Forest Research

Forests for Water Services: A Step-by-Step Guide for Payment Schemes

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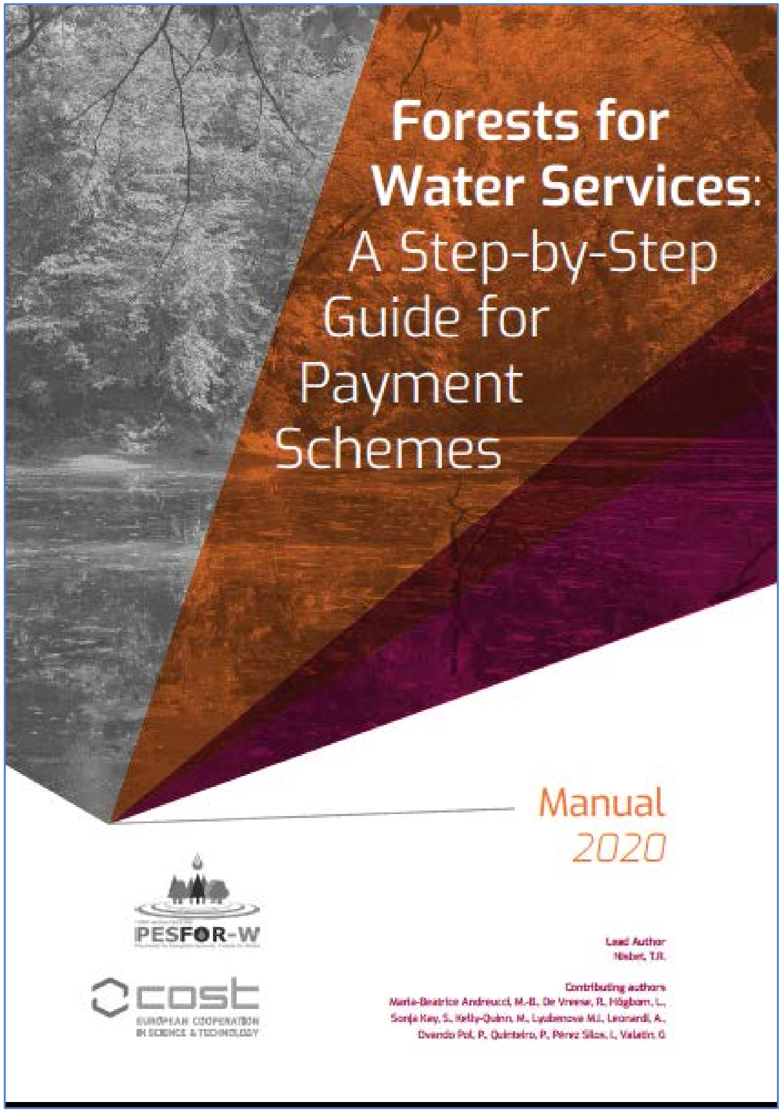

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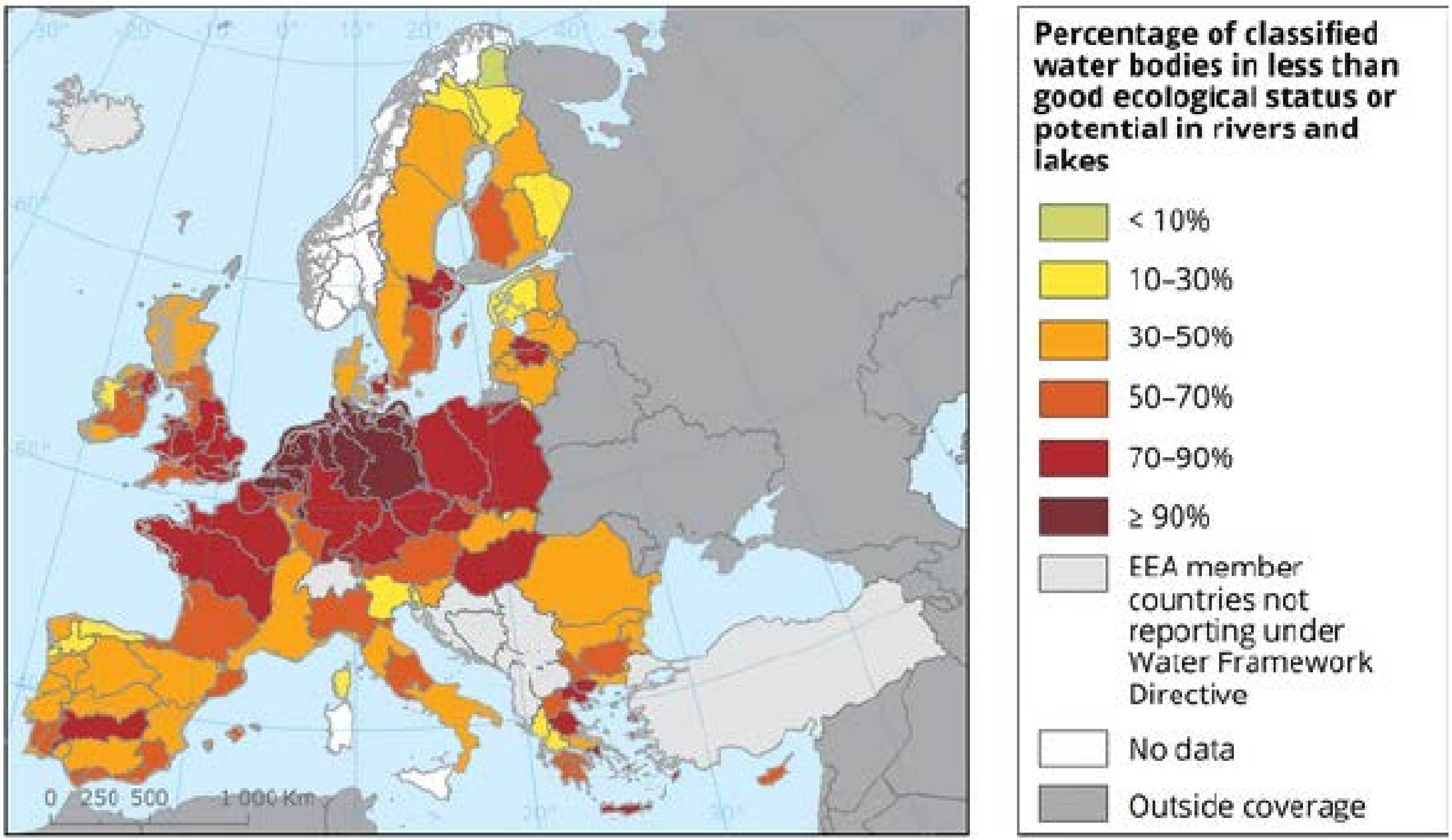
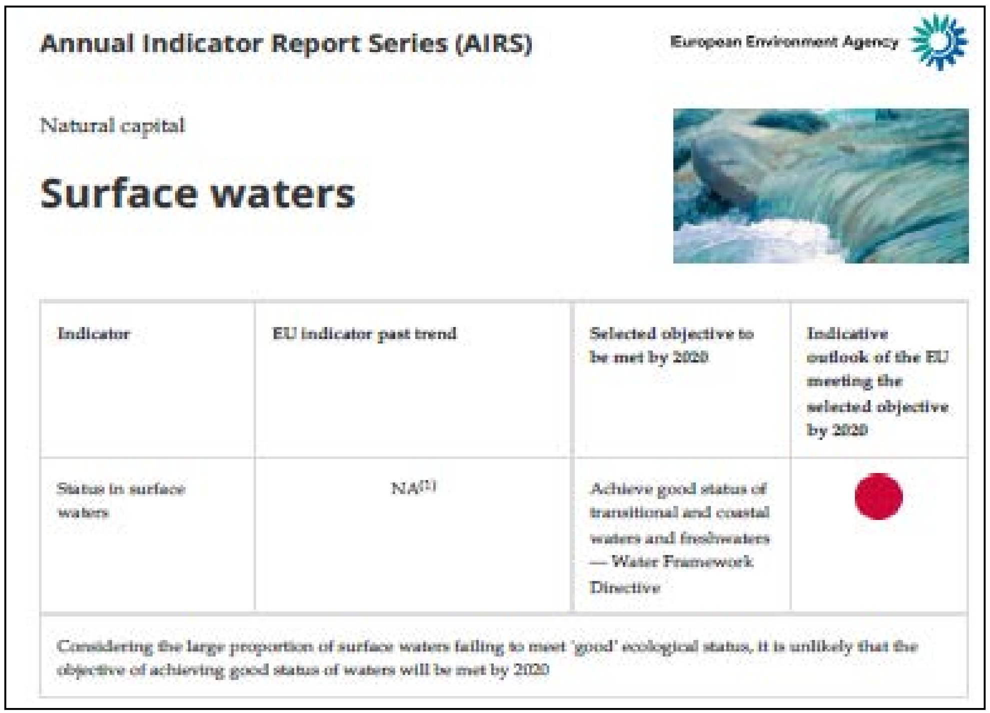
Status of Europe's Waters

Around 60% of surface water bodies in Europe are at less than Good Ecological Status



Diffuse pollution is a major problem – 38% of RWBs in EU24 fail due to diffuse pollution; 90% of RBMP's identify agriculture as primary source



Annual Indicator Report Series (AIRS)

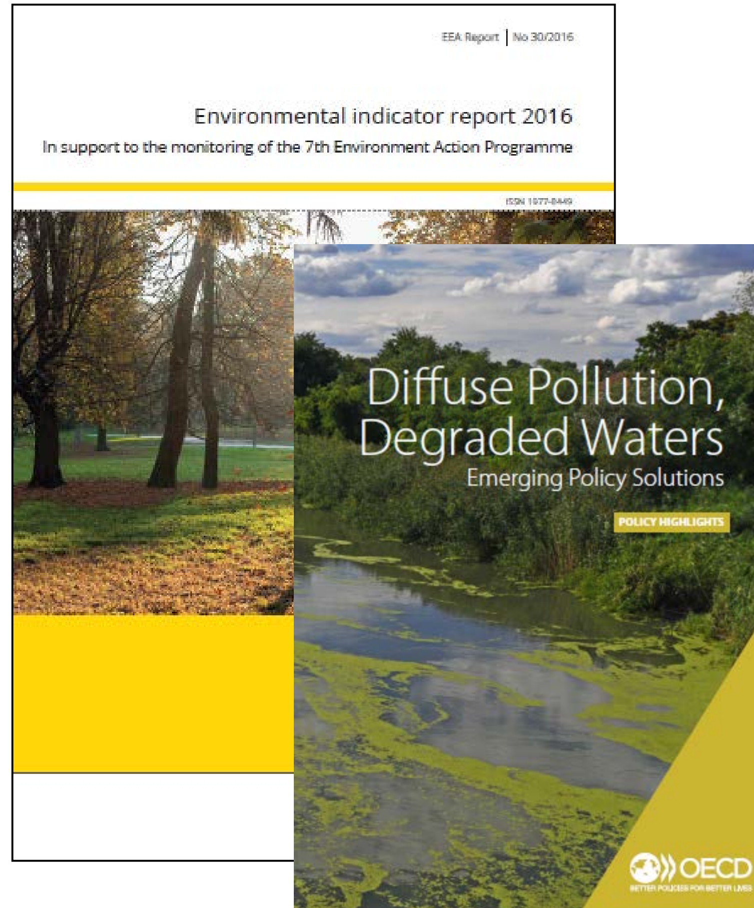
European Environment Agency

Natural capital

Surface waters

Indicator	EU indicator past trend	Selected objective to be met by 2020	Indicative outlook of the EU meeting the selected objective by 2020
Status in surface waters	NA[1]	Achieve good status of transitional and coastal waters and freshwaters — Water Framework Directive	

Considering the large proportion of surface waters failing to meet 'good' ecological status, it is unlikely that the objective of achieving good status of waters will be met by 2020



Limits of Good Agriculture Practice

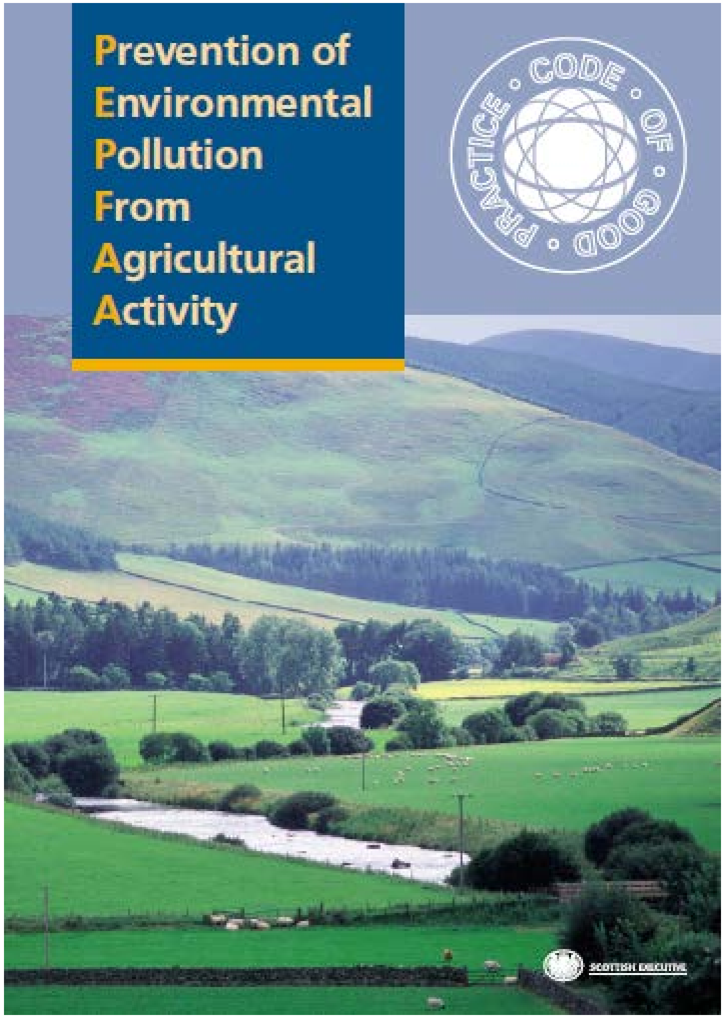


Table 16: Estimated percentage reduction in annual losses of pollutants from agriculture

Uptake Level	Nitrogen	Phosphorus	Sediment	Ammonia	Methane	Nitrous Oxide	FIOs
Central	0.9	4.6	0.3	0.5	0.0	1.3	1.7
Low	0.4	3.2	0.1	0.2	0.0	0.7	0.7
High	1.3	5.8	0.5	0.8	0.0	2.0	2.8

(Defra Impact Assessment, 2018)

Table 1: Spillover Costs from Agricultural Water Pollution

Spillover effect of agricultural water pollution	Annual cost to third parties (£m, 2014 prices)
Drinking water quality (surface and groundwater)	16-86
Lost recreational value due to worse water quality	18-46
Poorer fishing	18-45
Freshwater eutrophication	203-399
Marine eutrophication	Not available
Bathing water quality	30-54
River ecosystems and natural habitat impacts	447-626
Wetland ecosystems and natural habitat impacts	16-51
Total	748-1307

EEA State of Water Assessment Report 2018: only 1 to 2% improvement in RWB status between first two River Basin Management Plan Cycles

How Can Tree Planting Help?

- Increased recognition of need for land use change to meet water quality targets (1.5M ha in England);
- Woodland cover protects the soil, removes/reduces fertiliser and pesticide inputs, intercepts pollutants, protects river banks;
- Woodland creation provides a secure and sustainable measure, plus other benefits;
- Careful integration of woodland with farming can reduce land take and increase acceptability;
- But how to deliver woodland creation on high value farmland that is often the main source of diffuse pollution?

To provide guidance on designing appropriate and cost-effective forests for water payment schemes that support tree planting and forest management to protect and improve water quality

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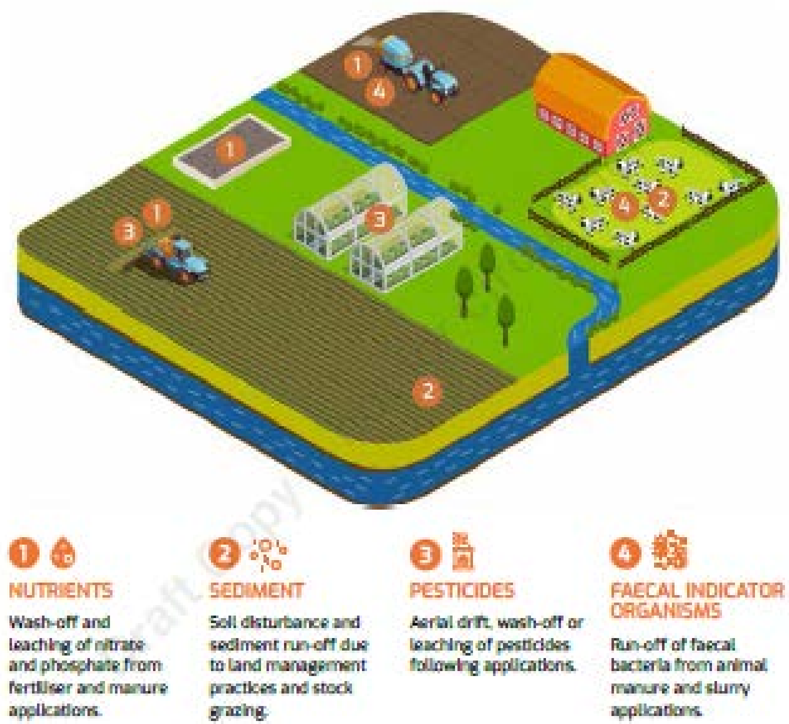
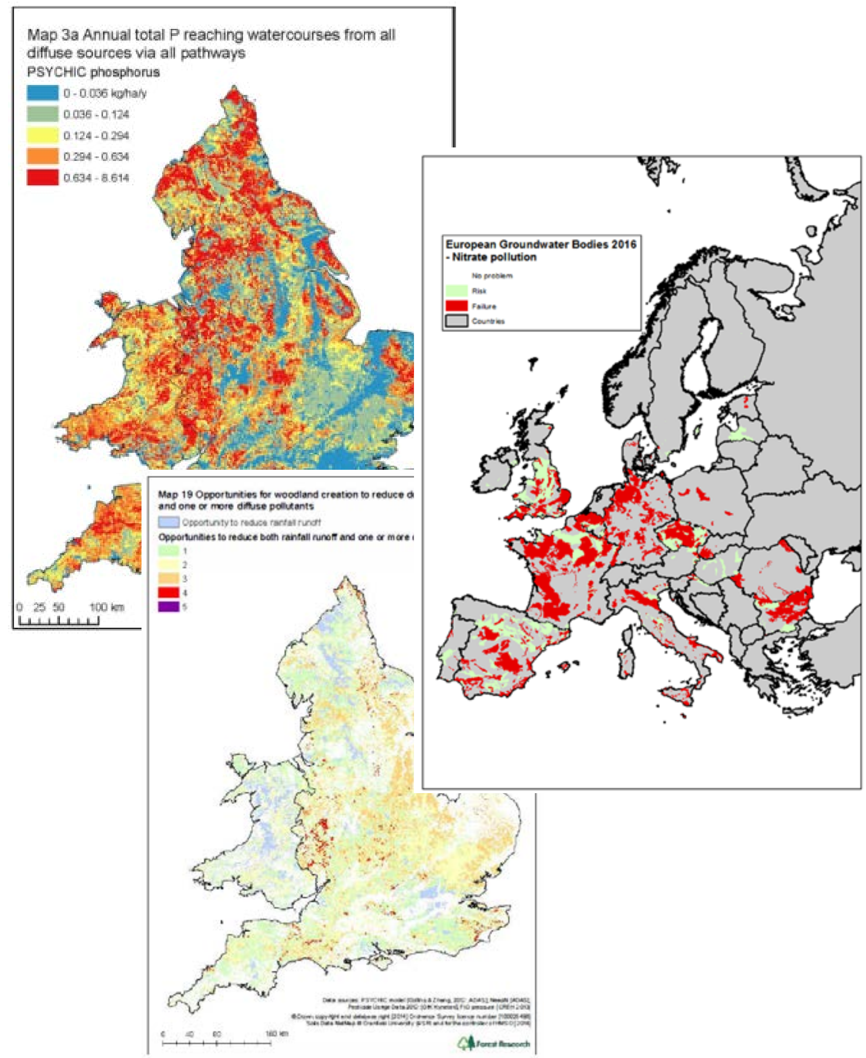


Figure 1
Catchment sources and pathways of agricultural diffuse pollution impacting on the water environment and water users

Role of Opportunity Mapping

Identifying pollutant sources, pathways and receptors:

- Use measured and modelled spatial data for each diffuse pollutant;
- Select water bodies failing good status due to diffuse pollution;
- Map constraints and sensitivities to tree planting;
- Consider other benefits and potential trade-offs.



Where to Plant

1 **ALONG WATERCOURSES**

Tree planting provides a protective buffer from management activities on the adjacent land, reducing nutrient, sediment, pesticide and FIO inputs to water. A tree cover also provides much needed shade and cooling of watercourses, while tree roots strengthen banksides and reduce channel erosion and siltation.

2 **AROUND BOREHOLES**

Tree planting protects local groundwater sources from contamination by nutrients and pesticides.

3 **ON FLOODPLAINS**

Restoring floodplain woodland slows flood flows and retains diffuse pollutants.

4 **AROUND ANIMAL HOUSING**

Tree planting around animal housing captures ammonia and improves air quality.

5 **ALONG WATER PATHWAYS**

Tree planting along and across water pathways increases infiltration of run-off and pollutant retention.

Figure 2
Preferred locations in a farmed landscape for tree planting to reduce diffuse pollution

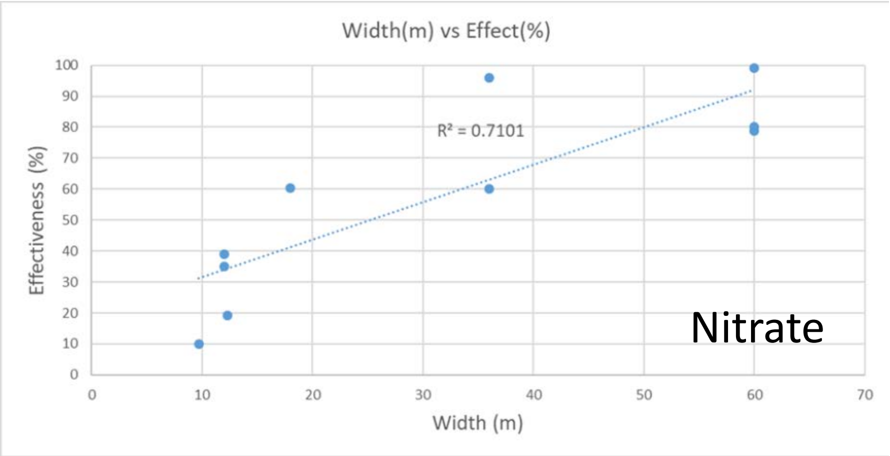
Pollutant inputs are much lower to woodland compared to agriculture

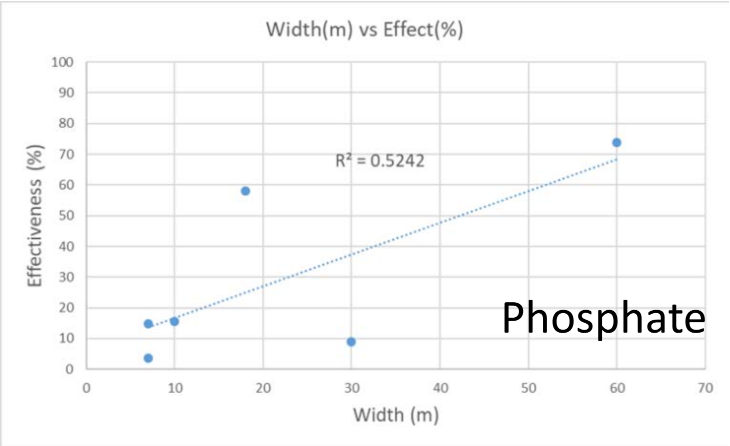
	Permanent Grassland	Rough Pasture	Wheat	Barley	Maize	Oil Seed Rape	Woodland
Nitrogen Input (kg/ha/yr)	94-135	10	131-167	120-132	46-62	155-189	20
Nitrate-N Export (kg/ha/yr)	0.86-10.58	0.02-0.05	1.54-19.72	1.54-19.72	1.52-19.72	3.29-17.4	0.02-0.1
Phosphate Input (kg/ha/yr)	6-16	0	13-35	18-41	27-43	15-37	0
Phosphate Export (kg/ha/yr)	0.012-0.169	0.008	0.038-0.458	0.038-0.458	0.038-0.458	0.15-1.834	0.008

Table 1
Nutrient loads and modelled export coefficients for different crops vs woodland in Great Britain. Nutrient loads taken from the British Survey of Fertiliser Practice for 2000-2011 (BSFP, 2013) and export coefficients based on the same data modelled for the UK National Ecosystem Assessment Follow-on Report (Bateman et al., 2014).

Woodland buffers are effective for removing pollutants draining adjacent land; buffer width is a key factor:

Width	5 m	10 m	20 m	30 m	40 m	50 m
Nitrate (n=38)	20%	30%	40%	55%	70%	80%
Phosphate (n=8)	10%	20%	30%	40%	50%	60%
Sediment (n=11)	89%	90%	91%	92%	93%	94%





Factors influencing effectiveness:

- Nature of existing land use and management practices;
- Condition of water body
- Scale and location of woodland creation;
- Woodland design, e.g. in terms of type, age, shape and structure;
- Woodland management, including scale and timing of practices such as felling;
- Lag times
- Managing potential dis-benefits.

How to Design a PES Scheme

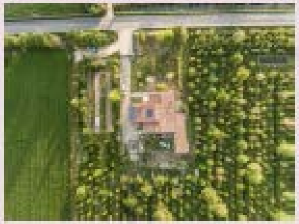
- Define the water quality issue;
- Identify local actors
- Assess the feasibility of a PES scheme;
- Explore potential win-win solutions;
- Define roles and responsibilities;
- Resolve or minimise potential legal issues;
- Draw up technical specifications;
- Formulise scheme contract;
- Monitor, evaluate and review.

CASE STUDY: TREE PLANTING TO PROTECT GROUNDWATER QUALITY

There are three notable woodland for water PES schemes in Denmark. Two of these are located near Odense on Funen and the third near Aalborg on Jutland. All are designed to tackle the growing issue of groundwater pollution by agricultural practices, especially the contamination of drinking water by rising nitrate and/or pesticide levels. The scheme at Aalborg is one of the oldest and established in 1991 with funding from EU LIFE and the Aalborg Municipality to purchase land from farmers within vulnerable groundwater recharge zones. 900 ha of intensive farmland were converted into 500 ha of broadleaved woodland and 400 ha of low-input pasture, primarily to reduce nitrate levels. The drinking water benefit was estimated at a minimum of €489/ha/yr and the net social benefit (excluding drinking water) at €189/ha/yr, which included the provision of local recreation and carbon gain. The two schemes near Odense are Elmelund Skov and Brylle Water, both of which involve woodland creation to reduce pesticide pollution of local groundwater supplies. This is achieved by a voluntary process of land consolidation whereby agricultural land is purchased in low vulnerable areas and used to encourage land swaps with farmers for land within vulnerable groundwater recharge zones. The land is transferred to public or private partners at a reduced price for woodland planting and management, with a permanent change from farmland to forest legally guaranteed. At Elmelund Skov, 380 ha of farmland have been converted to woodland since 2001 under a partnership agreement between the local water utility, the Odense Municipality and the state forestry agency. The Brylle Water scheme is the most recent and commenced in 2014. 156 ha of farmland were purchased and planted with woodland by a private foundation, who met 40% of the cost, with the other 60% funded by the local water utility. The land consolidation process involved a significant transaction cost in negotiating agreements with farmers and building trust. Open access for recreation was a strong component of the schemes and underpinned municipality funding and support.

CASE STUDY: TREE PLANTING TO IMPROVE GROUNDWATER INFILTRATION

This PES scheme is located on the edge of the town of Carmignano di Brenta, near Padua in northern Italy. It was established in 2012 as a 'Forested Infiltration Area' (FIA) to help replenish and improve groundwater resources in the area. Overexploitation of the aquifer had led to the disappearance of local springs and streams, while agricultural activities had degraded groundwater quality. A 2.5 ha woodland was planted on arable (maize) land and a system of trenches dug to channel surface water (at a rate of ~1 million cubic metres per hectare per year) onto the site during periods of excess flow in the nearby River Brenta. The establishment of the woodland helped to facilitate water infiltration into the aquifer and enhanced phyto-purification, removing nutrients and other contaminants. The woodland also provided a carbon gain to the landowner and woodland products such as firewood, biomass and timber in the longer-term, as well as benefiting the local community as a valuable habitat and opportunities for recreation and education. A group of local and regional stakeholders, including municipalities and local companies, formed a partnership to bid for supporting funds that were used to design and set-up the PES scheme on private farmland. Around 80% of implementation costs were financed by LIFE+ and RDP funds. The loss of income to the landowner from the change in use from maize cropping to woodland was exceeded by payments from the Brenta Land Reclamation Board for the infiltration water service (€1,200/ha/yr), the municipality for community access and related recreation and education events (€1,500/yr), plus the value of generated wood products and carbon gain.



Cost Effectiveness Analysis

- Identify water quality issue and desired level of improvement (e.g. concentration or load);
- Estimate amount of planting or other measures to achieve target (modelling);
- Calculate aggregate cost over life span of measure(s);
- Compare measures by dividing aggregate cost by environmental benefit index or a benchmark cost comparator;
- Estimate value and costs of other benefits and any dis-benefits, and calculate net cost;
- Calculate average and range of cost-effectiveness ratio – consider using Marginal Abatement Cost Curves;
- Select least cost measure or mix of measures to secure target in required time frame.

Any questions or comments on the guide?

- Anything wrong?
- Any gaps?
- Easy to follow?
- How useful?
- Scope to apply?
- If not, what needs to change?
- Any interest in exploring application in UK?