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OSCAR definition of study areas: woody riparian buffers, riparian area, ecosystem services study area

Riparian area

There is no universal definition of "riparian" but an increasing consensus to delineate riparian areas based on the functions they provide, resulting in a variable width, instead of delineating riparian buffers using a fixed width (DeSosa et al. 2018). The functional definition of Ilhardt et al. (2000) adapted by Verry et al. (2004) is increasingly used (e.g. Holmes and Goebel 2011, Abood et al. 2012, DeSosa et al. 2018) and considers the riparian area as an ecotone, i.e. a transitional zone including all ecosystems which significantly influence the exchange of energy and matter between the aquatic and terrestrial ecosystems: *"Riparian ecotones are a three dimensional space of interaction that includes terrestrial and aquatic ecosystems that extend down into the groundwater, up above the canopy, outward across the floodplain, up the near-slopes that drain to the water, laterally into the terrestrial ecosystem, and along the water course at a variable width."* (Verry et al. 2004).

The flux of materials and energy results in the following important functions and related services of the riparian area which will be considered in OSCAR: aquatic habitat provision, terrestrial habitat provision including its function as migration corridors, provision of organic material as food source, shading and regulation of water temperature, fine sediment and nutrient retention, flood retention (Ilhardt et al. 2000 and reviews on riparian buffer effects like Castelle et al. 1994, Broadmeadow and Nisbet 2004, Hickey and Doran 2004, Parkyn 2004, Sweeney and Newbold 2014, Feld et al. 2018).

The different functions operate at different spatial scales. For example, the input of large wood as habitat and food source is restricted to a distance from the river of about the height of the trees while the process of nutrient retention acts at larger spatial scales. Moreover, areas further away usually contribute less to the functions compared to areas near the river channel. Therefore, the number and intensity of functions decreases with distance from the river channel and there is no clear boundary but a decreasing probability of areas further away from the river channel being part of the functional riparian ecotone (Fig. 1).

Since delineating riparian areas based on these functions is rather complex, Ilhardt et al. (2000) suggested to use geomorphological criteria as proxies because the fluvial landforms that result from the interaction between the aquatic and terrestrial environment govern important environmental variables like soil and moisture conditions which in turn affect the riparian ecotone and related ecosystem functions. For alluvial rivers, the riparian area as defined by Ilhardt et al. (2000) and adapted by Verry et al. (2004) consists of the river channel

and bank, the floodplain, the slope of the first terrace adjacent to the floodplain, and one tree length on top of the terrace (Fig. 1). The width of the floodplain to the first terrace slope usually corresponds to the meander belt width and the floodprone area of the 50-years flood (Rosgen 1996 cited in Ilhardt et al. 2000), proxies that have been used in several studies to delineate the riparian area (Abood et al. 2012, DeSosa 2017). In headwater streams with V-shaped valleys without an alluvial floodplain, Ilhardt et al. (2000) proposed to include the stream channel and bank, the slope to its top, and one tree length on top of the slope. In lowland streams missing a distinct terrace slope, 10 times channel width was recommended as a proxy for meander belt width and riparian area based on empirical data of Rosgen (1996), which corresponds to the relationship between river channel and meander belt width reported in other empirical studies (Carlston 1965). In small streams (width <3 m), they proposed to use the stream channel and bank plus one tree length each side as riparian area.

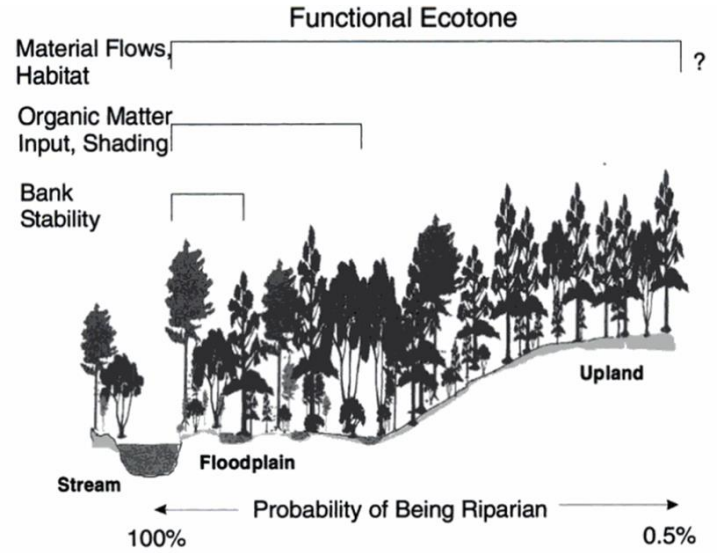

Fig. 1: The probability of areas belonging to the functional riparian ecotone decreasing with distance from the river channel (from Ilhardt et al. 2000).

In OSCAR, the effect of woody riparian vegetation on biodiversity and ecosystem functions / services is investigated, and hence, it seems reasonable to use the functional definition and delineation of riparian areas of Ilhardt et al. (2000) adapted by Verry et al. (2004). Since woody vegetation is absent in the wetted channel, their definition of riparian areas was slightly adapted not to include the wetted river channel itself but the river banks, alluvial floodplain to the first terrace, and one tree length on top of the terrace. For rivers missing a distinct terrace slope, 12 instead of 10 times natural bankfull channel width was used as a proxy for meander belt and riparian area width since several studies indicated that the lower value is a rather too conservative estimate (Amoros et al. 1987, Chang 1988, Pinay et al. 1990, Newbury and Gaboury 1993, Wasson 1998, Soar and Thorne 2001). For small streams (mountain and lowland), one tree length (30 m) each side was used in absence of an alluvial floodplain. This is the maximum area with a significant influence on the exchange of energy and matter between the aquatic and terrestrial ecosystem resulting in the ecosystem functions listed above, i.e. the riparian ecotone.

Developing woody vegetation in this whole riparian area is unrealistic in most cases hence should be seen as a kind of natural reference condition (similar to the natural reference conditions used for assessing the ecological status). Comparing effects of this whole riparian area to the effects of narrower woody buffers of a fixed width of 30 m and 10 m will allow to quantify the functionality lost compared to the natural riparian conditions. By comparing it to

the absence of woody buffers, we can quantify what we gain by 10 m and 30 m woody buffers.

Riparian buffers (woody)

The above definition of the riparian ecotone encompasses larger areas than the original Latin word “riparius” (meaning “bank”) implies and is also larger than the zone usually considered as riparian buffers, stream protection zones, streamside or riparian management zones in river management and water legislation.

As mentioned above, some functions like the input of organic matter as food source or shading operate at smaller scales and the contribution of the areas to the ecosystem functions and biodiversity usually decreases with distance from the river channel. There is some empirical evidence that several of the functions are already largely provided by riparian buffers about 30 m in width (see Table 1). Furthermore, narrow riparian buffers of about 10 m (e.g. single tree lines) potentially can provide single functions like regulating water temperature (already providing 80% of shade, Collier et al. 1995 in Parkyn 2004). Most important, riparian buffers of about 10 m - being narrow from an ecological and functional point of view - are already rather the upper limit for buffers that realistically can be achieved in river management, and hence are of greatest practical interest (Hickey and Doran 2004). Therefore, smaller riparian buffers of fixed 10 m and 30 m width were delineated and investigated in OSCAR in addition to the whole riparian area as defined above.

Table 1: Examples for the empirical evidence of woody buffers smaller than the full riparian ecotone already being effective in providing ecosystem functions. To be further filled during the project.

Ecosystem functions	References for 10 m buffers already being effective	References for 30 m buffer already being effective
Flooding control		
Nutrient retention		Sweeney and Newbold (2014) Molló Manonelles (2017)
Fine sediment retention		Sweeney and Newbold (2014)
Shading / water temperature	Parkyn (2004): 80% shading with single line of trees, no substantial increase in water temperature unless buffers are < 10 m	Sweeney and Newbold (2014): Less than 2°C increase with woody buffers >20 m, natural temperature with >30 m)
Organic matter input (food source)		
Migration corridor (biodiversity)		Van Looy et al (2014): Otter recolonization positively affected by the 30 m woody riparian area.
Habitat for terrestrial biota (biodiversity)		
Habitat for aquatic biota (biodiversity)		Sweeney and Newbold (2014): No further increase of river width with woody buffers >25 m, input of LWD with buffer width > tree height ~30 m, invertebrate and fish diversity >30 m)
General effects		Broadmeadow and Nisbet (2004) Castelle et al. (1994): Minimum width of 15-30 m)

Ecosystem services study area

Ecosystem services of woody vegetation in the riparian buffers and riparian area do not only depend on the land use and conditions in this riparian area but provide the services in a larger landscape context. In Oscar, the whole valley floor (including the riparian area PLUS possibly present higher terraces) was considered to be the spatial context in which riparian areas provide their ecosystem services. The valley floor - which includes the riparian area plus the rest of the flat valley floor - was used to demarcate the study area for the ecosystem services analysis since this includes the riparian area as well as the landscape and scenery used for cultural services linked to the river like biking along rivers or canoeing.

Acknowledgments

OSCAR is funded through the 2015-2016 BiodivERsA COFUND call for research proposals, with the national funders German Federal Ministry of Education and Research (01LC1618A), Agence National de Recherche (ANR-16-EBI3-0015-01), and Research Council of Norway (268704/E50).

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