Is the future for resilient watercourses 'in the bank?'

By Marc Stutter

Many of our streams and rivers have been forced into very unnatural forms where no identity to the riparian zone accompanies a lack of functions

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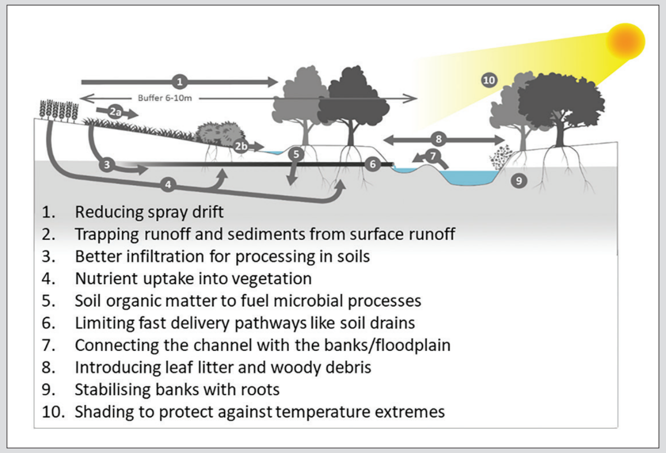

Above: Figure 1. The range of functions supporting healthy watercourses, banks and river corridors that can be promoted by enhanced structural aspects of 3D buffers as part of designing enhanced natural functioning into riparian zones in managed landscapes. Whilst current designs of grass buffer zone focus mostly on function (2) an integrated package will counter landscape biodiversity loss, diffuse pollution and climate impacts, such as thermal stress, within realistic constraints of river corridor widths that can be as little as 6-10m in streams and smaller rivers

If you are able to enjoy a walk alongside a twisting, babbling stream through trees and scrub growing on gently-sloping banks then you should consider yourself very fortunate as, even in Scotland, rivers that follow natural courses through rich waterside habitat are few and far between. You are far more likely to experience a watercourse that is more utilitarian and has a less appealing identity, appearing restricted, deepened, straightened, or even piped underground. Yet a river's banks and floodplain are integral to its corridor and without them its natural functions are greatly restricted.

The banks of a river are influenced by environmental gradients that operate in two directions. From the channel outwards, a dynamic river influences the surrounding land when high flow pulses shape the banks, wet the floodplains and deposit silt that builds rich alluvial soils. From the land towards the channel comes runoff water carrying eroded soils and nutrients. There is a transition of slope form, wetness and vegetation that characterises the riparian interface. Under good conditions, as in the first of our opening scenarios, this riparian interface is sufficiently sized and with an interplay of above and below ground processes. These enhance biodiversity, allow rivers and their floodplains to interact, promote processing of excess nutrients and exchanges of resources (e.g. leaf litter, insects) between land and water ecosystems. It is this transition zone and its space for features that makes river corridors stand out when we look down from the air, or using aerial imagery; these river corridors stand out as strips of the former ancient land cover, dividing and crossing our rural landscapes, historically for example being the bounds of estates. In the contrasting negative scenario, the space and ability for riparian processes to offer environmental benefits have become restricted by factors such as removal of natural trees, soil and wetland drainage and encroachment by cultivation, forestry, roads and wider development. These visual clues of pressures are strongly associated with water quality degradation; of siltation, excess nutrients, oxygen stress, seasonal water temperature extremes, perhaps trace chemical pollutants. All of these are very damaging to ecosystems and strongly linked to fish declines.

Since the late '90s, catchment management policies have sought to couple river water quality and quantity to the condition of the surrounding land. The widespread development of catchment management plans followed. Most of the plans advocated riparian buffer strips. These buffer strips were proposed as a physical barrier between land uses, typically agriculture, to set-back cultivation and agrochemicals and buffer the passage of polluted and/or fast flowing runoff waters. The inference was that such a style of buffer would provide effective pollution reduction at the field edge if coupled with in-field management. Whilst in some countries buffers of 10 to 30 m were proposed, it was more usual in the busy landscapes of Europe to see buffers less than 10 m wide. Essentially, in addition to setting-back agricultural activities and fencing stock out of watercourses, these buffers manifested as grass-planted filter strips where polluted runoff flowing from the surface of fields was encouraged to infiltrate and deposit any sediment load before reaching rivers. This is typically the field-riparian edge grass buffers that we see today in many situations. Being uniformly narrow to comply with fixed width requirements, instead of widened at erosion hot spots, these buffer strips result in mixed success and lost opportunities in protecting watercourses. Current designs have key limitations in their intended runoff filtering actions; failing to trap fine soil particles, being overwhelmed during storm runoff and allowing subsurface soil drains to pass through them. In addition, the conventional grass buffers lack wider benefits. Most notably, they lack the diversity of habitat and soil conditions needed to drive nutrient processing, absorb pesticides and provide resilience against high flows, low flows and temperature extremes. Simply put, today's narrow grass buffer strips are not providing the required water quality protection, have a limited range of designs and lack stakeholder take-up as their effectiveness is questionable.

Water quality protection and resilience against declining condition could be improved by incorporating a greater range of natural functions into bespoke riparian buffer strips, tailored to a site's pressures and in the context of a wider catchment plan. To achieve this we should look at the transitional processes and functions in natural riparian zones and aim to reproduce or 'eco-engineer' these into the available space in our managed landscapes (see Figure 1).

So-called 3D buffer zones package a range of measures to intercept pollution (below ground, across the soil surface and above ground in the vegetation canopy) and maximise multiple environmental, rural business and public goods outcomes. The 3D element refers to the fact that the horizontal width of the buffer works in unison with a range of vertical ►

Riparian planting is common and the many benefits can be further enhanced with aspects such as footpath networks

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Useful features can include novel use of on-hand farm machinery, here a potato Tied Ridger has been used to create mini cross-slope infiltration ponds along the stream banks, then seeded with grass

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Integrated measures in a 3D buffer zone can include small wetlands intercepting surface and field drain runoff, biomass production and use of wildflower seed mixes

structures from roots and soils, to surface topography, ground vegetation, to the tree canopy. A recent synthesis reports on the elements of 3D buffer designs and their relative effectiveness to current approaches. The study shows that multiple designed features, including tree planting and additional 'eco-engineered' measures such as ridges, swales, and mini wetlands, can capture and retain diffuse agricultural pollutants most effectively. The 3D buffers promote a mixture of drier and wetter ground that diversifies pollutant mitigation processes and habitats. The review evaluates the effectiveness of five different types of buffer zones, ranging from simple grass strips to wooded, altered ground profiles, such as sediment traps, and bunds. The different approaches were scored for a range of functions including flood mitigation and pollution reduction, as well as their potential to deliver multiple environmental benefits. Wooded and engineered buffers scored the highest and conventional grass buffers the lowest across outcomes for diffuse pollution control, carbon retention, and geomorphic and flood management. In essence, 3D buffers aim to maximise environmental benefits through designing banks and riparian margins (potentially smaller stream channels themselves) across our managed landscapes, inspired by the way that nature cleans-up pollution and builds resilience.

For many rivers, the benefits of riparian trees for fish habitat and wider water quality has led to substantial efforts at bankside planting. The practical work of the River Dee Trust and Dee Catchment Partnership in Aberdeenshire, and the Ribble Rivers Trust and partners in NW England, are just two examples of many riparian woodland efforts. However, the novelty of the 3D buffer approach is that it brings wider design options for structural and functional riparian change. The approach creates bespoke packages from a menu of measures, giving inspiration, guidance and understanding of the mechanisms. For example, the well-known grass filter strip styles of buffers rely on infiltration on well-drained soils to reduce sediment loads from fields, but often become overwhelmed in storms. Sediment traps and sculpted ground profiles can enhance the sediment trapping ability. New thinking is that pollutants such as nitrogen can be broken down by microbes in wet soil pockets, or that carbon-rich soils give microbes energy to break down pesticides (Stutter et al., 2019). Scientists in the US are trialling designs to tap into and raise nitrogen laden waters in field drains and irrigate them onto wet buffer soils to allow natural denitrification. In Scandinavia and the UK ponds and wetlands are being trialled to slow fast delivery of runoff and allow time for natural treatment processes, with excess nutrients encouraged into biomass growth (Zak et al., 2019).

Riparian designs should be proportionate to the nature of the pollution pressure, status of the water environment and specific ecological and other goals. Such measures must always go together with good management in the upslope field, forestry or development area. Whilst trees are well accepted elements of our river corridors, some elements of the packages of measures are less familiar. A significant challenge lies with evidence and awareness-raising through demonstration that we hope will lead to improved guidance and greater acceptance and uptake of 3D buffers. It's been really encouraging that some of these measures have made practical sense to landowners. One farmer in NE Scotland went ahead and built in an afternoon, at minimal outlay, a simple engineered soil bund at the base of a long arable field slope. Months later we watched this bund back up runoff during a large storm, protecting an adjacent wetland; the ponded water behaved as predicted by the sizing of an outlet pipe, draining after a day, leaving the crop unaffected and the sediment in the hollow. We want people to see for themselves how such uncomplicated structures can be effective when simple design principles are followed and minimal maintenance carried out.

It's important to recognise that one size doesn't fit all; we are advocating moving from blanket narrower buffers to bespoke measures, proportionate to the issues and using a smarter range of features to be more effective and better justify funding and wider support. This will allow river managers, fisheries bodies, farmers, foresters and their advisors to tailor a package of features into a 6-10 m watercourse margin designed for their site. We hope that extra certainty of outcomes associated with bespoke measures may enhance public support. It is a time of opportunity for designing multi-functional river corridors. The new UK Agriculture Bill looks set to reorganise agricultural payments around delivery of public goods; multi-stakeholder catchment partnerships are proving effective in delivering work on the ground; the UK Research Councils are investing in knowledge through their current UK Treescapes program; the Environment Agency has secured £1.4M for riparian planting; Scotland's RiverWoods is an example of an initiative seeking a step change in biodiversity funding via public-private partnerships. As delivery potential increases so does a need to stimulate vision and improve our understanding of possible measures. Future bespoke designed riparian zones, combined with the ongoing push for pollution source management, will greatly increase the robustness of river water quality protection and habitats for important aquatic species. ❐

FURTHER READING: *Stutter et al., 2019. Current Insights into the Effectiveness of Riparian Management, Attainment of Multiple Benefits, and Potential Technical Enhancement. J. Env. Qual. 48, 236-247. Zak D et al., 2019. A review of the multi-functionality of integrated buffer zones in Northwest Europe. J Env. Qual. 48, 362-375.*

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