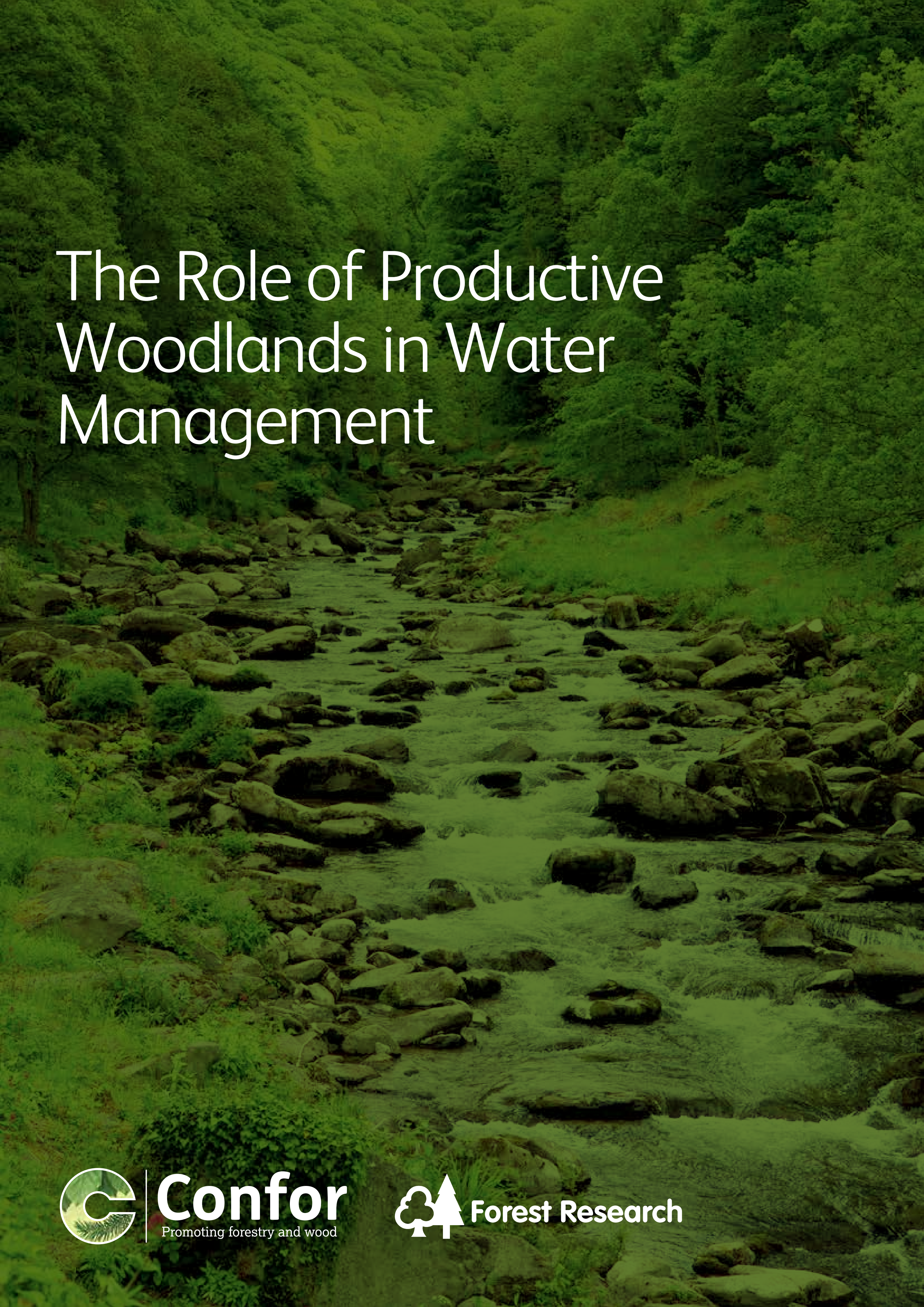

The Role of Productive Woodlands in Water Management

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Promoting forestry and wood

Forest Research

1.0 Introduction

The benefits of woodland for water are increasingly being recognised and influencing approaches to woodland creation. For example, since April 2012, the English Woodland Grant Scheme has included an enhanced grant rate to encourage woodland planting where it could help reduce flood risk for affected communities, including in downstream towns and cities, and improve the freshwater environment. This had delivered around 1,800 ha of new woodland across the country by December 2013. Much of the planting has involved non-productive woodland with little or no conifer, partly informed by the widely held view that more natural, less intensively managed woodlands are best for water.

Perceived negative associations between productive woodlands and water are largely historic, an apparent legacy from the large scale, upland conifer afforestation of the last century. These issues have been addressed by major developments in forest design and management over the last 20 years, starting with the introduction of the first edition of the Forests and Water Guidelines (1988) and culminating in the publication of the UK Forestry Standard and fifth edition of the guidelines in 2011. As a result, planting productive woodland can offer similar and in some cases greater benefits to the water environment than non-productive woodlands. Additionally, productive woodlands deliver greater economic and environmental benefits by providing timber or wood fuel for the market, supporting economic growth and employment, and contributing to carbon sequestration.

As the UK continues to import 75-80 per cent of its timber, there is a growing call to meet more of our needs from home-grown, sustainably managed, productive woodlands. The income secured through the sale of timber will also help secure the continued delivery of water (and other) benefits from the woodland. This leaflet describes the water benefits that can result from investing in an expansion of well-designed, productive woodlands.

Planting productive woodland can offer similar and in some cases greater benefits to the water environment than non-productive woodlands.


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2.0 What do we mean by productive woodlands?

'Productive woodland' is defined in Government open habitats policy for England as woodland likely to achieve, at least, yield class 10 for conifers and yield class 6 for broadleaves, i.e. reasonable annual growth.

This usually means sites with more productive soils and the selection of appropriate tree species and provenance to suit local site conditions, now and in future. They are designed with a minimum planting density of 2,250 trees per ha and a varied structure in terms of tree age, species and open space, increasing resilience to climate change and pests and disease. Significant areas of open space (minimum 10 per cent) and non-productive ground (minimum 5 per cent) are incorporated to enhance habitat diversity and connectivity for species, such as along streamsides.

Productive woodlands are sustainably managed in line with the UK Forestry Standard and supporting guidelines. A range of standard practices are applied such as ground preparation, tending, thinning and felling to ensure successful establishment, tree growth and eventual harvesting of a productive crop of timber and/or wood fuel. Woodland size is variable, although productive woodlands tend to be larger for ease of management and economic return.

Productive woodlands are sustainably managed in line with the UK Forestry Standard and supporting guidelines.

3.0 Managing flood risk

Forests and woodlands have long been associated with an ability to reduce flood flows compared to other land uses. There are four main ways that woodland can help:

» the greater water use of trees reduces the volume of flood water at source;

» the higher infiltration rates of woodland soils reduces rapid surface runoff and flood generation;

» the greater hydraulic roughness exerted by trees, shrubs and large woody debris (LWD) along streamsides and within floodplains acts as a drag on flood waters, slowing down flood flows and enhancing flood storage; and

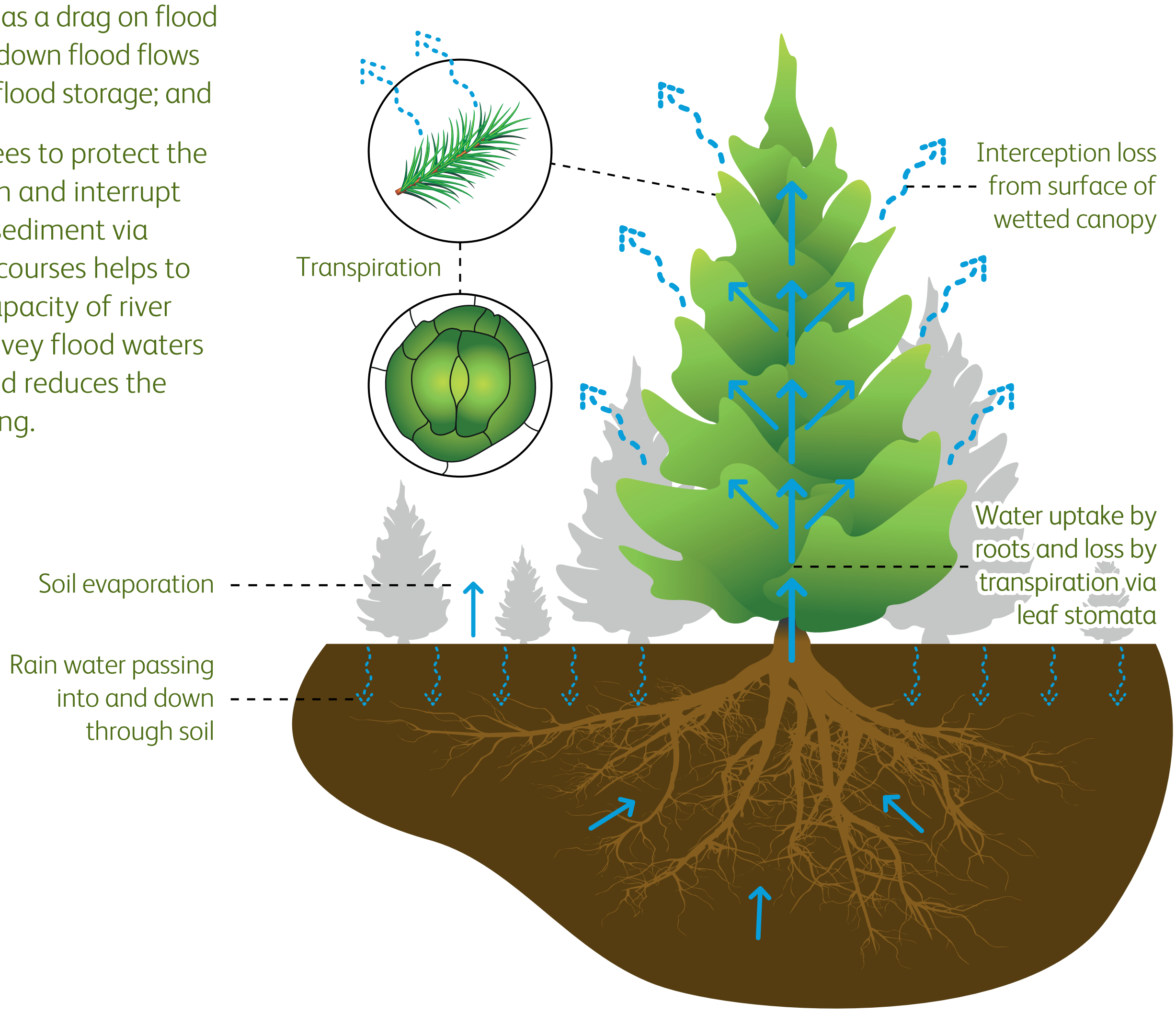
» the ability of trees to protect the soil from erosion and interrupt the delivery of sediment via runoff to watercourses helps to maintain the capacity of river channels to convey flood waters downstream and reduces the need for dredging.

The planting of **productive woodland can enhance a number of these benefits,** as described below:

Water Use

Water use tends to be greatest for productive woodland, especially conifers. This reflects the larger evaporation or 'interception' of rain water by conifer canopies, which can reduce the volume of rainfall landing on the ground by 25-45 per cent on an annual basis, compared to 10-25 per cent for broadleaves. While the effect reduces for shorter periods of more intense rainfall associated with flash floods, there remains a significant daily interception loss, at least for conifers (6-7 mm/day for conifers vs 1-2 mm/day for broadleaves). While broadleaves demonstrate lower water use, the taller and more developed canopies of productive broadleaves, together with their higher growth rates, could be expected to enhance the evaporative loss compared to non-productive woodland.

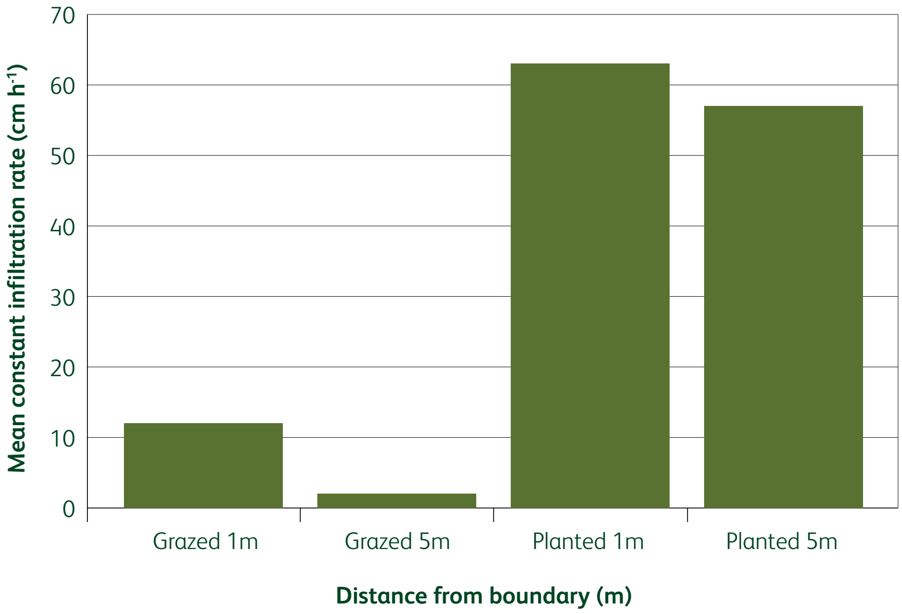
In addition, the cumulative effect of the greater water use of productive woodlands over consecutive days can lead to drier soils and a build-up of a higher soil moisture deficit during the growing season. This can amount to 10s of millimetres of additional potential soil water storage in drier parts of the country, which could help to significantly reduce flood runoff during summer storms. With climate warming predicted to lead to more extreme summer rainfall events, this could become increasingly important. The soil-drying effect is usually lost after re-wetting of soils in the autumn, so it will have less influence on winter floods.



Soil Infiltration

Soil infiltration rates are generally high under all types of woodland, although the drier soils under productive woodland may make them better able to receive and store rainfall, at least during summer and autumn periods. Studies have found infiltration rates to be up to 60 times higher within woodland shelter belts compared to grazed pasture. A particular benefit of productive woodland results from the use of ground preparation for planting. Shallow cultivation can be very effective at disrupting surface compaction in grazed pasture or plough pans in cultivated agricultural soils, markedly increasing rainfall infiltration into the soil and thereby reducing rapid surface runoff that would otherwise contribute to flood flows.

A comparison of mean soil infiltration rates along a transect from sheep grazed pasture into a woodland shelterbelt, at Pont Bren in mid Wales (from Carroll *et al.*, 2004).



Studies have found infiltration rates to be up to 60 times higher within woodland shelter belts compared to grazed pasture.

3.0 Managing flood risk (continued)

Hydraulic Roughness

Productive woodland has mixed effects on hydraulic roughness. The closer tree spacing, coupled with the large average size and multiple stemmed nature of the trees (in the case of short rotation coppice) presents a high roughness to flood flows. This is partly offset by the smaller amounts of LWD and reduced scope for LWD dams to form, as well as by the potentially lower sub-canopy roughness of the less developed shrub and ground vegetation layers. Depending on the scale, design and timing of the work, hydraulic roughness will be temporarily removed at harvesting, reducing the flood benefit for a number of years.

The aquatic environment is very sensitive to heavy shading and the design of productive woodland reflects this by targeting the planting of broadleaves and open space to stream-sides. Productive broadleaves can be well-suited to riparian zones, including energy crops such as short rotation coppice, which can deliver rapid establishment of hydraulic roughness. They can also facilitate the construction and maintenance of LWD dams in preferred locations. Regular harvesting of the crop should be carefully designed and managed to maintain some functionality in all years, as well as to minimise potential impacts on soils and water yield.

Soil Protection

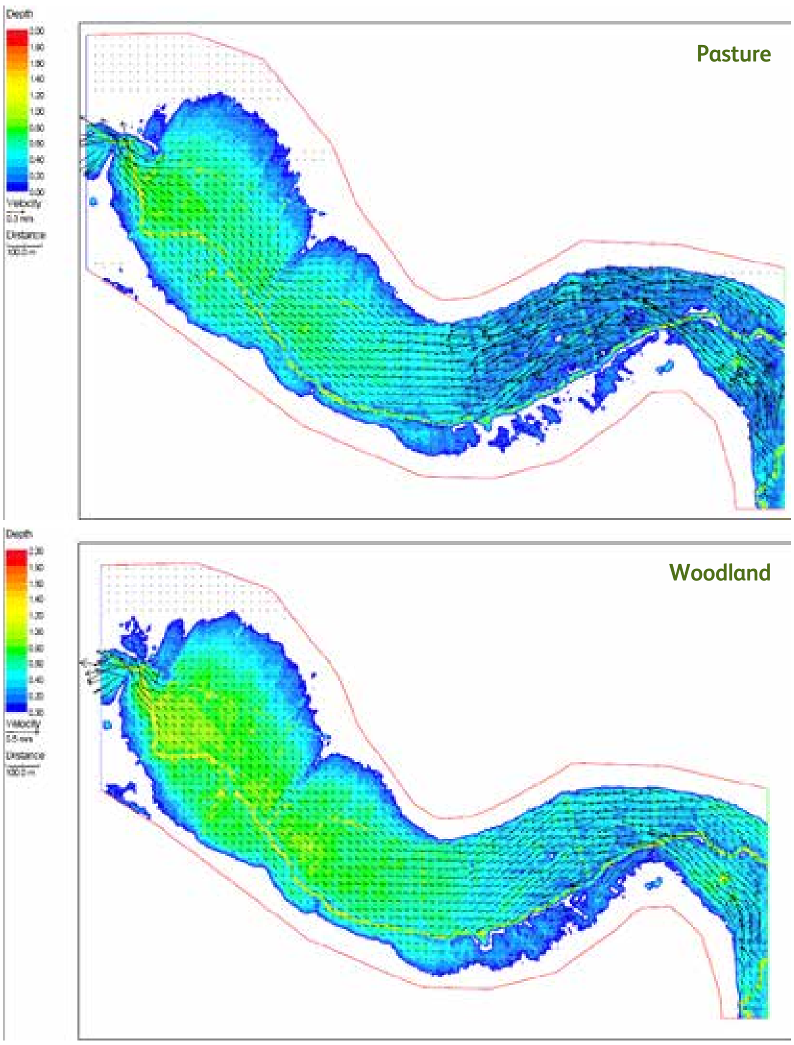
Management interventions associated with productive woodlands have the potential to disturb the soil and increase sediment delivery to watercourses. These risks are controlled by the water requirements and guidelines under the UK Forestry Standard, which means that well-designed and managed productive woodlands should pose a low risk of soil damage and erosion, securing a similar, soil-mediated, flood benefit to that provided by non-productive woodland.

Scale

In general, the greater the area of planting within a catchment, the greater the benefits and the scope for woodland creation to make a significant contribution to flood risk management. Since productive woodlands tend to be larger and more economical, and often more attractive to landowners, there is greater potential for achieving a sizeable level of land use change – so it is, therefore, more likely that the planting of productive woodlands will deliver the required scale of change to reduce downstream flood flows, especially in larger catchments.

It is more likely that the planting of productive woodlands will deliver the required scale of change to reduce downstream flood flows.

A comparison of model predictions of flood depth and water velocity between woodland and grassland along a 2.2 km length of the River Cary in Somerset, showing how floodplain woodland is more effective at slowing down and holding back flood waters (from Thomas & Nisbet, 2007)



4.0 Managing diffuse pollution

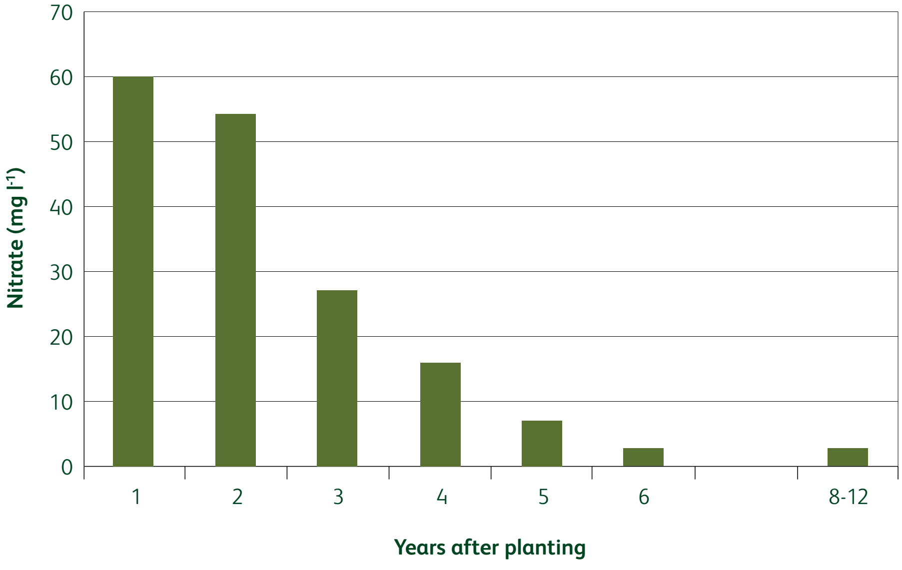
Water quality is generally very high in streams and rivers draining woodland and a tree cover is often the preferred choice for water managers to protect water supplies. This has led to increasing interest in woodland creation to help address the large diffuse pollution pressures acting on the water environment from agriculture and other intensive land use activities, which tend to be greatest within the lowlands. There is strong evidence to show that woodland can be very effective at reducing the delivery of a range of diffuse pollutants to water, including phosphate, nitrate, pesticides, sediment and Faecal Indicator Organisms (FIO). The benefits of woodland planting partly reflect the simple removal of the high polluting activity but also the ability of woodland buffers to intercept and retain pollutants draining from such activities on upslope or adjacent land. Productive woodland can be particularly effective at pollutant capture and removal, as described below:

Replacement function

Pollutant inputs are generally very low to productive woodlands. Fertiliser needs should be small or absent for planting on the more productive soils, leading to low nutrient concentrations in drainage waters. The main exception concerns the enhanced capture of nitrogen pollutants from the atmosphere by conifer woodlands, especially within drier lowland areas. Here, high water use by conifers can further increase nitrate concentrations, causing a problem for water quality. Pesticide use in productive woodlands is declining and rarely impacts on water, being limited to spot applications of herbicide or insecticide for the first few years after planting and/or restocking. Sediment losses to water are low, as are FIO inputs, especially where fencing excludes livestock, reducing the risk of direct faecal contamination.

Acidification is an important issue in some acid-sensitive upland areas, and concern remains about the ability of tree canopies to increase the capture of acidic sulphur and nitrogen pollutants from the atmosphere. While emission reductions are continuing to promote recovery and reduce the significance of the forest effect, restrictions on large-scale forest planting and restocking are likely to persist for a number of years or even decades in the worst affected areas. This applies to both conifer and broadleaved woodland in view of the relatively small difference in pollutant scavenging between the two. However, if nitrogen emissions lead to greater soil nitrogen saturation in the future, it is possible that this could be countered by the higher uptake and removal of nitrogen by productive woodlands.

Average response in nitrate concentrations in water draining through the soil profile at 75-90 cm depth following afforestation of former arable land at nine sites in Denmark (from Hansen *et al.*, 2004)



Water quality is generally very high in streams and rivers draining woodland.

Interception function

Productive woodlands can be particularly efficient at intercepting and reducing the delivery of diffuse pollutants to water from upslope land. For the nutrients nitrate and phosphate, this mainly reflects the strong nutrient demand by the growing trees, which is maintained by regular thinning or harvesting. Such active management ensures woodland buffers do not become saturated by high nutrient inputs in drainage waters as the trees mature.

The fast establishment and dense canopies of productive woodland are very effective at reducing pesticide spray drift, especially for evergreen conifers, while their high water use and drier soils help to reduce the contamination of surface runoff. The latter factor may also act to reduce the delivery of sediment and FIO to watercourses, provided runoff volumes are not excessive.

Incorporating a grass edge to the productive woodland buffer will minimise loss of the water use effect when surface runoff is sustained and saturates the buffer.

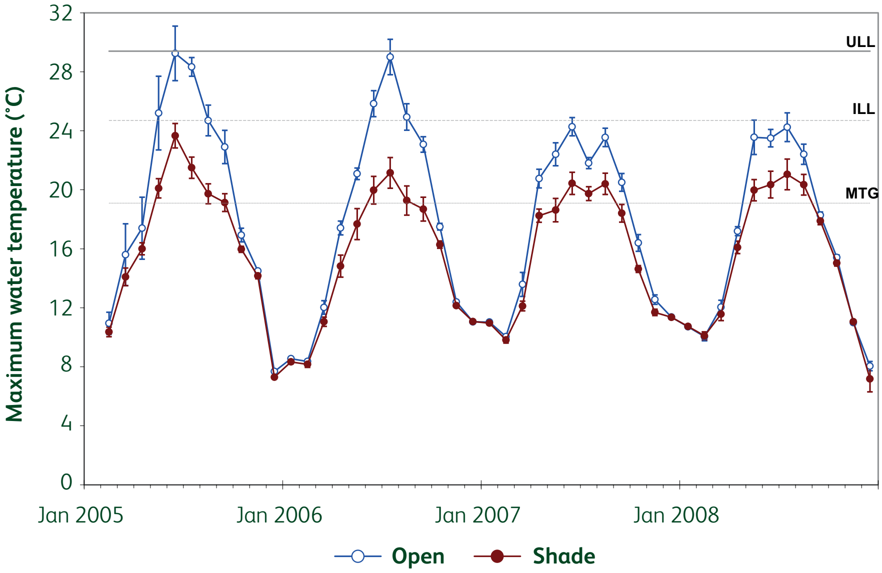
Some water quality benefits of productive woodland buffers can be diminished in riparian situations due to restrictions on conifer planting, limited water use by productive broadleaves, the wetter nature of riparian soils and dominance of surface runoff pathways. The additional benefits that productive compared to non-productive broadleaves can offer are likely to be limited to a greater phosphate removal by tree uptake and reduced pesticide spray drift due to presenting a better physical barrier. Productive broadleaved riparian woodland buffers can present greater risks of soil damage and diffuse sediment pollution due to the vulnerability of riparian soils to management interventions.

Productive woodlands can be particularly efficient at intercepting and reducing the delivery of diffuse pollutants to water from upslope land.

5.0 Managing other water issues

Other benefits provided by woodland include helping to reduce thermal stress to freshwater life by the cooling effect of canopy shade, and improving river channel and bankside morphology through tree rooting and LWD inputs. These both relate to the riparian zone and are greatest for broadleaves. Managing this zone as productive broadleaves can help to optimise and maintain levels of canopy shade for local objectives, as well as support the development and maintenance of LWD dams.

A comparison of the annual variation in water temperature between shaded (solid symbols) and open (open symbols) lengths of stream in the New Forest in southern England: ULL = Ultimate Lethal Limit for brown trout; ILL = Incipient Lethal Limit; MTG = Maximum Temperature for Growth (from Broadmeadow *et al.*, 2010)



6.0 Managing potential dis-benefits

The Forests and Water guidelines recommend avoiding large-scale planting of productive woodlands in areas where their potentially high water use is an issue for the maintenance of water flows. While climate warming could accentuate this problem by enhancing canopy evaporation, rising carbon dioxide concentrations may offset this by increasing the efficiency of water use by trees.

Other benefits provided by woodland include helping to reduce thermal stress to freshwater life by the cooling effect of canopy shade.

7.0 Conclusions

Society is increasingly threatened by flooding, while the water environment remains seriously impacted by a range of human pressures, including diffuse water pollution. There is strong evidence to support woodland creation in appropriate locations to help manage these issues.

Productive woodlands are well suited to the purpose and, due to their ongoing management, are more likely to be resilient in the face of a changing climate and pests and disease. They can offer significant benefits to the water environment, as well as safeguarding and growing investment and jobs in the UK forestry industry, securing domestic timber supplies, reducing imports and capturing more carbon. Opportunity mapping by Forest Research is helping to identify, map and target areas where woodland creation can maximise water benefits and minimise risks. Linking this to information on species suitability and potential productivity can show where planting productive woodlands will deliver the greatest benefits. This can be applied across a range of scales, from assessing opportunities for planting at a strategic regional or river basin level down to the practical farm scale.

They can offer significant benefits to the water environment as well as safeguarding and growing investment and jobs in the UK forestry industry.

There is a strong case for further investment in well-targeted woodland creation to help meet a wide range of environmental and social goals, including contributing to the Floods Directive, Water Framework Directive, Biodiversity 2020, Greenhouse Gas reduction, climate change adaptation and growing the rural economy.

There is strong evidence to support woodland creation in appropriate locations to help manage these issues.

8.0 Further reading and useful sources of information

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Confor, 59 George Street, Edinburgh EH2 2JG
Telephone: +44 (0) 131 240 1410

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