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Losing ground - managing water runoff and soil erosion on farms

- Around 2.2 million tonnes of top soil are eroded annually in the UK
- Around 70 per cent of soil sedimentation of water bodies comes from agricultural sources
- Erosion reduces soil fertility and costs farms money
- Erosion leads to loss of seeds, fertilisers and pesticides and requires repeat operations
- An estimated 25 per cent of the phosphates and 50 per cent of nitrates in rivers are from agricultural sources.
- Trees and woodland integrated into farming systems can reduce harm to water quality, while also helping to support agricultural production.

A cost to the farm

Water runoff and erosion during heavy rain is a loss to the farm and a cost to society. Around 2.2 million tonnes of topsoil are eroded annually in the UK, reducing the long term fertility of the soil by removing nutrient rich top soil and organic matter. In the short term erosion leads to loss of seeds, fertilisers and pesticides and incurs costs associated with repeat operations[1].

Developments in agriculture over the last 50 years such as increase in field size, use of heavier machinery and loss of hedgerows have increased the risk of soil erosion. Climate change and predicted increase in frequency of severe weather is likely to magnify the impact of erosion[2].

Erosion and runoff have a significant impact on water quality and flooding. As the major land use, agriculture is important both as a source of water pollutants but also in providing opportunities for mitigating measures.

Sedimentation

Erosion leads to sedimentation and contamination of streams, rivers and other water bodies, damaging fisheries and wildlife and increasing water treatment costs. Although soil sediment enters water bodies through natural erosion, around 70 per cent of soil sedimentation is estimated to come from agricultural sources[3].

Susceptibility to soil erosion is affected by farming system, soil type, local climate, and topography, all of which need to be considered when assessing risk. Sediment losses are greatest from arable land, with late sown cereal, potatoes and sugar beet particularly vulnerable. Bare soil surfaces exposed to heavy rain leads to formation of rills or runoff along tram lines[4].

On grassland, problems can occur where livestock have direct access to the water's edge and can destabilise banks. Whilst part of the process is natural, trampling and poaching of river banks by cattle increases the rate of bank erosion. Similarly poaching in gateways, around cattle feeders and water troughs or as a result of high stocking rates during wet weather may significantly increase the rate of runoff and increased sedimentation.

Sediment deposits can increase the turbidity of water bodies; affecting the gills of some fish, and their ability to feed. Deposition of sediment on gravel beds affect spawning of fish and impact on economically important fresh water fisheries. Many invertebrates are also adversely affected by sedimentation.

Nutrient pollution

An estimated 25 per cent of the phosphates and 50 per cent of nitrates in rivers are from agricultural sources. Faecal indicator organisms (FIO) such as *E.coli*, associated with manures, can also contaminate water supplies. Timing and type of cultivations, crop selection, siting of cattle feeders and water troughs, and location of manure heaps, can all affect the likelihood of runoff and contamination of water courses.

In water bodies, enrichment with high concentrations of nutrients, especially phosphates and nitrates, leads to eutrophication; excessive growth of algae which, as it dies and decomposes, leads to the decomposing organisms depleting the water of available oxygen, causing the death of fish and other wildlife.

Pollution from agriculture is a major cause of failure of river catchments under the Water Framework Directive[a], in particular nitrogen and phosphate pollution as a result of leaching from both organic manures and inorganic fertilisers. Such a loss represents a cost both to the farm and to water quality.

Nitrogen losses from agricultural land are estimated to account for over half of nitrogen entering surface waters[5]. While nitrate occurs naturally in surface waters, elevated concentrations of can damage ecological quality through eutrophication, acidification and direct toxic effects on some species[6] .

Levels are particularly high in lowland areas dominated by arable agriculture. Nitrate loss is encouraged by over application of fertilisers and significant periods of bare soil during winter months. Nitrate concentrations from grassland systems depend upon the intensity of stocking and management, and the use of manures. Too high stocking and autumn application of manures increases nitrate loss[7].

As with nitrates, phosphates mainly arise from application of inorganic fertilisers and animal manures and where lost into water bodies, may lead to eutrophication. About 25per cent of the phosphates entering rivers are from agricultural sources. The principle pathway for loss is through soil erosion and overland flow; phosphates attach to soil particles. Many agricultural soils are enriched with phosphate due to large applications of phosphate fertilisers over many years.

Phosphate losses are greatest during storm runoff, such as in the recent rains. Some will be immediately flushed downstream, but in slowing moving rivers it can be deposited with the soil particles, and act as a reservoir for phosphate discharge into the water.

Integrating trees in to farming systems

Whilst changing agricultural practices can be an important first step, some residual issues will persist. Targeted tree planting is one of the ways to mitigate runoff and pollution from agriculture and deliver the quality standards of the WFD.

The use of trees and woodland integrated into farming systems can help to reduce the risk of harm to water quality and contribute to mitigation of flood risk, while also helping to support agricultural production.

[a] The Water Framework Directive (WFD) provides overarching legislation aimed at maintaining and improving water quality. The WFD became part of UK law in 2003. It places a responsibility for applying the regulations and policies to deliver the WFD in England and Wales on the Environment Agency (EA), and in Scotland on the Scottish Environmental Protection Agency (SEPA).

The role of trees and woodland is to intercept the pollution pathways and capture pollutants. Pollution pathways include overland runoff (such as soil erosion and concomitant phosphate loss), and subsurface movement through drainage channels (such as dissolved nitrates).

Trees can reduce soil and water movement by increasing water infiltration rates and slowing the flow of transported sediments. Woodland buffers on mid-slope and down slope field edges can be effective in increasing water infiltration, reducing and slowing runoff and intercepting nutrient and sediment[8].

They can also act as locations for biochemical processes that remove or reduce the potency of the pollutant – such as the conversion of ammonia to nitrate or the capture of faecal pathogens within tree belts.

By trapping pollutants bound to soil particles, trees reduce water pollution, acting as nutrient sinks. Phosphates in particular are associated with trapping of sediment, while nitrate removal can occur by plant uptake. Studies in the USA and New Zealand show that buffers composed of grass, trees and shrubs can be effective at lowering levels of sediments in run-off[9]. While studies from Europe and North America show that phosphate can be removed by tree/grass buffers, a UK study showed that 99 per cent of subsurface nitrate applied to an arable field could be removed by grass/tree buffer[10]. Further work in Poland, Italy, Estonia, USA, and Canada has also shown that tree/grass buffers can be effective at reducing nitrate levels in runoff.

Tree planting and woodland creation

Where they are present, existing hedgerows and shelter belts may already be helping to reduce impacts on water bodies. However planting trees and the creation of tree belts with their associated vegetation can be incorporated into farming systems to mitigate pollutants and safeguard water resources. Studies at Pontbren in mid Wales found that water infiltration increased by 60 per cent within 5m of tree shelter belts after just 3 years of planting[11].

The width of the buffer, gradient, amount of vegetation and leaf litter, and soil type will all influence the time taken for water to pass through the buffer. The longer the buffer holds the water, the better it will function. Planting across the contour or in areas known to be vulnerable to runoff will provide the greatest benefit; knowledge at a farm level will be able to match this ideal to the practical opportunities.

Native trees appropriate to the site are preferable to achieve wildlife benefits. For woodland to act as a nutrient soak, fast growing species such as willow and poplar can be beneficial. They are quick to establish and rapidly provide a filtering and stabilising effect. Willow has multiple benefits because of its dense root structure, and its wildlife value – it harbours a wide variety of insects, which can provide a food source for fish. Planting a wide variety of trees and shrubs will help to achieve varied structure, will benefit a wider range of wildlife, and will prevent heavy losses if one species is hit by disease.

Research, has identified the need for better guidance to farmers on woodland creation and management for water[12]. Individual farms will have particular concerns reflecting local circumstances, for instance the predominant farming system, the nature of the pollution source, local weather patterns and so on. The evidence and advice should be tailored to meet these particular needs and practical considerations.

References

[1] Kort, John, Collins, M. and Ditsch, D., 1998. A review of soil erosion potential associated with biomass crops. *Biomass and Bioenergy*, 14, pp.351-359, in Donnison, L. (2011) *Review of the effects of farmland trees on erosion and pollution in the local farmed landscape.* Report to the Woodland Trust

[2] DEFRA (2009a) *Safeguarding our soils* Available at: http://www.defra.gov.uk/publications/files/pb13297-soil-strategy-090910.pdf, [accessed 20th March 2012]

[3] DEFRA (2008) *Understanding the Environmental Effects of Farming on Aquatic Ecosystems – W Q0112*, Final report 31st January 2008. Available at: http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=14417, [accessed 21st March 2012]

[4] Silgram, M., Jackson, D., Bailey, A., Quinton, J. and Stevens, C., 2010. Hillslope scale surface runoff, sediment and nutrient losses associated with tramline wheelings. *Earth Surface Processes and Landforms*, 35(6), pp.699-706.

[5] DEFRA(2004) *Updating an estimate of the source apportionment of nitrogen to waters in England and Wales – phase 2 report to the Department for Environment, Food and Rural Affairs,* London, Available at: http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=12833, [accessed 20th March 2012]

[6] DEFRA (2008) *Catchment sensitive farming*. DEFRA archive web page. Available at: http://webarchive.nationalarchives.gov.uk/20090306103114/defra.gov.uk/farm/environment/water/csf/ , [accessed 21st March 2012]

[7] Dampney, D., 2002. *Methods and measures to minimize the diffuse pollution of water from agriculture, – a critical appraisal.* Available at: http://www.freshwaterlife.org/servlet/BinaryDownloaderServlet?filename=1169116430785_dwpa05_1_.pdf [accessed March 22, 2012].

[8] Calder, I., Harrison, J., Nisbet, TR and Smithers, R., 2008. Woodland actions for biodiversity and their role in water management. *Flooding, Water and the Landscape*, 7(1), p.153

[9] Hussain, Z., 2007. *Environmental effects of densely planted willow and poplar in a silvopastoral system:* a thesis presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy (Ph.D.) in Agroforestry, Institute of Natural Resources, Massey University, Palmerston North, New Zealand

[10] Haycock, N. and Pinay, G., 1993. Groundwater nitrate dynamics in grass and poplar vegetated riparian buffer strips during the winter. *Journal of environmental quality*, 22(2), pp.273-278.

[11] Bird S.B., Emmett B.A., Sinclair F.L., Stevens P.A.,Reynolds B., Nicholson S.and Jones T. (2003) *Pontbren: Effects of tree planting on agricultural soils and their func*tions, Final Report, March 2003, available at: http://www.ceh.ac.uk/sections/bef/Pontbren_report.html, [accessed 6th July 2011)

[12] Nisbet, T., Silgram, M., Shah, N., Morrow, K., and Broadmeadow, S., 2011. *Woodland for Water: Woodland measures for meeting Water Framework Directive objectives.* Available at: http://www.forestresearch.gov.uk/pdf/FRMG004_Woodland4Water.pdf/$FILE/FRMG004_Woodland4Water.pdf.