Assessment of Potential Contribution of Woodland Creation to Mitigating the Impacts of Agriculture on Water Quality

The report 'Woodland for Water: Woodland measures for meeting WFD objectives' provides a detailed review of the interactions between woodlands and water (EA, 2011; Nisbet et al., 2011). It concludes:

- There is strong evidence to support woodland creation in appropriate locations to achieve water management and water quality objectives.

- Woodland contribution to tackling diffuse pollution includes both a barrier and interception function. They help to trap and retain nutrients and sediment in polluted runoff.

- The benefits of riparian and floodplain woodland for protecting river morphology and moderating stream temperatures are well proven, while a good case can also be made for mitigating downstream flooding.

- Targeted woodland buffers along mid-slope or downslope field edges, or on infiltration basins appear effective for slowing down runoff and intercepting sediment and nutrients, but the evidence base is limited.

- Wider targeted woodland planting in the landscape can reduce fertiliser and pesticide loss into water, as well as protecting the soil from regular disturbance and so reduce the risk of sediment delivery to watercourses.

- Evidence from Europe and further afield provides a range of examples of effective action plans and incentive schemes for water-related woodland services, which have succeeded in achieving woodland creation and a reduction in nutrients reaching watercourses.

- The evidence presented supports the use of woodland measures in helping to meet water quality objectives in future River Basin Planning cycles.

The report also notes that woodland creation can deliver a number of other important ecosystem services, including carbon sequestration, a valuable habitat for wildlife, recreation and the provision of fuel and timber.

This note focuses on the potential effectiveness of woodland creation for reducing the delivery of diffuse pollutants from agriculture to water. In view of the many interacting factors that influence the effects of woodland on water, it is only possible to provide a broad range of values for each pollutant. Values are drawn from the literature and informed by expert judgement.

The ranges are tabulated below under two headings. The first deals with the more simple case of replacing agriculture with woodland and assumes that it is the agricultural activity that forms the main source of the pollutant that is being replaced (and the activity is relocated to another water body where the impact can be better accommodated). The second addresses the use of woodland as an intervention to buffer the effects of the agricultural polluting activity on the upslope or adjacent land. Both cases rely on careful targeting of known pollutant sources or pathways and therefore better integration of woodland into the lowland agricultural landscape. In this way the land take and impact on farm economies can be minimised; note that in some cases woodland planting could be expected to increase crop yields e.g. through the action of shelter belts.

It is also assumed that the woodland will be designed and managed in a way that will protect soil and water, and in the case of woodland buffers, to promote and maintain their effectiveness for pollutant uptake or removal. This means that woodland buffers will be of an appropriate width and structure to address a particular pollutant, and will not be bypassed by artificial drains. Buffer width is obviously a dominant factor determining effectiveness and would usually be a minimum of 10-20 m between the pollutant source and watercourse. Other key woodland design and management factors include woodland type and species choice, the extent/scale of woodland planting in relation to the area contributing the pollutant, the nature and timing of woodland management operations such as thinning and felling, and woodland age; it is assumed that these would be tailored to the site/area (e.g. avoiding planting alder where nitrate or ammonia is an issue because of its ability to fix N).

The effectiveness of the two woodland scenarios for removing a number of diffuse pollutants is considered below:

Woodland planting replacing the agricultural activity on the land forming the main source of the pollutant

Nitrate

It is assumed that the primary source of the pollutant is from applications of nitrogen (N) fertiliser or organic manure that are required to sustain agricultural activity. Since woodland creation rarely involves any N fertiliser or organic amendments, planting would completely remove this source (i.e. 100% effectiveness). However, this benefit could be partly offset by an enhanced level of atmospheric N deposition due to pollutant scavenging by the woodland canopy, and by a potential evapo-concentrating effect resulting from higher woodland water use (the latter would increase nitrate concentrations in water but not loads). These mechanisms would be spatially variable and dependent on the local pollution and rainfall climate. Forest type exerts an important control over both mechanisms, which are greatest for conifer and least for broadleaves. The main offset would be for conifer planting close to high N emission sources, such as intensive livestock rearing units, and in drier parts of the country (<650 mm annual rainfall). Based on a comparison on N fluxes to water from agriculture and woodland, it is estimated that planting could deliver reductions of 70-90%.

Phosphate

As with nitrate, fertiliser and manure inputs are considered to be the main source of phosphate losses from agriculture to water, although often enhanced by soil erosion and sediment delivery. The general absence of phosphate fertiliser use in woodland creation, especially on improved ground, combined with the ability of woodland to protect soils and reduce sediment movement, means that woodland planting could potentially achieve a 90-100% reduction in P losses to water. P export coefficients from woodland and concentrations in runoff can be expected to be at natural background levels for the local typology.

Sediment

Woodland creation provides a semi-permanent, protective land cover, removing the disturbance regime and compacting/poaching pressure associated with arable and livestock grazing activities, respectively. Organic matter inputs in the form of leaf litter and dead wood under woodland and the action of tree rooting will also improve soil structure, rainfall infiltration and the stability of river banks, further reducing the risk of soil erosion. Sediment losses from woodland can therefore be expected to be at or close to natural background levels. There is potential for short-term, increased rates of sediment delivery above background associated with occasional periods of woodland management, mainly linked to initial cultivation and final felling activities. However, these can be effectively minimised through application of good practice measures as described by the Forests and Water Guidelines (Forestry Commission, 2011). Consequently, it should be possible to achieve reductions in sediment delivered to water of 90-100% compared to that associated with improved pasture or arable.

<u>FIOs</u>

Assuming that livestock is excluded from planted woodland, FIO losses should be restricted to background levels typical of managed wildlife. Thus reductions of 90-100% should be achievable compared to intensively grazed pasture.

<u>BOD</u>

Following on from the above, the absence of organic matter amendments to woodland means that BOD concentrations in woodland streams should be at background levels. Reductions of 90-100% are therefore possible.

<u>Pesticides</u>

Pesticide use in woodland is very low and declining. Usage is mainly limited to broad spectrum herbicides such as glyphosate for a few years after planting for weed control. There is also a short-term use of insecticide such as cypermethrin in the form of dipped plants and top-up sprays for one or two years after planting on some restock sites. Field applications are largely confined to spot treatments around the base of each newly planted tree, greatly reducing the scope for losses to water. Consequently, reductions of 90-100% can be expected compared to intensive agriculture systems.

<u>Ammonia</u>

There are no ammonia fertiliser applications to woodland and thus planting will exclude this form of N pressure. Potential reductions should be similar to nitrate and within the range 70-90%, depending on local N deposition.

Woodland planting as an intervention to buffer the effects of the agricultural polluting activity on the upslope or adjacent land

<u>Nitrate</u>

Woodland buffers have the capacity to remove a portion of the nitrate from through-flowing waters. In common with most of the other pollutants considered below, much depends on the nature of water pathways, the form of the pollutant, and the width, structure and management of the buffer area. Buffers will have very little effect on pollutants moving by deeper groundwater pathways or via artificial drains that bypass the buffer. Their effect on attenuating dissolved pollutants in overland flow is also likely to be limited where discharge rates are high, as will be the scope for the uptake of nutrient pollutants outside of the growing season or when the woodland is just planted, felled or old aged.

Nitrate uptake will be greatest for unsaturated or slow saturated flow/drainage through a wide buffer of young, fast growing woodland such as short rotation coppice crops of willow or poplar, or conifer stands. Removal will also be strong where seepage occurs through wetter/waterlogged buffers more typical of riparian systems, where denitrification and microbial immobilisation will predominate. Excessive N loadings from the adjacent land can saturate the buffer, as can high atmospheric N deposition. The latter can occur downwind of local N emission sources and could potentially exceed losses from some agricultural crops. Overall, it is estimated that reductions of 50-90% of pollutant fluxes draining from upslope agricultural activities may be possible for appropriately designed woodland buffers.

Phosphate

P removal is likely to be greatest where this is bound to sediment. Buffers can be very effective at filtering out sediment in overland flow, either from waters flowing through surface vegetation (via settlement or attachment) or by enhancing soil infiltration. While surface leaf litter, roots and dead wood can promote sediment capture and retention, this can be increased by maintaining a cover of ground vegetation (e.g. either by managing the woodland design and canopy structure, or by incorporating a grass edge). The scope for curtailing dissolved P losses will be dependent on maintaining active tree growth/uptake and avoiding soil saturation. Strong retention could be achieved where woodland buffers divert/infiltrate more surface runoff into the soil, especially into mineral soil horizons with a strong P adsorption or fixation capacity. P removal rates are expected to range between 70-100%.

Sediment

As noted above, appropriately designed woodland buffers can effectively intercept and retain sediment in runoff, preventing delivery to watercourses. They can also strengthen and protect river banks and adjacent steep side slopes from erosion, reducing the risk of bank collapse and debris flows. Effectiveness at removing suspended sediment is directly proportional to particle size, being lowest for very fine material such as colloidal clays. Retentions of 50-100% are achievable, depending on particle size (e.g. 50% for clay and 90% for silt).

FIOs

Limited data are available to judge the effectiveness of woodland buffers for removing FIOs in surface runoff. Removal is likely to be good where the main sources are livestock entering watercourses (which can be excluded) or where volumes of polluted runoff are low and most water can be diverted through the soil. In such cases, reductions of 50-100% may be possible.

BOD

The scope for woodland buffers to reduce BOD is thought to be similar to that for FIOs and therefore fall in the range of 50-100%.

Pesticides

Retention of dissolved pesticides will depend on many factors, including runoff pathway, the type of pesticide and its properties (including solubility, soil adsorption, persistence and volatility), timing of application, and rate/volume of water flow. Woodland buffers can also be effective at reducing spray drift and contamination of waters from pesticide applications on adjacent land, depending on wind conditions and buffer width. Overall, reductions of 60-100% are thought to be achievable.

Ammonia

The efficacy of woodland buffers at removing dissolved ammonia is expected to follow that of nitrate (50-90%; see above). The main exception is in areas of high N deposition, where woodland buffers can be very effective at scavenging gaseous ammonia from the atmosphere. In such circumstances, N fluxes to water could exceed those from some agricultural crops. It is possible to utilise this factor to help protect more vulnerable habitats downwind by planting a protective belt of woodland (especially conifer) in-between. Since this will increase ammonia leaching to local waters care is required in site selection.

References

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	Nitrate	Phosphate	Sediment	FIOs	BOD	Pesticides	Ammonia
Replacement of agricultural activity forming pollutant source	70-90%	90-100%	90-100%	90-100%	90-100%	90-100%	70-90%
Planting of woodland buffer, either riparian or downslope/field edge	50-90%	70-100%	50-100%	50-100%	50-100%	60-100%	50-90%