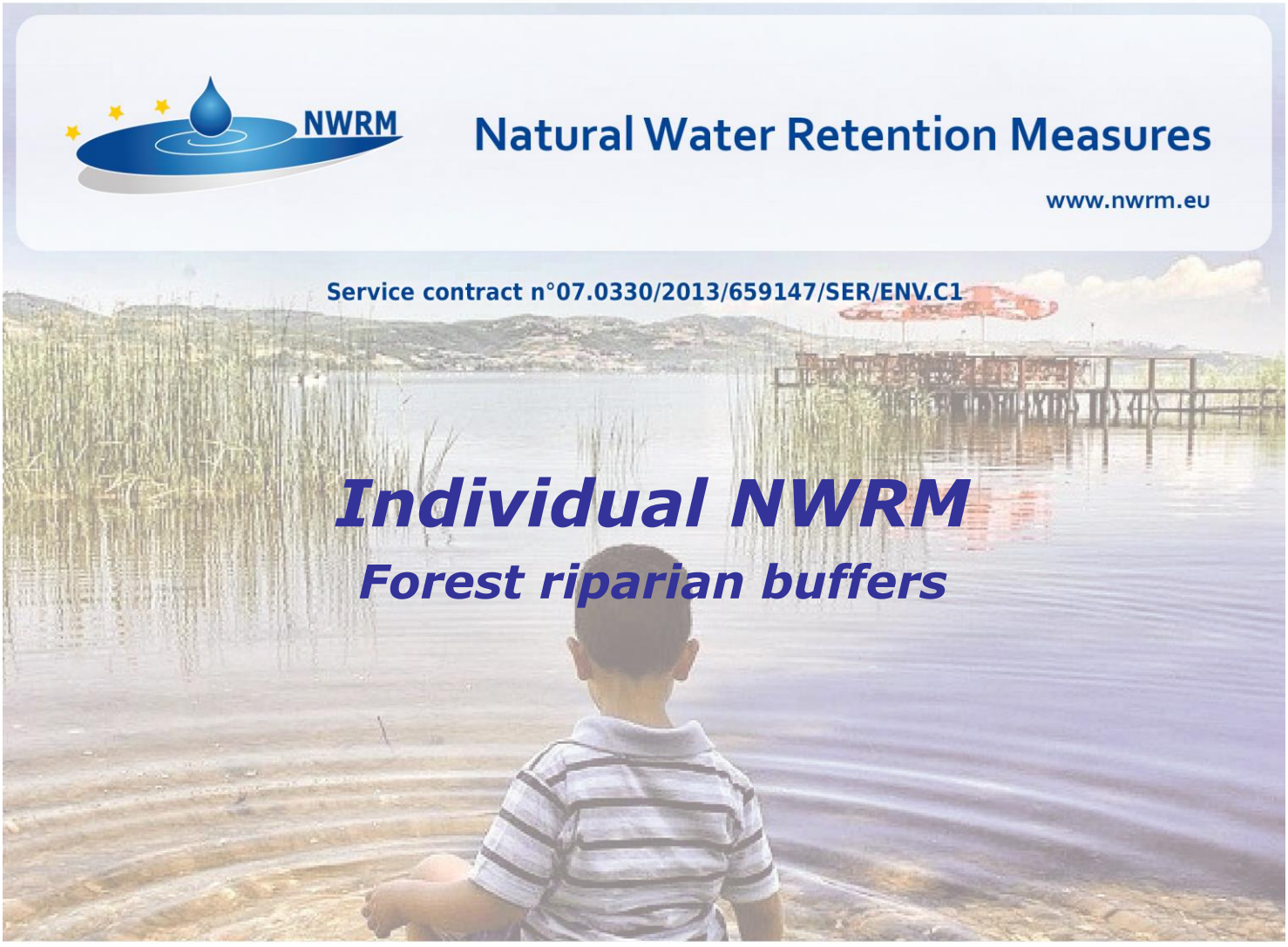

Individual NWRM

Forest riparian buffers

Environment

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I. NWRM Description

Riparian buffers are treed areas alongside streams and other water bodies. While most commonly associated with set asides following forest harvest, riparian buffers can also be found in urban, agricultural and wetland areas. By preserving a relatively undisturbed area adjacent to open water, riparian buffers can serve a number of functions related to water quality and flow moderation. The trees in riparian areas can efficiently take up excess nutrients and may also serve to increase infiltration. Riparian buffers serve to slow water as it moves off the land. This can decrease sediment inputs to surface waters.

II. Illustration

Example of riparian buffer

Source: http://en.wikipedia.org/wiki/Riparian_buffer

III. Geographic Applicability

Land Use	Applicability	Evidence
Artificial Surfaces	Possible	Treed riparian buffers can be created or conserved in areas with artificial surfaces. These areas are further described in measures "F05 Land Use Conversion" and "F11 Urban Forest Parks". Riparian buffers with planted trees may be classified as "Artificial non-agricultural vegetated areas".

Agricultural Areas	Possible	Treed riparian buffers can be created in agricultural areas and are a subset of measure "A2 Buffer Strips and Shelter Belts"
Forests and Semi-Natural Areas	Yes	In a forestry context, riparian buffers are areas of land adjacent to streams, rivers or lakes which are not disturbed during forest harvesting. The width of the buffer may vary between very narrow (2m) to 50m+ although a 10 m buffer is mandated in many jurisdictions. The width of the buffer may also be determined according to length or size of watercourse or waterbody Typically the width varies between 10 and 50m, based on national guidelines and regulations.
Wetlands	Yes	In a forestry context, riparian buffers can be placed around inland wetlands located in forests or other semi-natural areas

Region	**Applicability**	**Evidence**
Western Europe	Yes	Riparian buffers can be used to protect watercourses anywhere in Europe where forest harvesting is conducted.
Mediterranean	Yes	Riparian buffers can be used to protect watercourses anywhere in Europe where forest harvesting is conducted.
Baltic Sea	Yes	Riparian buffers can be used to protect watercourses anywhere in Europe where forest harvesting is conducted.
Eastern Europe and Danube	Yes	Riparian buffers can be used to protect watercourses anywhere in Europe where forest harvesting is conducted.

IV. Scale

	0-0.1km^2	**0.1-1.0km^2**	**1-10km^2**	**10-100km^2**	**100-1000km^2**	**>1000km^2**
Upstream Drainage Area/Catchment Area	Yes	Yes	Yes	Possible	Possible	Possible
Evidence	Riparian buffers are most effective at a small spatial scale and are typically seen in headwater areas (F02) where the local effects of sediment and nutrient retention are most pronounced. The impact of riparian buffers on surface water quality declines with increasing upstream area but there are not likely to be any circumstances under which riparian forest buffers are an ecosystem disservice. Riparian forest buffers slow the velocity of overland flow. This contributes to sediment and nutrient retention and will potentially moderate the size of flood peaks. There is some evidence that riparian buffers can also increase rates of infiltration. Riparian buffers also protect stream habitats and increase recreational value of the area.					

V. Biophysical Impacts

Biophysical Impacts		Rating	Evidence
Slowing & Storing Runoff	Store Runoff	Medium	Because of their relatively small coverage of the total landscape, riparian forest buffers have a limited ability to store terrestrial runoff. However, intact forests can have greater water holding capacity than clearcut or unforested areas.
	Slow Runoff	Medium	Forest riparian buffers have limited ability to slow runoff, primarily due to their relatively small breadth. Because of their rougher ground surface, forest cover can slow runoff more effectively than bare ground.
	Store River Water	None	
	Slow River Water	Low	Deadwood from forested banks may decrease stream velocity. During overbank flooding also riparian vegetation may potentially slow the flows.
Reducing Runoff	Increase Evapotranspiration	Low	Forest riparian buffers can cause a slight increase in evapotranspiration (ET) if the trees in the buffer have greater rates of ET than the surrounding area. This is most likely to be the case when the forest riparian buffer adjoins a clearcut or bare ground. Forests may also have higher ET rates than some agricultural cover crops.
	Increase Infiltration and/or groundwater recharge	Low	Forests are well known for their ability to increase infiltration and/or groundwater recharge. Forest riparian buffers have only a low effect on infiltration, groundwater recharge and soil water retention. This low effect is primarily due to their relatively small coverage of a whole catchment.
	Increase soil water retention	Low	
Reducing Pollution	Reduce pollutant sources	Medium	When operating properly, forest riparian buffers can significantly reduce nitrogen (N) leaching following forest clearcut and have the potential to contribute to denitrification of runoff from adjacent agricultural areas. Well-functioning forest riparian buffers can also intercept pollutant runoff including sediments, particulate matter and phosphorus associated with overland flow events in agricultural or clearcut areas. Forest riparian zones may also help to decrease sediment runoff after forest ditching and ditch network maintenance works.
	Intercept pollution pathways	Medium	
Soil Conservation	Reduce erosion and/or sediment delivery	High	One of the primary design purposes of riparian forest buffers is to reduce sediment delivery to streams following clearcut. Riparian buffers have little or no effect on erosion within the catchment but can retain much of the eroded sediment, preventing it from reaching streams. Riparian vegetation contributes to bank stability binding roots to mineral substrate and also trapping wood that is transported during floods.
	Improve soils	Low	Under some circumstances, forest riparian buffers can have a beneficial effect on riparian soils by promoting greater infiltration, soil porosity and organic carbon accumulation.

			However, these improvements will be limited to the buffer zone area.
Creating Habitat	Create aquatic habitat	Medium	Forest riparian buffers can contribute to the creation of aquatic habitat, both by moderating the stream temperature regime and by acting as a source of coarse woody debris which can provide additional structure to aquatic habitats. Wood is important for diversification of habitats, providing shelter from predators and stream current and storage of fine sediment that may provide important spawning substrate to some species. Wood may also serve as food source.
	Create riparian habitat	High	By their very nature, forest riparian buffers create and improve riparian habitat. The benefits of riparian zone habitats in the Nordic countries are summarized by Gundersen et al. (2010).
	Create terrestrial habitat	Low	Forest riparian zone buffers do, strictly speaking, create terrestrial habitat but the location of habitat improvement might be more appropriately classified as riparian areas. However, in cases of wider forest buffer zones this point is relevant.
Climate Alteration	Enhance precipitation	None	
	Reduce peak temperature	Medium	Relative to an open site, forest buffer tends to decrease solar radiation and wind speed and moderate diurnal air temperature variations. When the vegetation cover provided by forest riparian buffers shades most or all of a stream channel, it is possible that the buffers will contribute to reducing peak temperatures in the stream and providing a more attractive habitat for aquatic biota. It should be noted that while a closed tree canopy generally shades the stream more effectively, small streams can be shaded effectively also by understorey vegetation
	Absorb and/or retain CO_2	Low	When forest biomass in the riparian zone exceeds the biomass that had been present earlier, forest riparian buffers can play a limited role in retaining CO_2

VI. Ecosystem Services Benefits

Ecosystem Services		Rating	Evidence
Provisioning	Water Storage	Low	Because of their small area within a catchment, riparian forest buffers have only limited water storage capacity when compared to other measures such as ponds, etc.
	Fish stocks and recruiting	Medium	Riparian forest buffers provide organic food to aquatic fauna and are important energy source for aquatic food chain. Riparian forest buffers directly influence most important factors for the survival of salmonid species: lower water temperature, create habitat structure, provide food and control sediment flux.

	Natural biomass production	Low	When the trees in forest riparian buffers are comprised of natural or indigenous species, they will contribute to natural biomass production within an area. However, their overall contribution to natural biomass production is low because of their limited spatial extent.
Regulatory and Maintenance	Biodiversity preservation	High	Forest riparian buffers can play an important role in biodiversity preservation, both by direct provision of habitat and by providing habitat "corridors". The benefits of forest riparian buffers for biodiversity preservation are summarized in Gundersen et al. (2010).
	Climate change adaptation and mitigation	None	
	Groundwater / aquifer recharge	Low	Forest riparian buffers may have a positive influence on aquifer recharge through enhanced infiltration.
	Flood risk reduction	Low	Because of their relatively small areal coverage in a catchment, riparian forest buffers have limited scope for flood risk reduction.
	Erosion / sediment control	High	One of the primary design purposes of riparian forest buffers is to reduce sediment delivery to streams following clearcut and other forest management activities. Riparian buffers have little or no effect on erosion within the catchment but can retain much of the eroded sediment, preventing it from reaching streams.
	Filtration of pollutants	Medium	Properly functioning forest riparian buffers can have a significant filtering effect, especially with respect to groundwater nitrogen. Under some circumstances, forest riparian buffers can denitrify much of the nitrate in groundwater, returning it to the atmosphere as nitrogen gas. However, incomplete denitrification can lead to production of N_2O, a potent greenhouse gas.
Cultural	Recreational opportunities	Low	It is possible that wooded riparian buffers will interfere with angling opportunities in some rivers. On the other hand they may serve as suitable destination for other recreational activities, e.g., bird watching.
	Aesthetic / cultural value	Low	Forest riparian buffers may have aesthetic or cultural value. Well planned forest riparian buffers can mask the effect of forestry operations, giving an illusion of wilderness to the landscape when it is viewed from the water.
Abiotic	Navigation	Low	Large woody debris may block the watercourses and interfere with navigation.
	Geological resources	None	
	Energy production	None	

VII. Policy Objectives

Policy Objective		Rating	Evidence
Water Framework Directive			
Achieve Good Surface Water Status	Improving status of biology quality elements	Medium	Forest riparian buffers can potentially contribute to habitat used by the organisms enumerated to identify biological quality and to improving the water quality of streams feeding WFD water bodies and also to some extent of WFD water bodies themselves, if applied.
	Improving status of physico-chemical quality elements	Medium	Forest riparian buffers can directly contribute to improving several physico-chemical quality elements, such as water temperature, oxygenating conditions and nutrient conditions in streams feeding WFD water bodies and also to some extent of WFD water bodies themselves, if applied.
	Improving status of hydromorphological quality elements	Medium	Forest riparian buffers, if applied to WFD water bodies, will have direct impact on the hydromorphological quality elements (WFD Annex 5), as structure of the riparian zone itself is one of those elements and also structure and substrate of the river/lake bed may at least partly be influenced. There may also be some indirect effects of forest riparian buffers applied to feeder streams.
	Improving chemical status and priority substances	Low	Forest riparian buffers may have some role in reducing mercury and methylmercury run-off after forest management operations Note that there is a debate in the scientific community about the effectiveness of riparian buffers for improving water body chemical and priority substance status. However, theoretical considerations suggest that intact riparian buffers will have some role in retaining pollutants before they reach surface waters..
Achieve Good GW Status	Improved quantitative status	None	
	Improved chemical status	Low	If compared to an open site, riparian buffers may have positive impact on GW chemical status due to nutrient uptake in the vegetation.
Prevent Deterioration	Prevent surface water status deterioration	Medium	By reducing sediment loading to feeder streams and also WFD water bodies, if applied, forest riparian buffers can contribute to preventing deterioration of WFD surface water body status.
	Prevent groundwater status deterioration	Low	By the nutrient uptake in the vegetation, forest riparian buffers may have some effect in preventing groundwater status deterioration.
Floods Directive			
Take adequate and co-ordinated measures to reduce flood risks		Low	On their own, forest riparian buffers have at best a limited role in flood risk reduction (primarily due to their limited water holding / water slowing capacity). However, as part of a catchment management program or in combination with other

		measures, they may contribute to reducing flood risks.
Habitats and Birds Directives		
Protection of Important Habitats	Medium	Forest riparian zones can be important habitats for some birds and other species. This topic is reviewed by Gundersen et al. (2010).
2020 Biodiversity Strategy		
Better protection for ecosystems and more use of Green Infrastructure	High	Forest riparian buffers as one of the components of Green Infrastructure can directly contribute to better protection of riparian and aquatic ecosystems.
More sustainable agriculture and forestry	Medium	Forest riparian buffers can contribute to agricultural or forest sustainability by reducing the environmental footprint of food and fibre production on surface water quality.
Better management of fish stocks	Medium	Forest riparian buffers will not contribute directly to better management of fish stocks but can assist in preserving spawning habitat for some salmonid species.
Prevention of biodiversity loss	Medium	Forest riparian buffers can help to preserve riparian and aquatic biodiversity.

VIII. Design Guidance

Design Parameters	Evidence
Dimensions	Forest riparian buffers are linear features adjacent to streams or other watercourses. Typically, the buffers have a fixed width, ranging from 2 – 50+. Buffer effectiveness is approximately proportional to width.
Space required	The space required is proportional to the density of the stream network to be buffered and the width of the forest riparian buffer. For example, in Sweden where there is approximately 1 km of stream channel per km^2 of forest land, a 10m buffer on both sides of the stream network would require 20,000 m^2, or 2% of the total landscape
Location	Buffers are typically located adjacent to both sides of a stream in intact forests, harvested forests or agricultural areas.
Site and slope stability	Forest riparian buffers typically improve slope stability. 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.
Soils and groundwater	Forest riparian buffers prevent erosion, improve soil porosity and contribute to nitrates uptake.
Pre-treatment requirements	N/A

Synergies with Other Measures	Forest riparian buffers can have synergies with in-stream or in-catchment measures as they exist at the interface between terrestrial and aquatic environments.

IX. Cost

Cost Category	Cost Range	Evidence
Land Acquisition		Typically, land is not acquired for forest riparian buffers. The land occupied by the buffer is usually owned by the farmer or forest owner who manages the adjacent lands.
Investigations & Studies		Typically, no studies or investigations are needed before implementation of forest riparian buffers. In many European jurisdictions, forest riparian buffers are mandated by law or policy.
Capital Costs		There are typically no capital costs as no land is already owned.
Maintenance Costs		There are typically no maintenance costs for forest riparian buffers.
Additional Costs		The main cost associated with forest riparian buffers is the foregone income associated with land that cannot be harvested for forestry or agricultural purposes.

X. Governance and Implementation

Requirement	Evidence

XI. Incentives supporting the financing of the NWRM

Type	Evidence

XII. References

Reference	Comments
Neary, Daniel G., George G. Ice, and C. Rhett Jackson. "Linkages between forest soils and water quality and quantity." *Forest Ecology and Management*258.10 (2009): 2269-2281.	Good general reference on forest water issues
Matteo, Michelle, Timothy Randhir, and David Bloniarz. "Watershed-scale impacts of forest buffers on water quality and runoff in urbanizing environment."*Journal of water resources planning and management* 132.3 (2006): 144-152.	Discusses use of riparian forest buffers in urban areas
Gundersen, Per, et al. "Environmental services provided from riparian forests in the Nordic countries." *Ambio* 39.8 (2010): 555-566.	Useful review of other ecosystem services provided by riparian buffers with a focus on the Nordic countries
Welsch, David J. "Riparian Forest Buffers: Function and Design for Protection and Enhancement of Water Resources" (1991) U.S. Department of Agriculture, Forest Service, Northeastern Area, State & Private Forestry, Forest Resources Management, 20 pages	Discusses the importance of riparian forest buffers to water and biodiversity protection
Pike, Robin J., Redding, Todd E., Moore, R.D., Winkler, Rita D., Bladon, Kevin D. (Editors). Compenduim of Forest Hydrology and Geomorphology in British Columbia. Volume 2 (2010) B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C. and FORREX Forum for Research and Extension in Natural Resources, Kamloops, B.C. Land Manag. Handb. 66., 446 pages.	Highlights main functions of riparian forest buffers
Nieminen, M., Ahti, E., Nousiainen, H., Joensuu, S. & Vuollekoski, M. „Capacity of riparian buffer zones to reduce sediment concentrations in discharge from peatlands drained for forestry." Silva Fennica, 2005, 39(3): 331–339	Discusses effectiveness of riparian buffer zones to reduce sediment load from drained forests.
Jacks, G., Norrström, A.C. Hydrochemistry and hydrology of forest riparian wetlands. Forest Ecology and Management, 2004, 196 (2-3): 187-197	Investigates nitrogen retention in the riparian zone after clear-felling
Ahtiainen, M., Huttunen, P. "Long-term effects of forestry managements on water quality and loading in brooks." Boreal Environmental Research, 1999, 4: 101–114	Presents analysis of the impact of forest management operations on water quality, including effect of protective zones.

F1: Forest riparian buffers

Vidon, Philippe, Craig Allan, Douglas Burns, Tim P. Duval, Noel Gurwick, Shreeram Inamdar, Richard Lowrance, Judy Okay, Durelle Scott, and Steve Sebestyen, "Hot Spots and Hot Moments in Riparian Zones: Potential for Improved Water Quality Management." Journal of the American Water Resources Association, 2010, 46(2): 278-298	Summarizes current knowledge related to the occurrence of hot phenomena (spots and moments) for a variety of chemical constituents across the stream, riparian zone, and upland, discusses implications for riparian zone management.
Mayer, P. M., Reynolds, S. K. & Canfield, T. J. Riparian buffer width, vegetative cover, and nitrogen removal effectiveness: A review of current science and regulations. US Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory., 2005, 40 pages	Discusses the impact of riparian buffer width and vegetation cover on the effectiveness of nitrogen removal.