CENTRE OF EXPERTISE FOR WATERS

Policy Note

Can improved design concepts for riparian buffer measures and placement improve uptake and best practice in Scotland?

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Overview

- **Error in the margin?** It's now time to re-think buffer designs to address the pressing climate and biodiversity emergencies; traditional linear grassed buffers are not always fit for purpose.
- **Get the most out of this land unit.** Substantial opportunities exist to improve buffer design and placement to enhance a wider range of ecosystem services without significantly increasing land take.
- **New approaches don't need to further impact on farming** and there are potential opportunities for farmers with some measure designs (e.g. biofuels, recapturing lost soils).

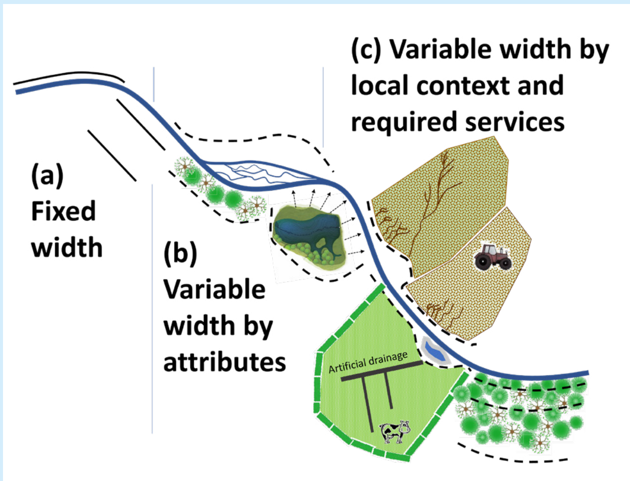
It is timely to review the developing research area of riparian buffer zone management for potential to improve best practice and enhance ecosystem services in Scotland. This CREW Policy Note examines how an enhanced range of designs and targeting can be achieved to improve multiple outcomes for water quality, quantity, biodiversity and climate change.

BACKGROUND

Riparian buffer zones are common field edge interventions aiming to improve water quality, with wider potential for multiple outcomes[1,2]. Their successful use at edge-of-fields critically depends on pairing with appropriate in-field source management. Buffer presence provides physical distance between cultivation, use of fertiliser, organic manures and pesticides to watercourses. However, many implemented buffers do not interrupt all pollution pathways nor adequately enhance multiple benefits due to mismatched designs or placement relative to site issues, or from poor coordination at catchment scales (Box 1). Presently many research programs are reporting outcomes for improving riparian concepts, designs, targeting and communication and it is timely to summarise recent innovations against an understanding of Scotland's implementation and policy needs for riparian management.

Box 1: A 'one size fits all' approach less effectively combats environmental pressures

Buffer width is often debated but should be rethought as to being site-specific by attributes with landscape functions needing protection or adjacent land use pressures needing localised actions[3].



Policy-defined fixed widths, or those associated with data resolution (a), can be contrasted with varied width by physical, vegetation or habitat characteristics (b), or by required level of protection responding to local pressures (c).

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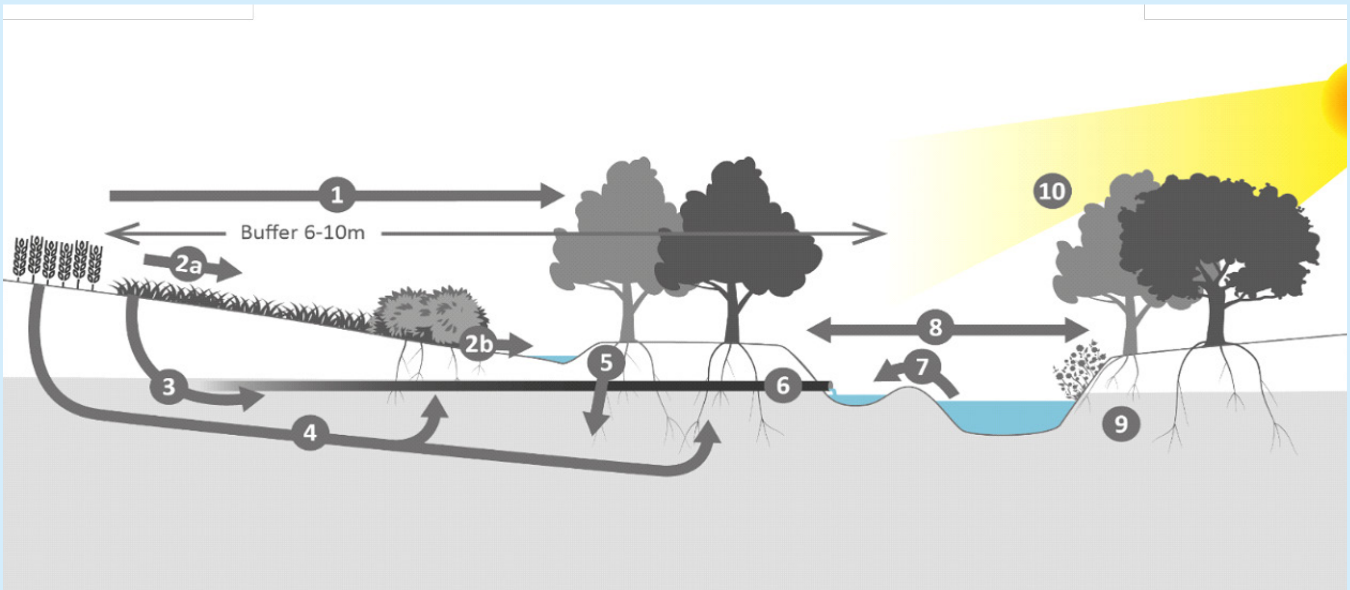
Box 2: Range of functions in the 3D buffer zone concept[2]



1. *Reducing spray drift*
2. *Trapping surface runoff and sediments (either in depressions or raised bunds)*
3. *Better infiltration for processing in soils*
4. *Nutrient uptake into vegetation*
5. *Soil organic matter to fuel microbial nutrient cycling and contaminant degradation*
6. *Limiting fast delivery pathways like soil drains*
7. *Connecting the channel with the banks/floodplain*
8. *Introducing leaf litter and woody debris (either natural or soft-engineered approaches)*
9. *Stabilising banks with roots*
10. *Shading to protect against temperature extremes*

AN EXPANDED RANGE OF RIPARIAN MEASURE DESIGNS

A greater range of designs are now being considered for the riparian management zone due to recognised weaknesses in current practices in terms of pollution retention and the imperative to realise wider ecosystem benefits to counter the pressing Climate and Biodiversity emergencies[1,2]. These have been conceptualised in terms of the role of three-dimensional structures from below ground to tree canopy in runoff pathways and habitat improvement processes (Box 2).

Runoff attenuation and sediment retention: Freely draining soils and stiff grasses promoting infiltration of surface runoff have until recently been considered ideal buffer zones for depositing sediment. In fact, wetter field slope soils conveying surface runoff towards infiltrating riparian soils is uncommon; riparian zones generally occupy low-lying landscape locations with seasonally high water tables[1]. As a result, the retention of sediments and particle-bound contaminants (e.g., phosphorus and some pesticides) in grass filter strips often fails, especially for clay soils yielding fine particles. Hence, designs reprofiling ground using raised bunds and sediment traps assure more certain functioning for sediment retention and temporary water storage in seasonally wet soils. However, these remain unfamiliar despite sharing functions with Natural Flood Management (NFM) measures[2,4].

Subsurface pathways: As well as surface runoff, pollution may bypass buffers via underground pathways such as artificial soil drainage[1]. Riparian measures that treat tile drainage have potential to capture drain flow fine sediments and phosphorus, mitigate nitrate loading and enhance microbial processing of soluble contaminants (e.g., pesticides) if designs are capable of interrupting drainage to slowly permeate through wet, organic matter rich, riparian soils (whilst maintaining in-field drainage). Such measures are rare in the UK and informed by developing practice in Scandinavia and the U.S.[5,6]

Manipulating riparian vegetation: Riparian vegetation management involving wildflower seeding, or tree planting are amongst the most recognised riparian manipulations, with potential to combat biodiversity loss, protect streams from solar heating, add leaf litter or stabilise eroding banks[2,7]. Furthermore, vegetation uptake, especially of phosphorus (P), can counter the accumulation of nutrients in the buffer zone that could otherwise lead to swapping incoming eroding P for soluble P leaching. Offtake of vegetation (grasses, woody material) may enhance this nutrient removal and provide a compensatory biomass crop[1].

Box 3: Novel riparian measures

The Smarter BufferZ project[8] has developed resources supporting understanding and implementation for groups of riparian baseline measures and simple to technical modular additions into the riparian space[9].

Baseline riparian margin space
1. Grass buffer strip
2. Wildflower buffer
3. Wooded buffer

Surface runoff and sedimentation options

4. Magic margins
5. Raised buffer: field runoff
6. Raised buffer: offline storage
7. Sediment trap
8. Sediment filter fences

Subsurface pathway options

9. Buffer surface-, ground-water wetlands
10. Tile drain-fed wetlands
11. Integrated buffer zones
12. Denitrifying bioreactors
13. Controlled drainage
14. Tile drain irrigation onto saturated soils

In-channel options

15. Two stage channel
16. In ditch sediment trap, or filter

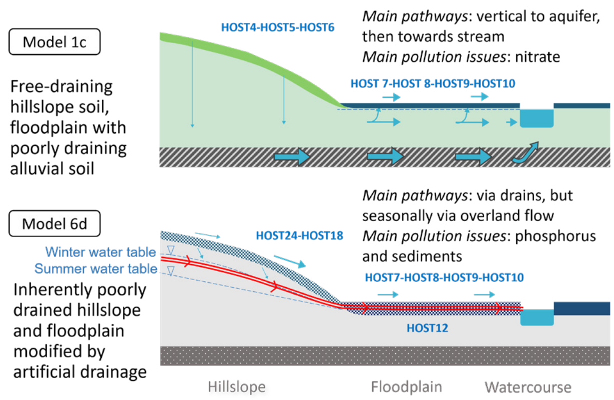
Sixteen measures are currently being assessed as part of modular package of options for riparian applications (Box 3)[9]. This expands on five previous simplified groupings of measures[2] (intended to be applied across a gradient of low to high pollution pressure situations): grass or wildflower buffers, wooded buffers, raised ground (bunded) buffers and fully engineered buffers (including sub-surface measures).

MATCHING MEASURES TO SITE REQUIREMENTS

Buffer zone requirements and options need to be assessed on site specifics[3,10]. Conceptual understanding and spatial data tools can provide screening-level planning at small catchment, farm to field scales, supported by water quality, flood and habitat monitoring generally[3]. Critically, exact decisions on designs and siting (and informing costs and maintenance requirements) must be informed by field survey and local knowledge (e.g., of seasonal flow extremes or erosion). Two complimentary spatial data methods are being developed for riparian buffer planning (Box 4). The first uses soil water flowpath models to classify landscape hillslope-riparian zones differing in prevalent surface and surface pathways for pollution[9], thereby allowing selection between measures targeting different pathways. The second uses surface topography to understand the number and magnitude of critical delivery points along the riparian boundary, showing where converging surface

Box 4: Targeting flowpaths and hydrology

Landscape variation in hillslope-riparian flowpaths, directly relatable to pollution pathways and measure suitability, can be depicted according to six models and component sub-models derived from HOST classes (Hydrology of Soil Types[11]) and drainage rules. These are being developed for Scotland to guide measure placement[12]. Below, the measures in Box 3 are shown assessed against two landscape contexts contrasting in flow generation and pathways.



Measure suitability: Highly suited / Potentially* / Unsuited

		Basic margin			Surface runoff options					Subsurface options						In-channel	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Model	1c	Unsuited	Unsuited	Potentially*	Unsuited	Potentially*	Potentially*	Unsuited	Unsuited	Potentially*	Unsuited	Potentially*	Unsuited	Unsuited	Unsuited	Unsuited	Potentially*
Model	6d	Potentially*	Potentially*	Highly suited	Unsuited	Highly suited	Highly suited	Potentially*	Unsuited	Highly suited	Highly suited	Highly suited	Potentially*	Potentially*	Highly suited	Potentially*	Highly suited

*Potential suitability is based on site-specifics such as local erosion risk, or channel form runoff (i.e. energetic, erosive overland flows) requires widened pollution interception zones or sediment traps and bunds[3] (Box 5). The application of combined planning tools will be in the selection of a short-list of suitable measures (from Box 3) matching required functions (Box 2) to the landscape and to develop field-scale maps able to inform advisor to landowner discussions on the ground.

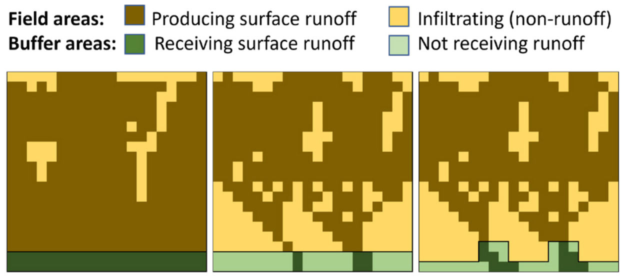
MOVING TOWARDS IMPROVED IMPLEMENTATION

Key areas to improve implementation can be summarised as:

Understanding multiple environmental pressures and the role of riparian management in alleviating interacting stressors. Careful selection of measures against issues can deliver multifunctional riparian zones. A narrow unmanaged grass buffer may have highly uncertain outcomes, whereas a wooded buffer with targeted sediment traps of subsurface interception may present a holistic package with certainty in multiple functions. Varying effectiveness of the different measures across contrasting (e.g., soluble versus particle) pollutants[10], floods and droughts, terrestrial and aquatic habitats, recreational and aesthetic benefits need to be understood to leverage uptake[2].

Box 5: Targeting converging surface runoff

Schematics below show examples of diffuse and converging surface runoff towards a riparian buffer and the effect of decreasing the runoff to effective buffer ratio using bespoke targeted buffers. With sufficient topographic data resolution (e.g. Lidar data) such tools can powerfully inform field survey validation of runoff delivery points leading to more effective pollution functions for a given field area out of production[3]. These can work alongside tools for communicating risks of generating runoff[13] and erosion[14] from farmed land.



(a) Diffuse flow with linear buffer

(b) Converging flow with linear buffer

(c) Converging flow with targeted buffer

	(a)	(b)	(c)
Source : effective buffer area ratio	8	40	20
% of field as buffer	10%	10%	8%

Equipping advisors and catchment officers with information on options and suitability for diverse field situations. Planning tool data resolutions (Boxes 4, 5; soil map units or Lidar topographic resolution) can often underrepresent field-scale complexity[3]. Skilled site assessment, for example recognising the role of management (tracks, gateways, compaction on converging erosive flows) will make implementation effort most effective.

Improved guidance and communication on designs, costs and maintenance requirements. Guidance and wider resources should be further developed and shared across different initiatives, for example water quality, NFM and river woodland expansion. This should include ongoing management to remove accumulated sediments (which can be a valuable resource for the landowner i.e., recapturing lost soil), or more novel aspects of biomass removal to mine nutrients.

Demonstration and evidence for collective benefits of scaling up multiple small opportunistic measures. Demonstration of on the ground practice and results will be key to spreading good practice messages. Positive results from multiple small measures will really prove how collective, well targeted small riparian interventions accrue real water quality and quantity results at catchment scales[1].

Integrated working across policy sectors to holistically address catchment issues through novel measure design and placement. There is a need for better coordination at national levels between river basin management, flood risk, biodiversity and rural economies sectors to deliver integrated, cost-effective measures. In combination, catchment forum groups, advisors and other facilitators then can support landowner engagement locally using consolidated cross-policy messages.

FUTURE PERSPECTIVES

As the human population grows, future pressures from development, intensified agriculture, loss of habitat, pollution and pressing climate related issues (e.g., thermal regime and hydrological extremes) will likely increase with complex, uncertain outcomes. The coordination and planning of designed riparian zones has potential to alleviate stress on the water environment by restoring multiple degraded functions (see Box 2) in space-efficient ways recognising other societal demands for space and effectively utilising field zones of least productivity (wet field corners)[2, 15].

This summary of latest research shows growing capabilities in supporting design and placement of riparian management. Future improvements in on-the-ground farm level demonstration may lead to some landowners' willingness to undertake proportionate riparian management under their own resourcing[16]. It is important that business benefits (controlling soil and seed loss, improved pollinators, alternative harvests, water storage) and lack of disbenefits (most productive land is retained, drains left functioning) are explained. Advisory resources and skills (soil survey, erosion, compaction assessment) would useful be expanded to maximise the jump between spatial data planning outputs and persuasive conversations with landowners clearly outlining actions, costs and maintenance. Such persuasion may include trial measures demonstrating the extent of soil loss.

New programs for rural environment funding provide future opportunity to reshape public funding for measures; it is vital these include advisory and coordination funding and post-installation maintenance contracts and not just capital cost funding for the measure. Wider initiatives such as Scotland's Riverwoods[17] are responding to topical rural economy pressures such as failing fisheries with public-private financing. Such innovation could be brought to widespread riparian management involving insurance (flood mitigation) and supermarkets (grower incentives for adopting environmental schemes). Formal accreditation schemes for carbon credits being applied recently to river management may usefully be expanded for valuing riparian water quality or habitat outcomes. Also, there are potential funding links to ongoing and future Flood Risk Management Plans in the Potential vulnerable areas to flooding across Scotland[18]. Here, Local Authorities are encouraged to consider NFM measures (many measures in Box 3 can be considered NFM).

POLICY RECOMMENDATIONS

Riparian management must be proportionate to local pressures and have an environmental role alongside food security. A shift needs to take place involving moving away from linear riparian margins towards bespoke placement, based on risk: wider buffer strips where justified, incorporating specific feature, going beyond the current minimum (as being developed for England's Sustainable Farming Incentives pilot[19], recommended in the 3D buffers report[2]). Current regulatory (2 m) margins provide baseline protection that can be added to according to site needs.

As an edge-of-field technique pollution retention in the riparian environment is dependent on stringent legislation for in-field management to minimise pollution loading. The design and placement messages here equally apply to use of buffer zones within field and non-watercourse margins. However, management to restore natural functions in the critical riparian land-water interface maximises benefits for water quality, hydrological extremes, habitat quality and should therefore cross policies to maximise leverage and funding.

Clarity of future messaging in riparian management policy is required and legislative barriers minimised. Key behavioural challenges around maintaining wetter riparian soils to promote nutrient processing and habitat diversity persist, associated with generational memory of post-war policies of ubiquitous landscape drainage.

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