Forest Research

Forest–Water Interactions

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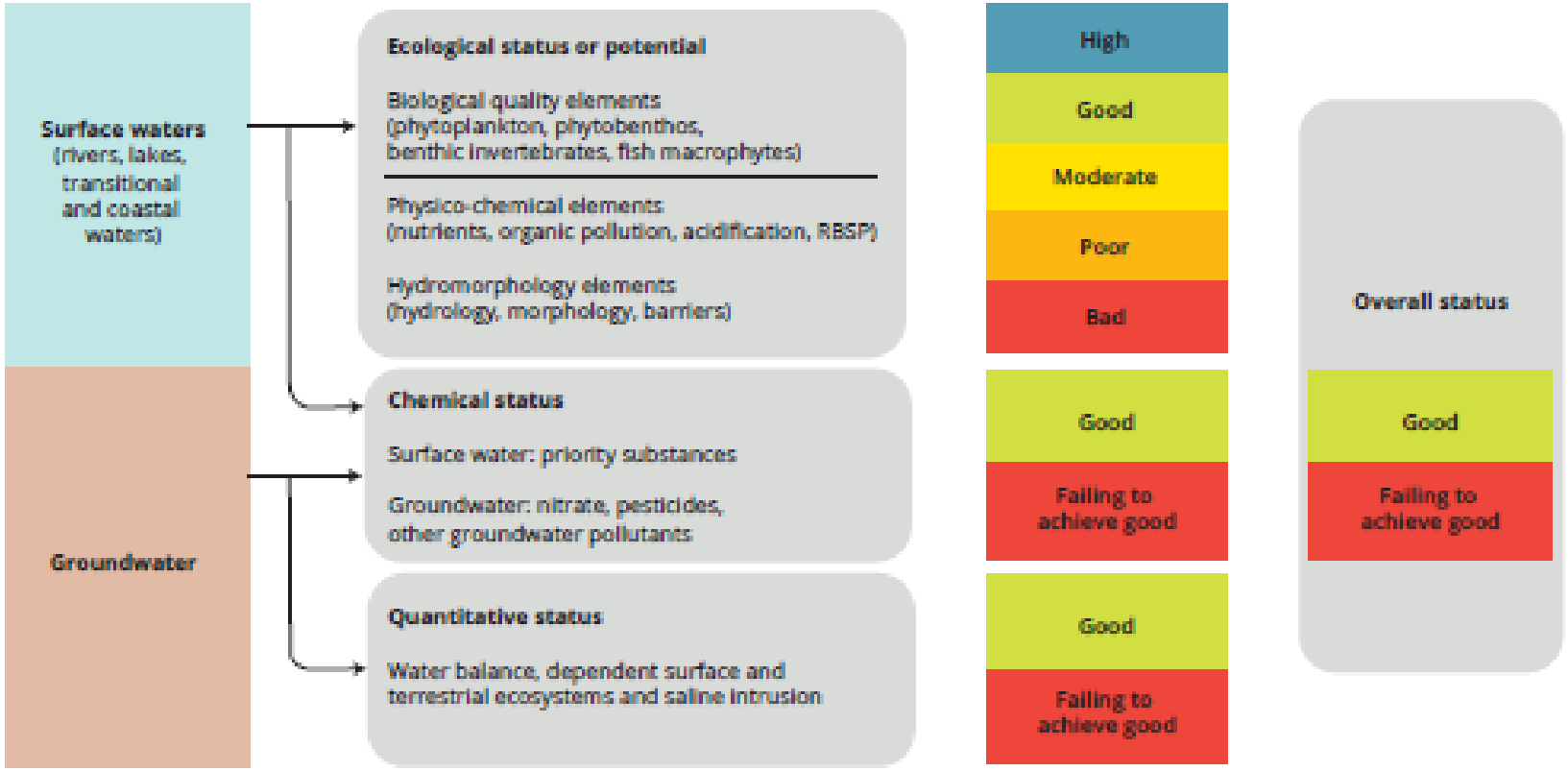
cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

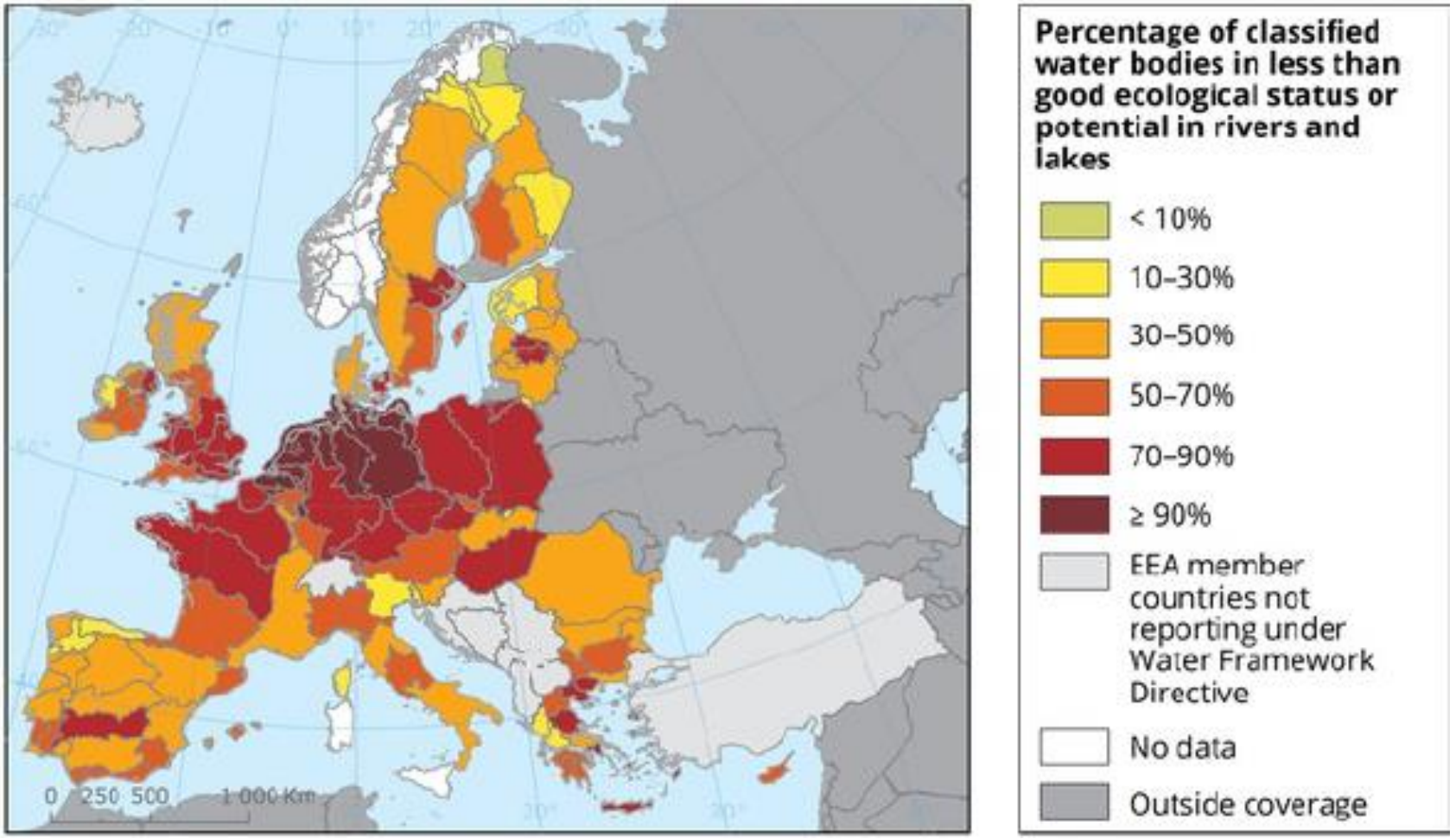
Funded by the Horizon 2020 Framework Programme of the European Union

COST Action CA15206
PESFOR-W
Payments for Ecosystem Services Forests for Water

Water bodies are required to achieve Good Water Status by 2027

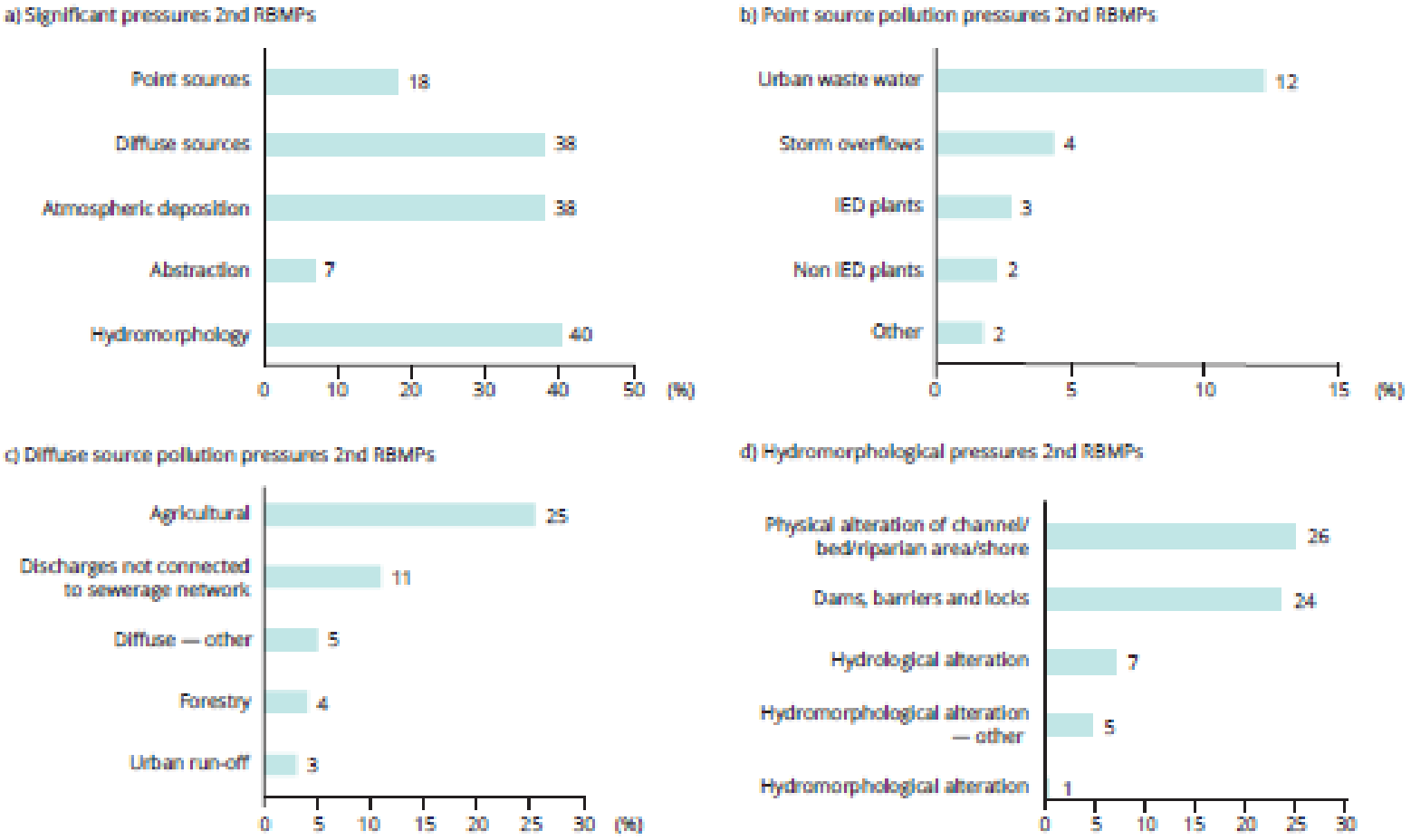


Around 60% of surface water bodies in Europe are at less than Good Ecological Status



Main Pressures on Surface Waters

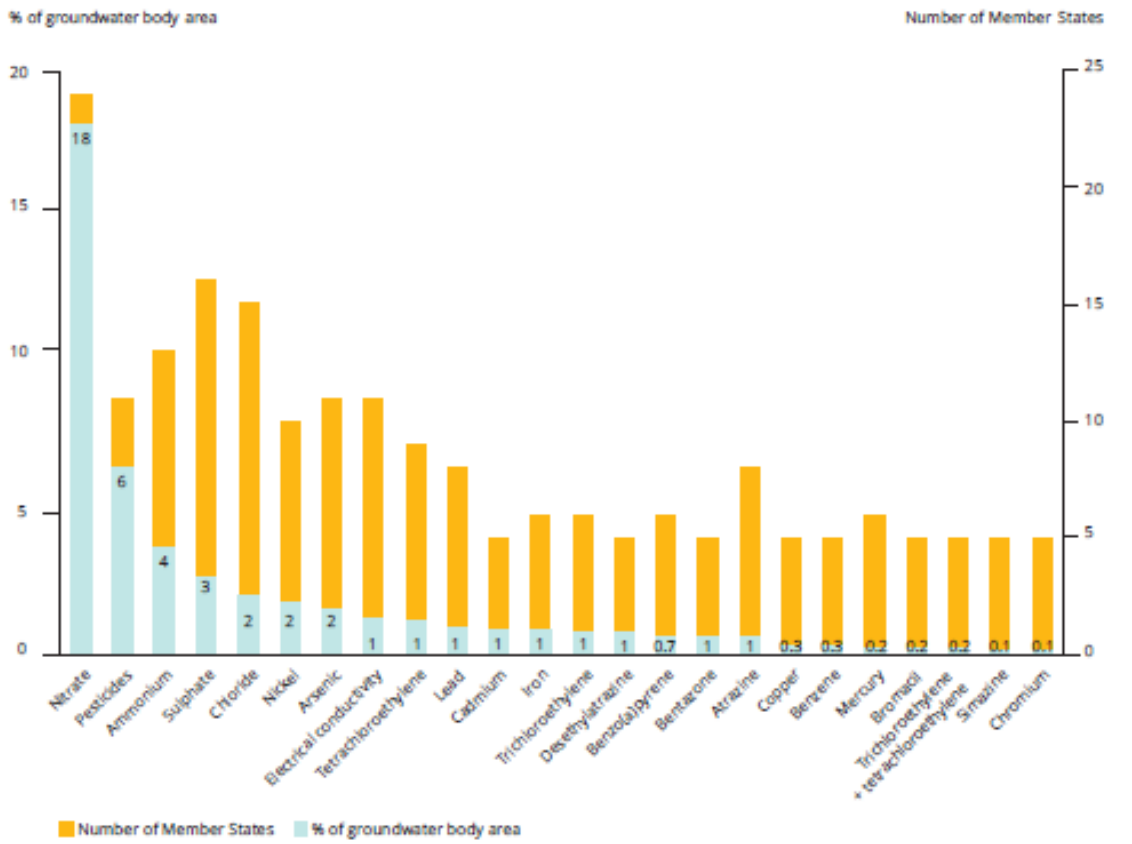
Figure 2.8 **Proportion of water bodies affected by a) main pressures, b) detailed point source, c) diffuse source and d) hydromorphological pressures**

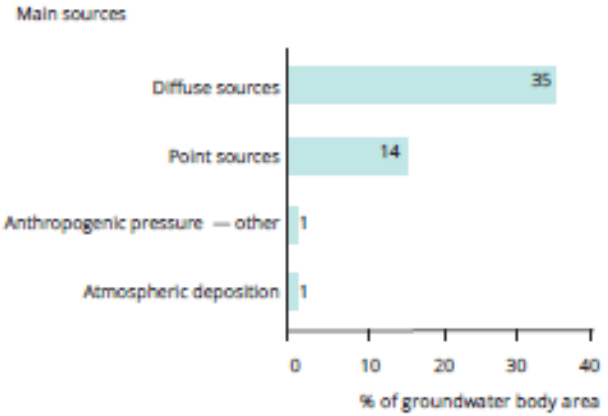


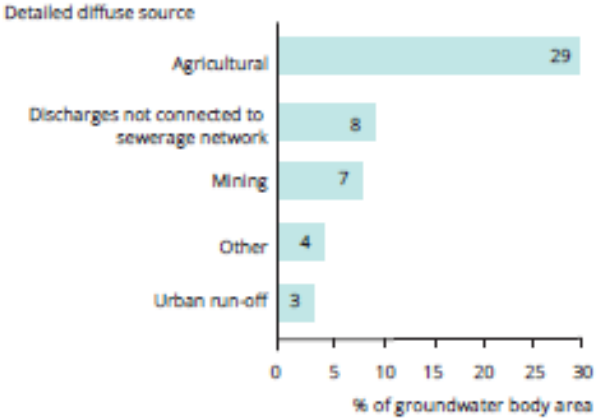
Main Pressures on Groundwater

Agriculture is also the main pressure causing groundwaters to fail Good Chemical Status

Figure 4.3 Groundwater pollutants causing poor chemical status in at least five Member States







Impact of Diffuse Pollution

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)

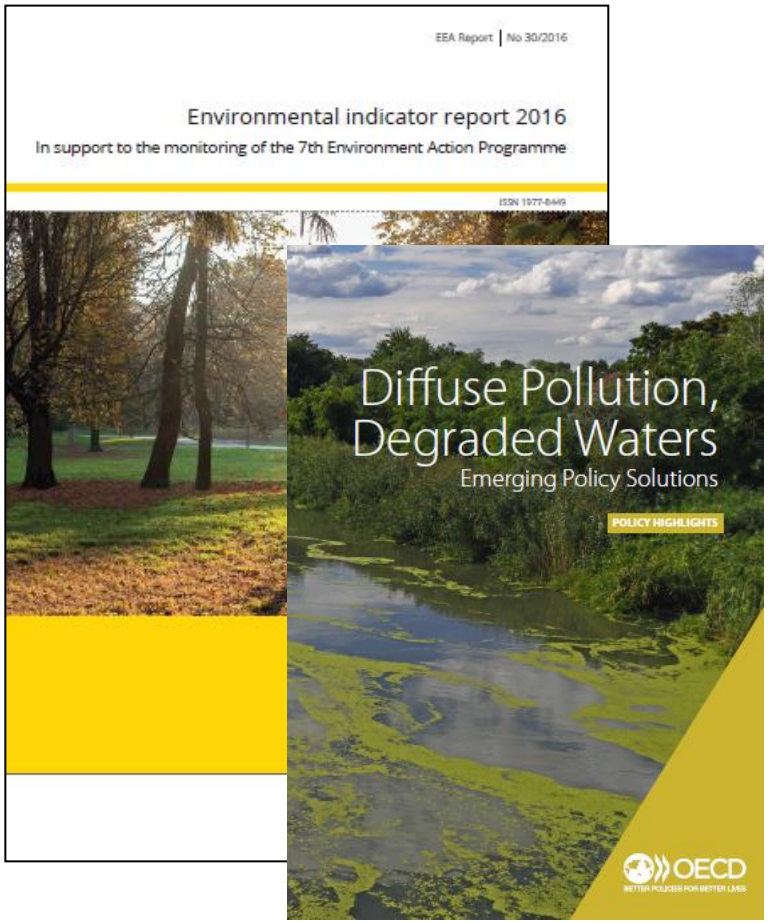
European Environment Agency

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



Role of Best Agriculture Practices

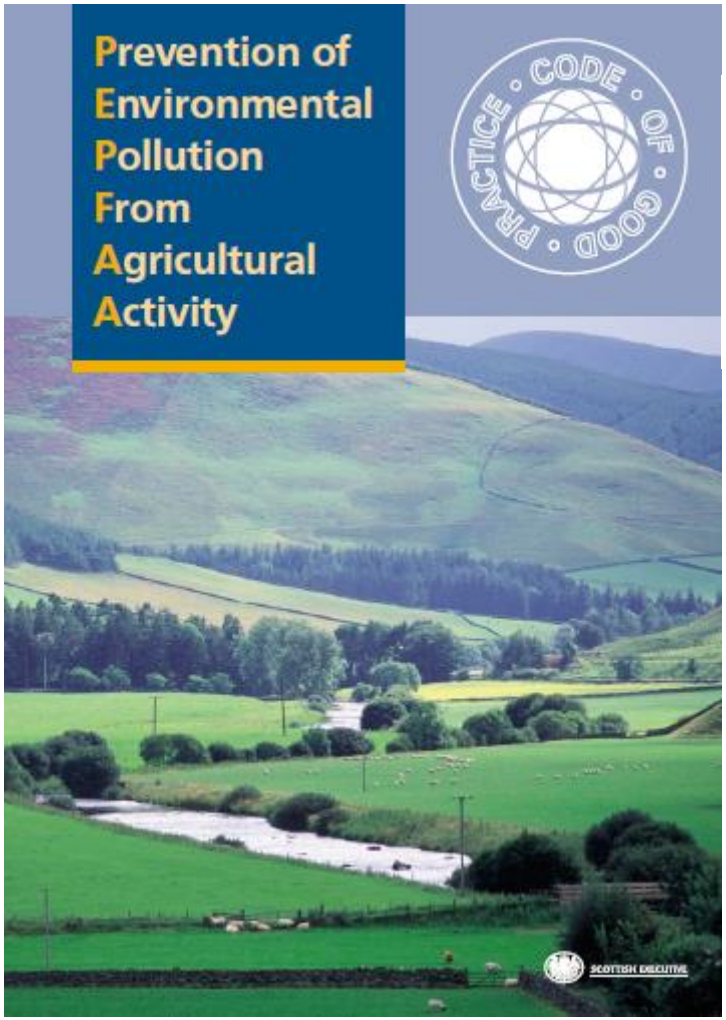


Table 16: Estimated percentage reduction in annual losses of pollutants from agriculture

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

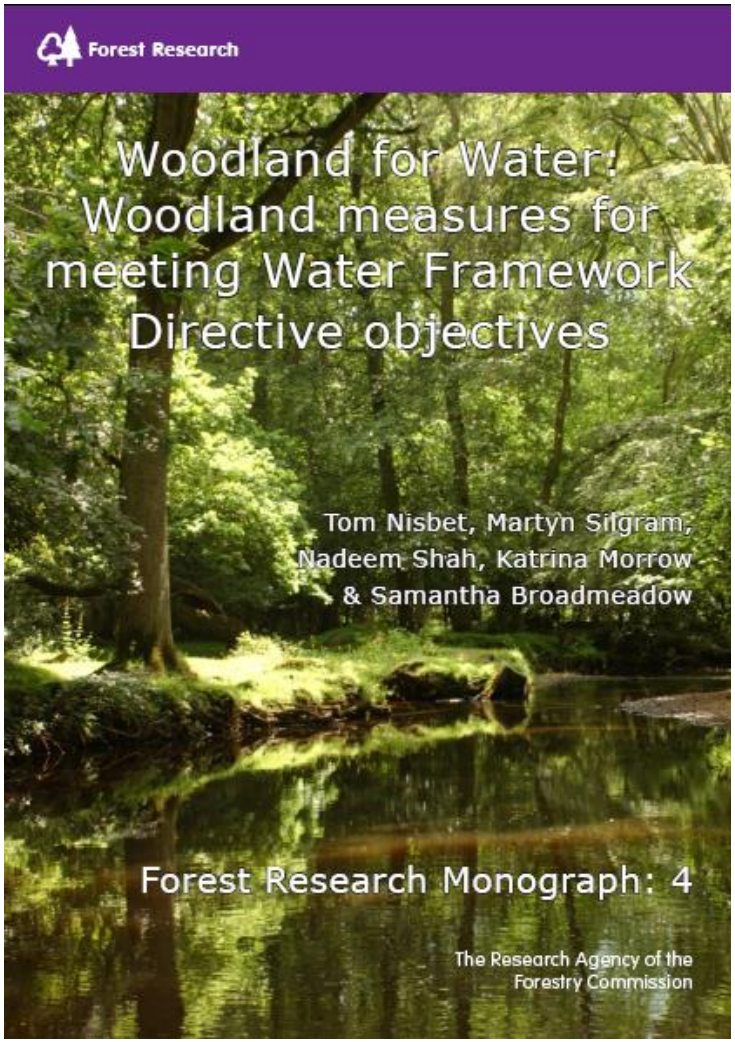
EEA State of Water Assessment Report 2018: only 1 to 2% improvement in RWB status between first two River Basin Management Plan Cycles

Need for Land Use Change

Forests are inherently good for protecting water!

Positive Interactions

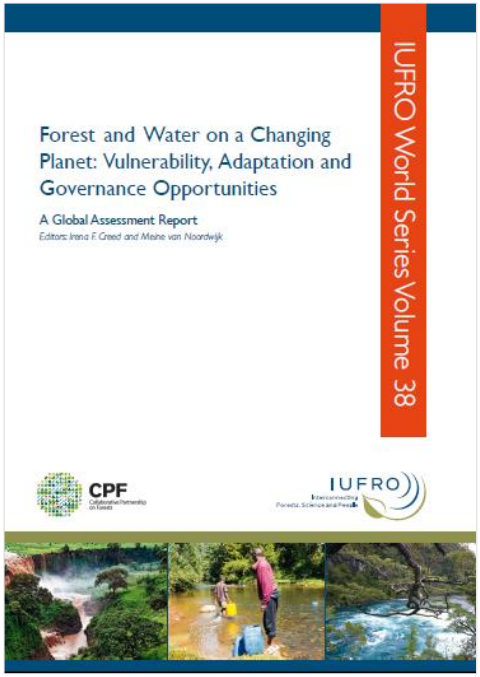
- Semi-permanent land cover, protecting soils and water from disturbance;
- Canopy provides physical shelter and moderates rainfall inputs;
- Well structured soils increase rainfall infiltration and water storage, reducing rapid runoff;
- Tight cycling of nutrients, yielding good water quality;
- Floodplain and riparian forests improve river channel form and connectivity, increasing habitat diversity, slowing the flow and moderating water temperature.



https://www.gov.uk/government/publications/woodland-for-water

"There is strong evidence to support forest planting in appropriate locations to achieve water management and water quality objectives"

5th MCPFE
FORESTS FOR QUALITY OF LIFE



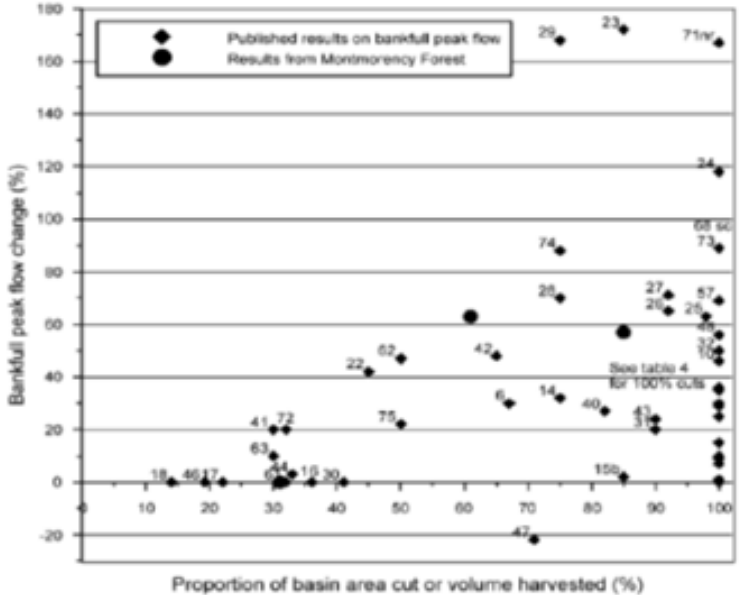
Pollutant inputs are much lower to forestry compared to agriculture

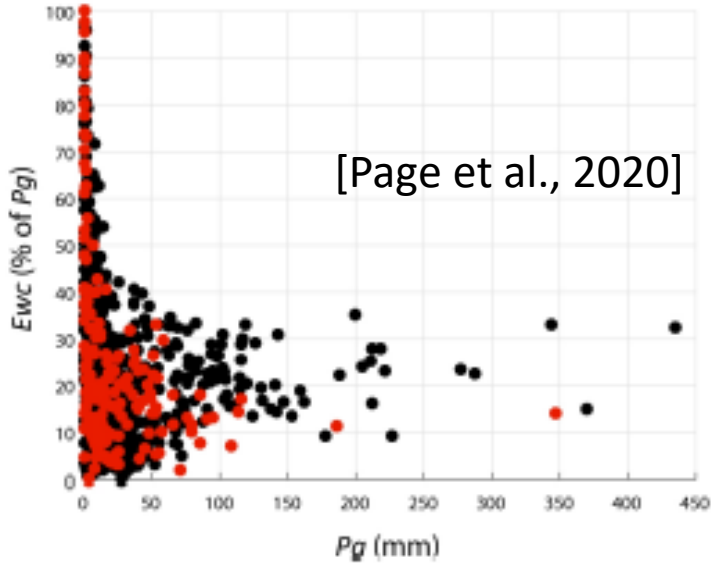
	Permanent Grassland	Rough Pasture	Wheat	Barley	Maize	Oil Seed Rape	Woodland
Nitrogen Input (kg/ha/yr)	94-135	10	131-167	120-132	46-62	155-189	20
Nitrate-N Export (kg/ha/yr)	0.86-10.58	0.02-0.05	1.54-19.72	1.54-19.72	1.52-19.72	3.29-17.4	0.02-0.1
Phosphate Input (kg/ha/yr)	6-16	0	13-35	18-41	27-43	15-37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

Evidence Base: Flood Flows

- Studies show forest planting can reduce flood peaks by between 5% and 65%, while the effects of clearfelling range from -22% to +172%;
- Modelling predicts forest planting can reduce flood peaks by -3 to +54%;
- Impact on flood flows is expected to decline with flood size.





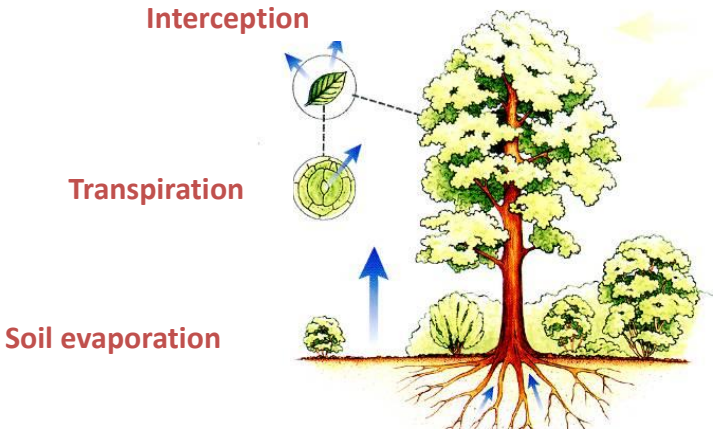
[Page et al., 2020]

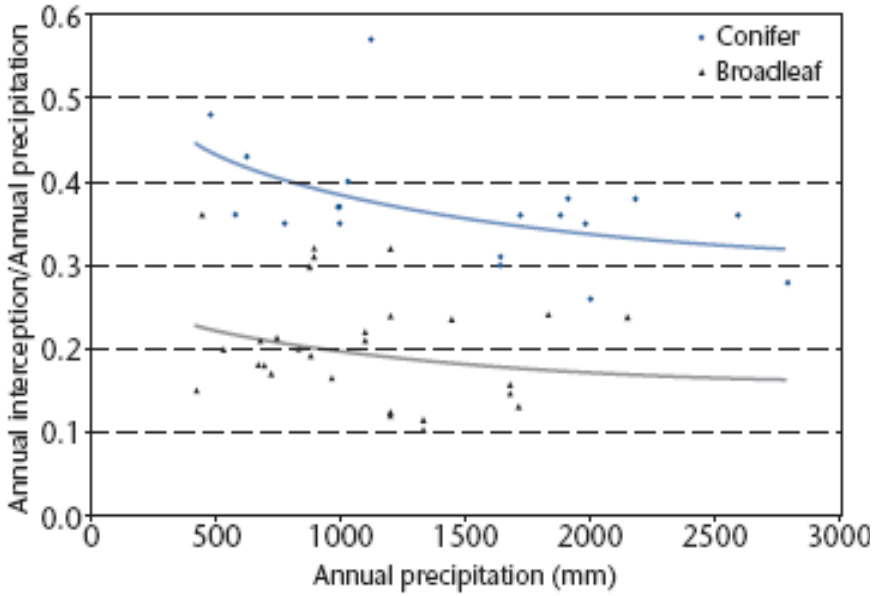
Forestry as a Potential Pressure

- Canopy interactions can enhance pollutant capture, e.g. acid deposition;
- Greater canopy evaporation can reduce water resources;
- Forest management practices, especially felling/harvesting, can temporarily remove benefits, as well as increase pollutant inputs and losses to water;
- Vulnerability to ‘natural’ disturbance in the form of fires, storms/wind damage, pests and disease, and landslides.

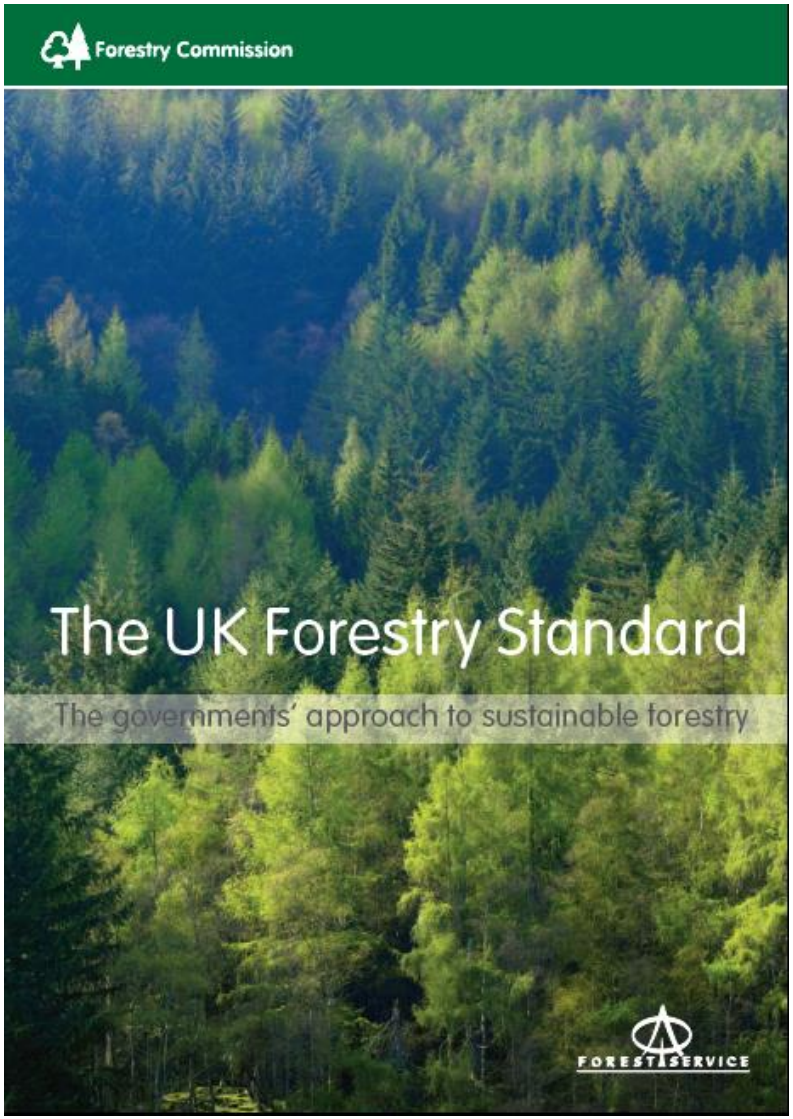
Forests generally reduce catchment water yield

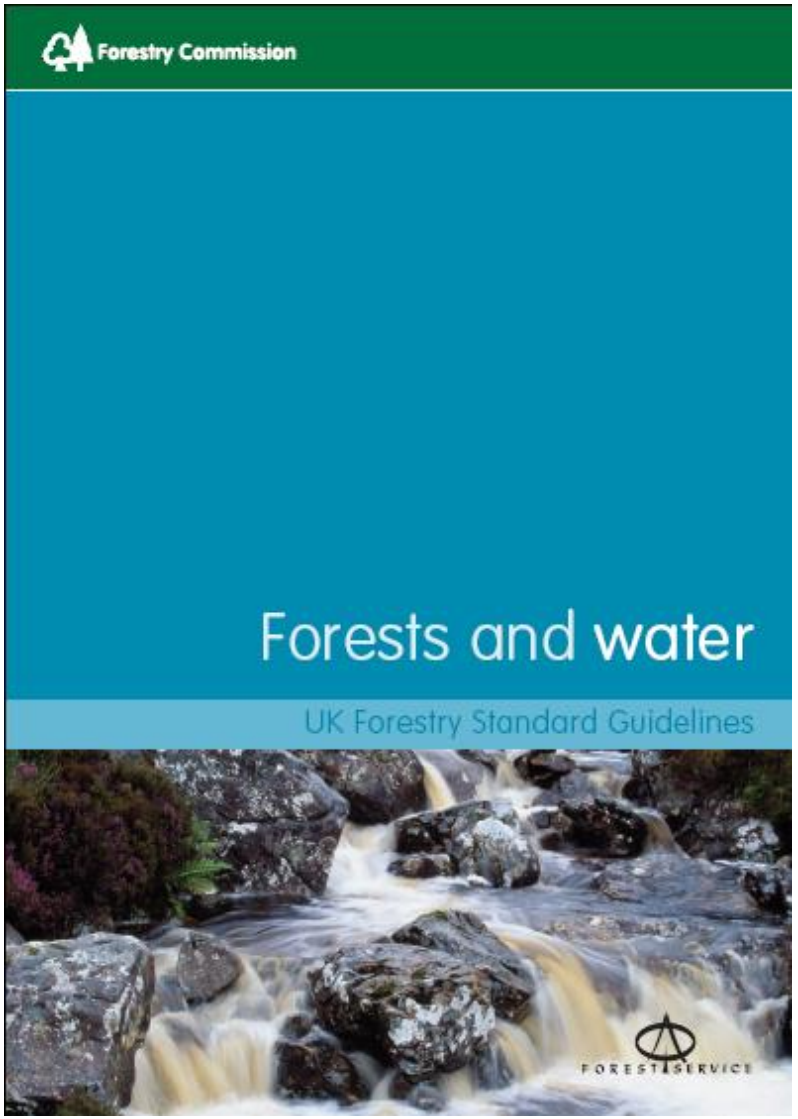
- Mainly due to canopy interception, reducing net rainfall by 30-40% for conifers and 10-20% for broadleaves;
- Conifers can reduce annual runoff by 15-20% in wet uplands and by >75% in dry lowlands - effect much less for broadleaves +/-10-15%





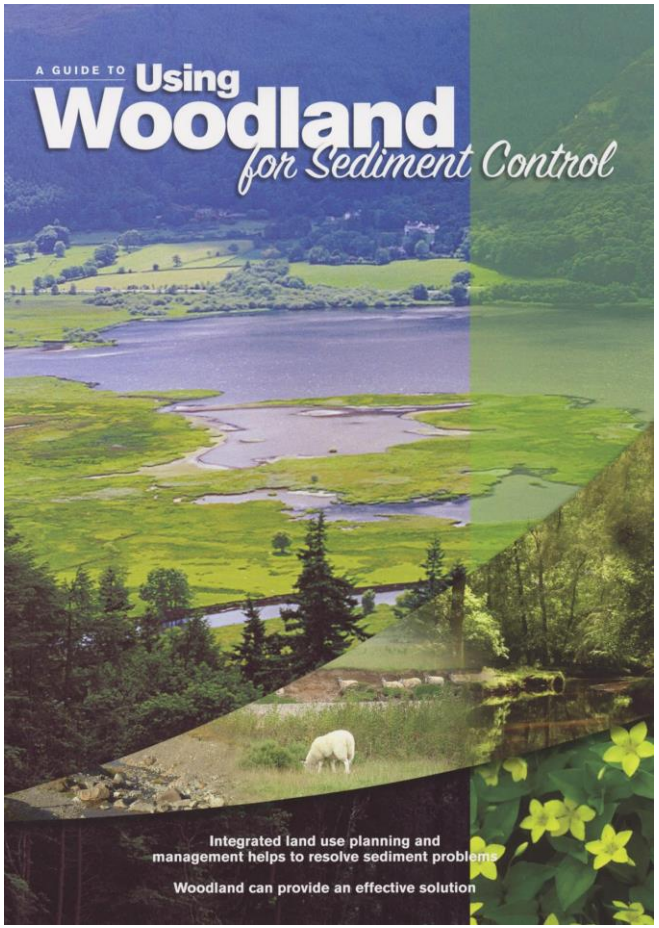
Minimising Pressures





Case for forest/woodland planting:

- Water environment and ecological status remains severely impacted by diffuse pollution, while flood risk appears to be increasing;
- Woodland creation provides a secure and sustainable measure;
- Careful integration of woodland with agriculture can reduce land take and increase acceptability;
- Target pollutant sources, pollutant pathways and water receptors.



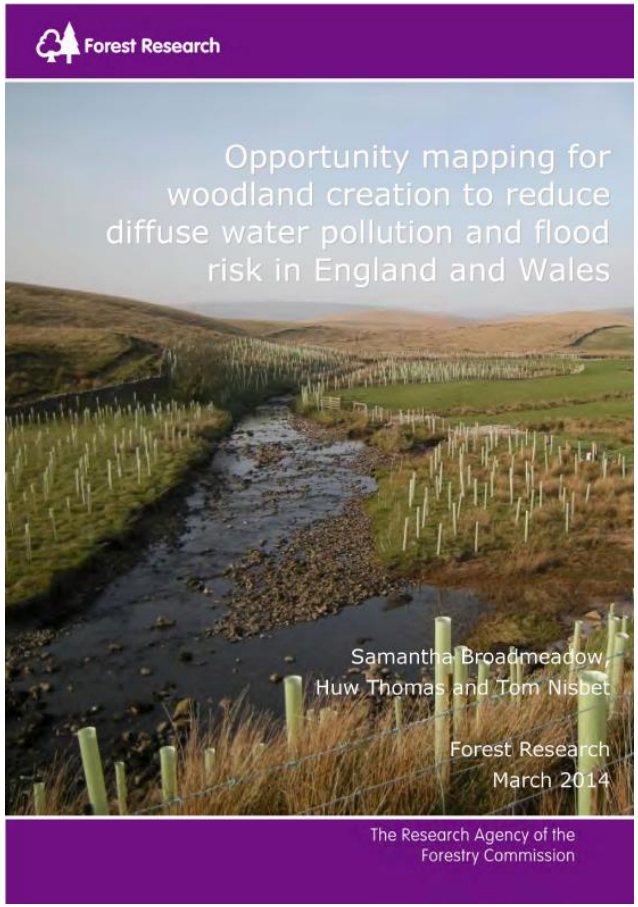
Where to plant?

Any Questions?

Role of Opportunity Mapping

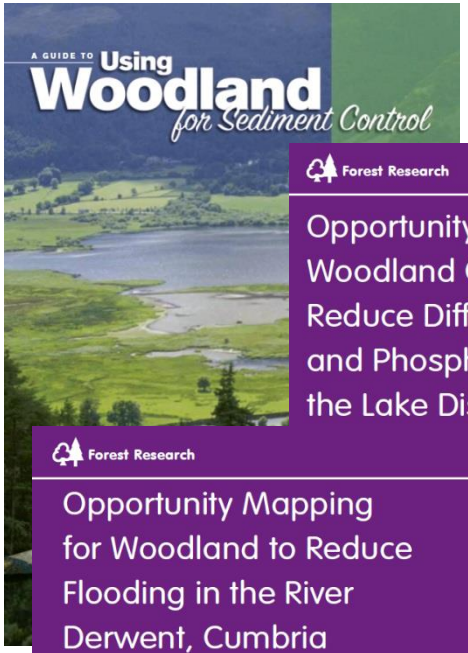
Identifying pollutant sources, pathways and receptors:

- 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.

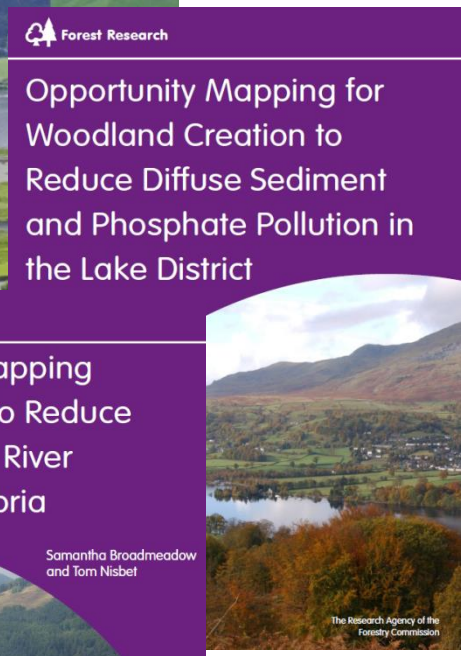


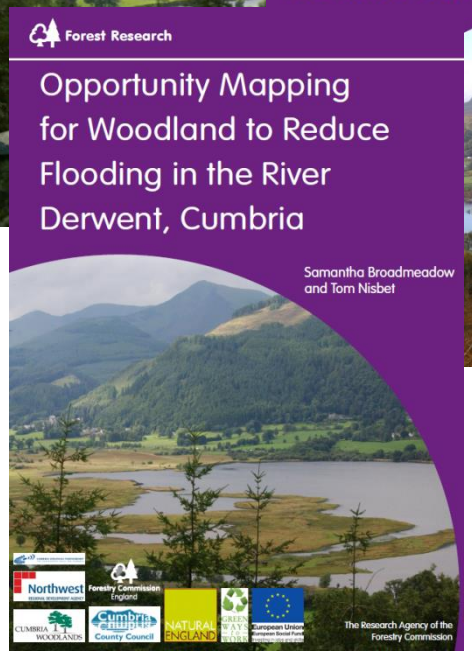
Applicable to a Range of Scales

Targeting action and grant aid:



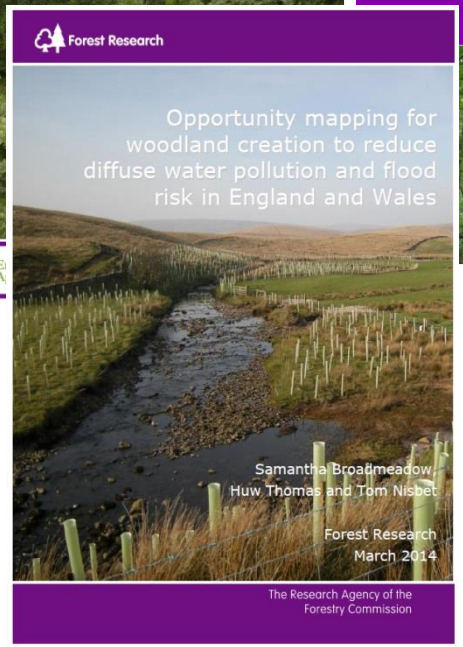
2004

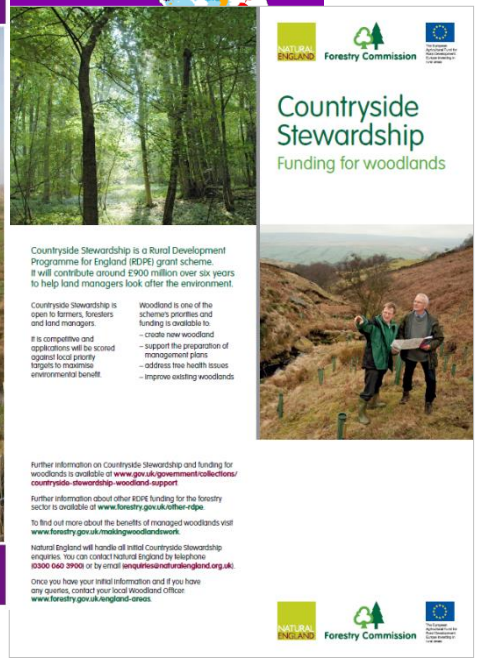




2010

2012

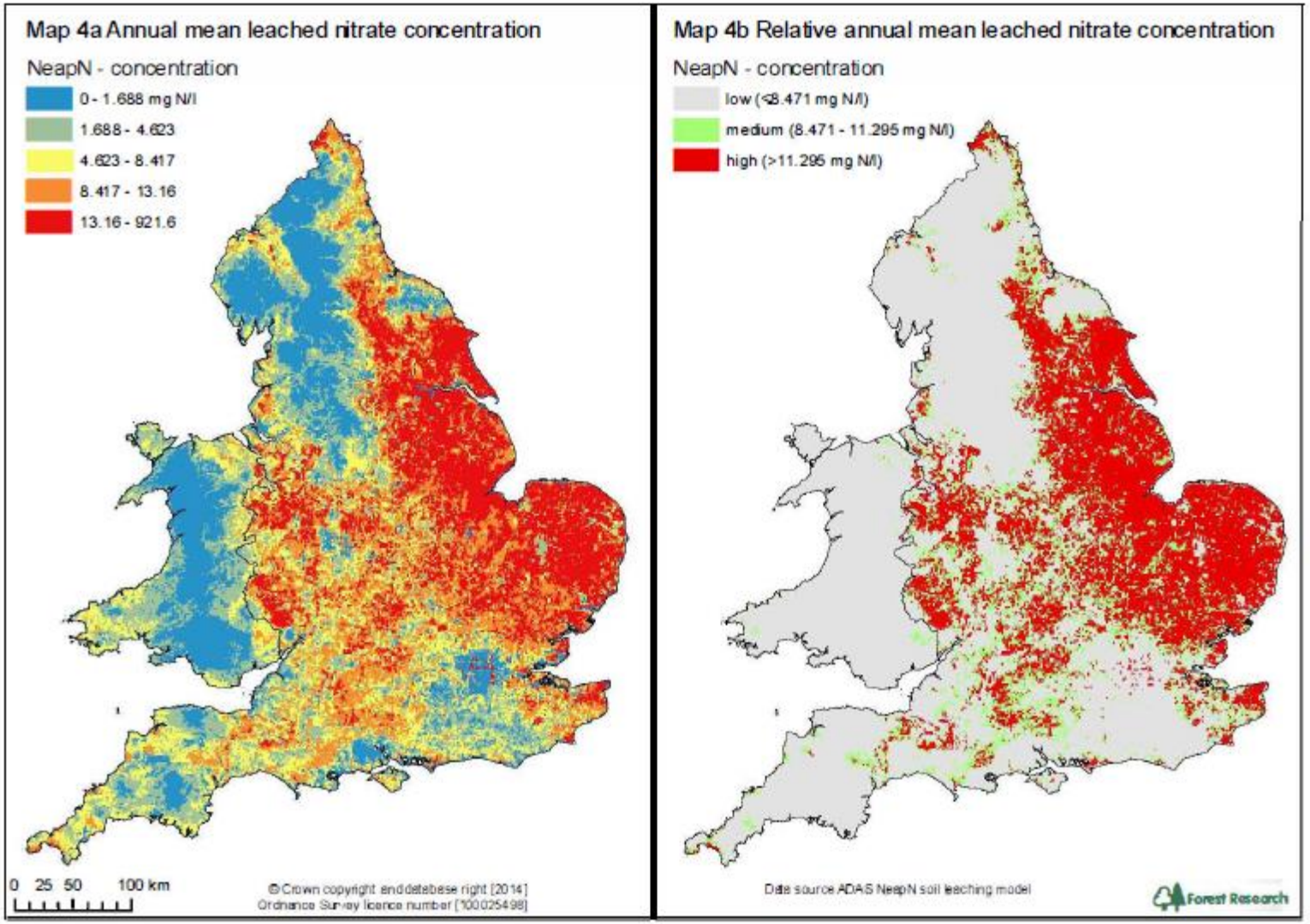




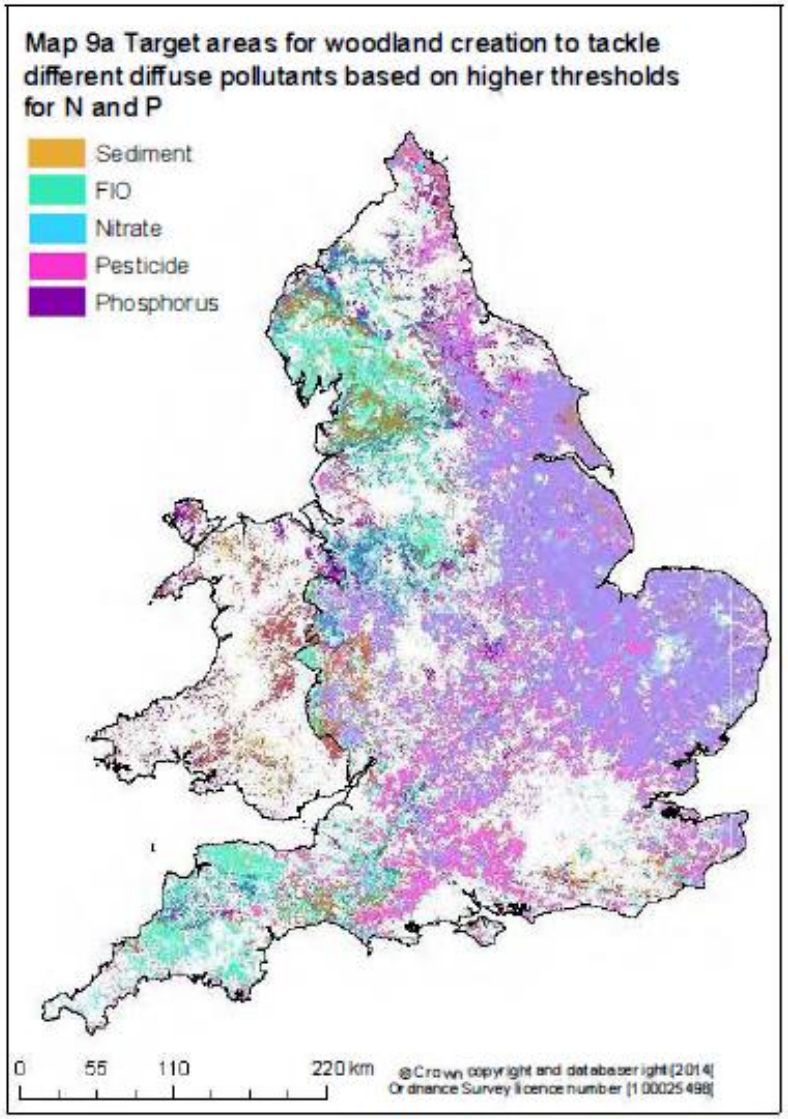
2014

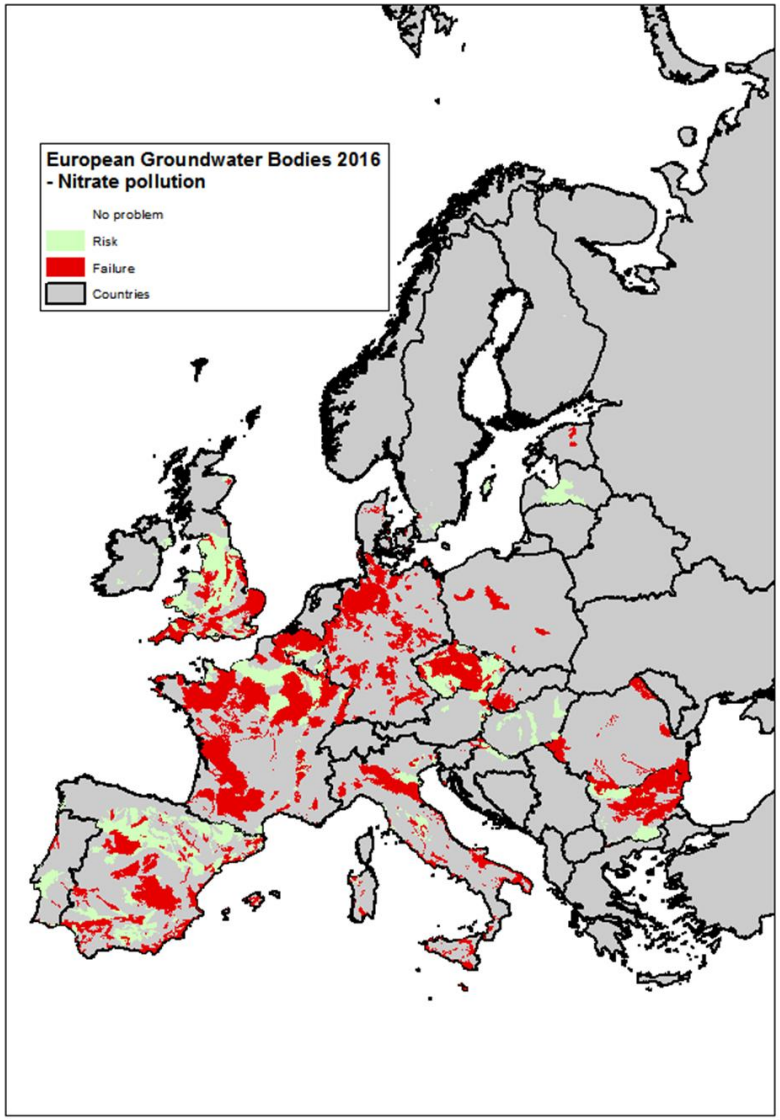
https://www.forestresearch.gov.uk/research/opportunity-mapping-woodland-for-water/

Identifying Nitrate Sources

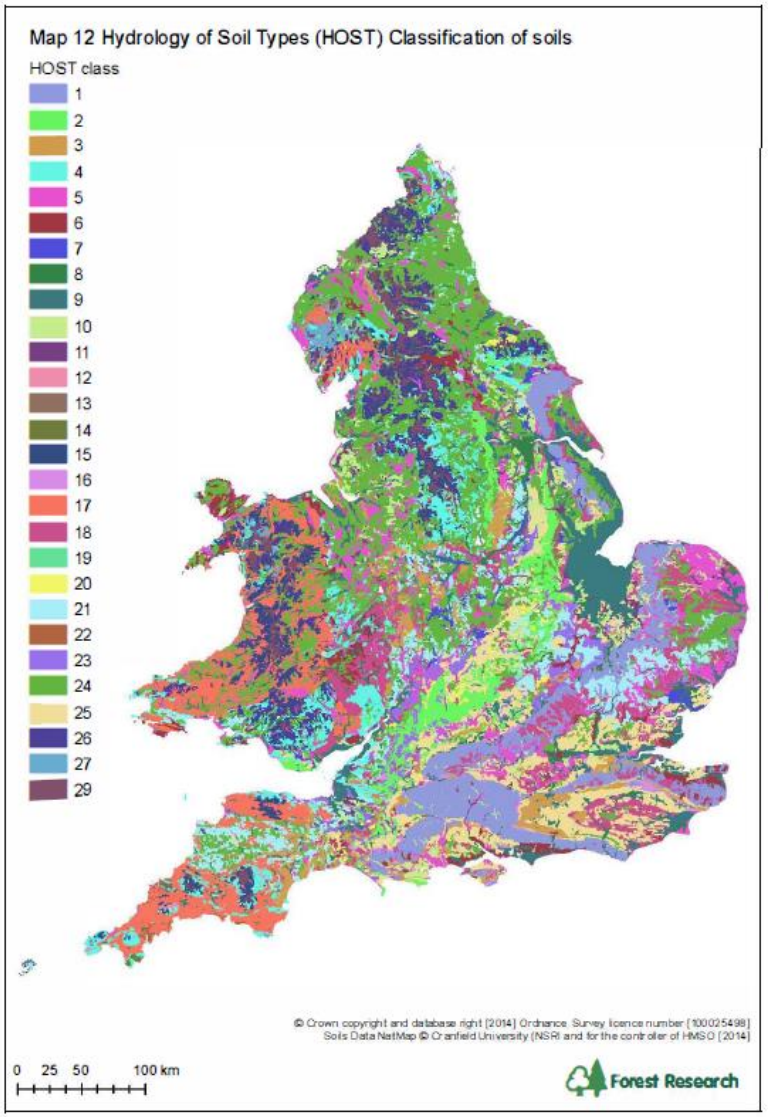


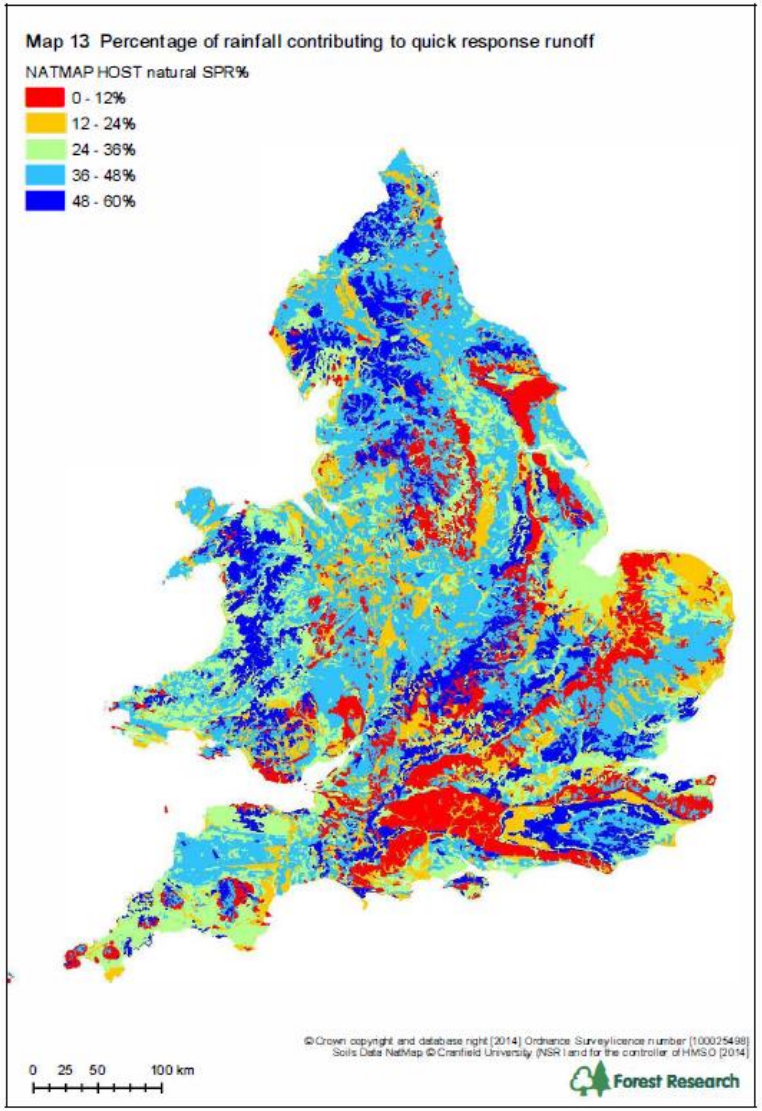
Identifying Failing Water Bodies



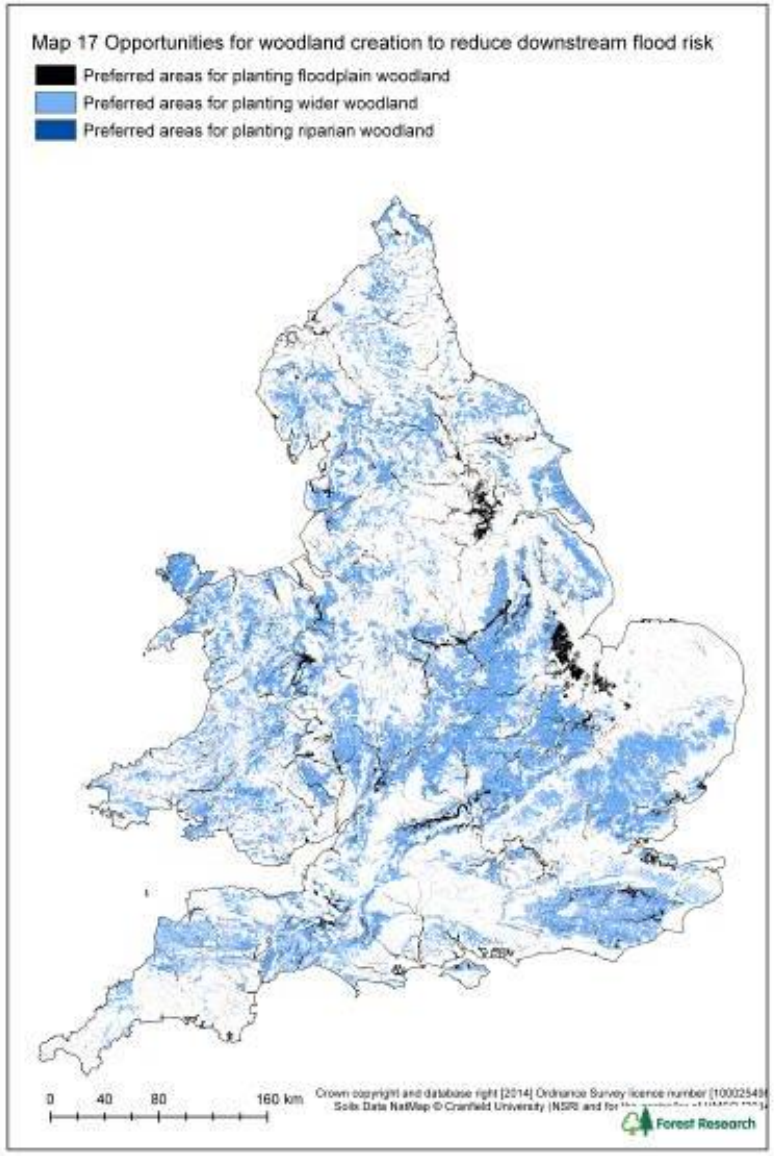


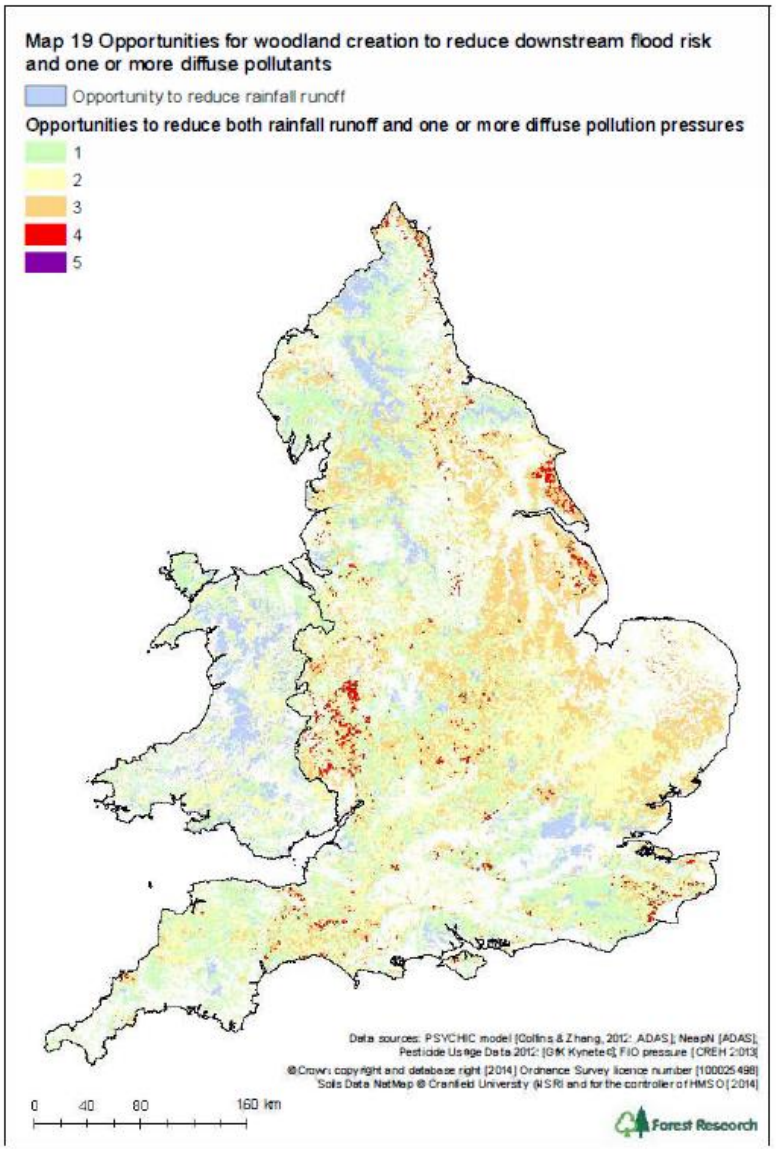
Mapping Flood Benefit





Identifying Win-Wins



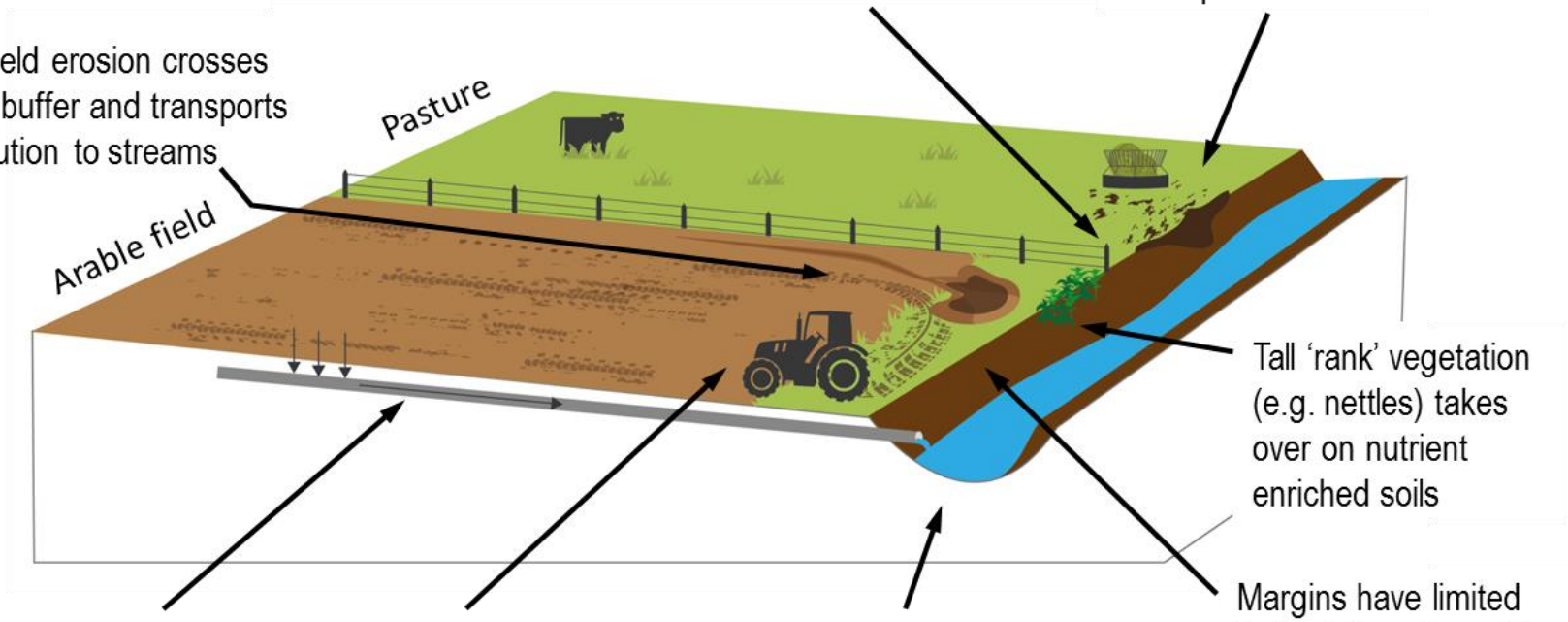


Applying knowledge to the site level within priority catchments - where is it best to plant?

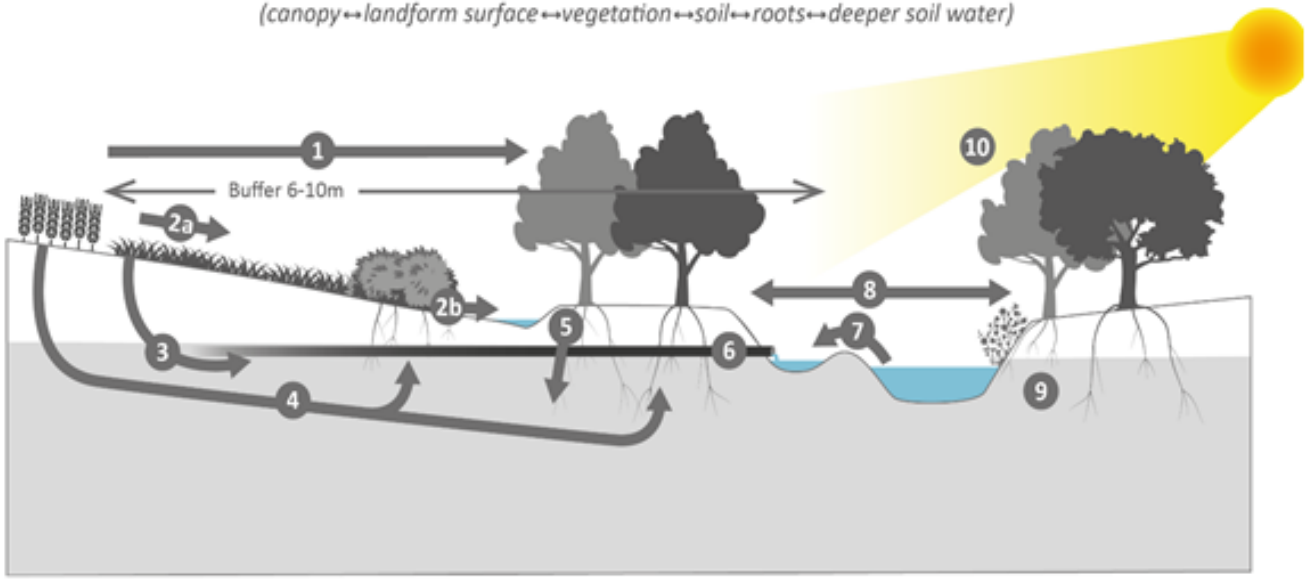
- To interrupt pollutant pathways to reduce delivery to watercourses;
- To remove pollutant sources on high-risk soils and from around vulnerable receptors (e.g. within groundwater and surface water protection zones);
- Where surface water temporarily collects and flows during heavy rain.

Limitations of Grass Buffers

Common aspects of failing watercourse margins



Concept of 3 Dimensional Buffers



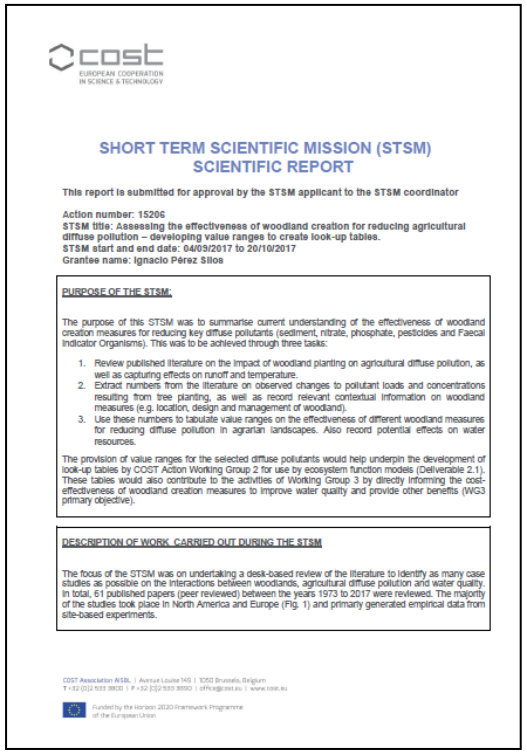
1	Reduced airborne spray drift of agrochemicals due to interception by tree canopy	6	Stopping direct discharges from soil drains to watercourses allows time for pollution removal
2	Filtering pollutants in runoff by trapping particles amongst vegetation (2a) and by water retention in hollows created by resculptured ground profiles (2b).	7	Altered bank profiles promote rewetting, water retention and sediment trapping
3	Improved infiltration and delayed vertical drainage promotes natural processing of nutrients and other contaminants by soil microbes and plants	8	Growth of riparian and aquatic vegetation increases channel 'roughness' and leaf litter inputs, aiding processing and removal of pollutants
4	Nutrient uptake and utilisation by growing vegetation	9	Tree rooting stabilises banks reducing erosion and sediment input
5	Enhanced levels of soil organic matter aids natural attenuating processes in soils	10	Increased shading cools water temperature and reduces thermal stress to aquatic life

Role of Design and Management

Key factors influencing buffer effectiveness:

- Woodland type and species
- Buffer width – minimum 6 m
- Structure – tree spacing and layout
- Placement and shape
- Management practices, including timing and scale
- All of above need to reflect the nature of the diffuse pollutant (type, quantity, pathway and timing), the site (slope, topography, soil/geology, climate) and status of the watercourse/water body (biological and chemical quality).

Review of 61 published papers on empirical studies of environmental effectiveness of riparian woodland buffers (1973 – 2015)



cost
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

SHORT TERM SCIENTIFIC MISSION (STSM)
SCIENTIFIC REPORT

This report is submitted for approval by the STSM applicant to the STSM coordinator

Action number: 15206
STSM title: Assessing the effectiveness of woodland creation for reducing agricultural diffuse pollution – developing value ranges to create look-up tables.
STSM start and end date: 04/09/2017 to 20/10/2017
Grantee name: Ignacio Pérez Silos

PURPOSE OF THE STSM:

The purpose of this STSM was to summarise current understanding of the effectiveness of woodland creation measures for reducing key diffuse pollutants (sediment, nitrate, phosphate, pesticides and Faecal Indicator Organisms). This was to be achieved through three tasks:

1. Review published literature on the impact of woodland planting on agricultural diffuse pollution, as well as capturing effects on runoff and temperature.
2. Extract numbers from the literature on observed changes to pollutant loads and concentrations resulting from tree planting, as well as record relevant contextual information on woodland measures (e.g. location, design and management of woodland).
3. Use these numbers to tabulate value ranges on the effectiveness of different woodland measures for reducing diffuse pollution in agrarian landscapes. Also record potential effects on water resources.

The provision of value ranges for the selected diffuse pollutants would help underpin the development of look-up tables by COST Action Working Group 2 for use by ecosystem function models (Deliverable 2.1). These tables would also contribute to the activities of Working Group 3 by directly informing the cost-effectiveness of woodland creation measures to improve water quality and provide other benefits (WG3 primary objective).

DESCRIPTION OF WORK CARRIED OUT DURING THE STSM

The focus of the STSM was on undertaking a desk-based review of the literature to identify as many case studies as possible on the interactions between woodlands, agricultural diffuse pollution and water quality. In total, 61 published papers (peer reviewed) between the years 1973 to 2017 were reviewed. The majority of the studies took place in North America and Europe (Fig. 1) and primarily generated empirical data from site-based experiments.

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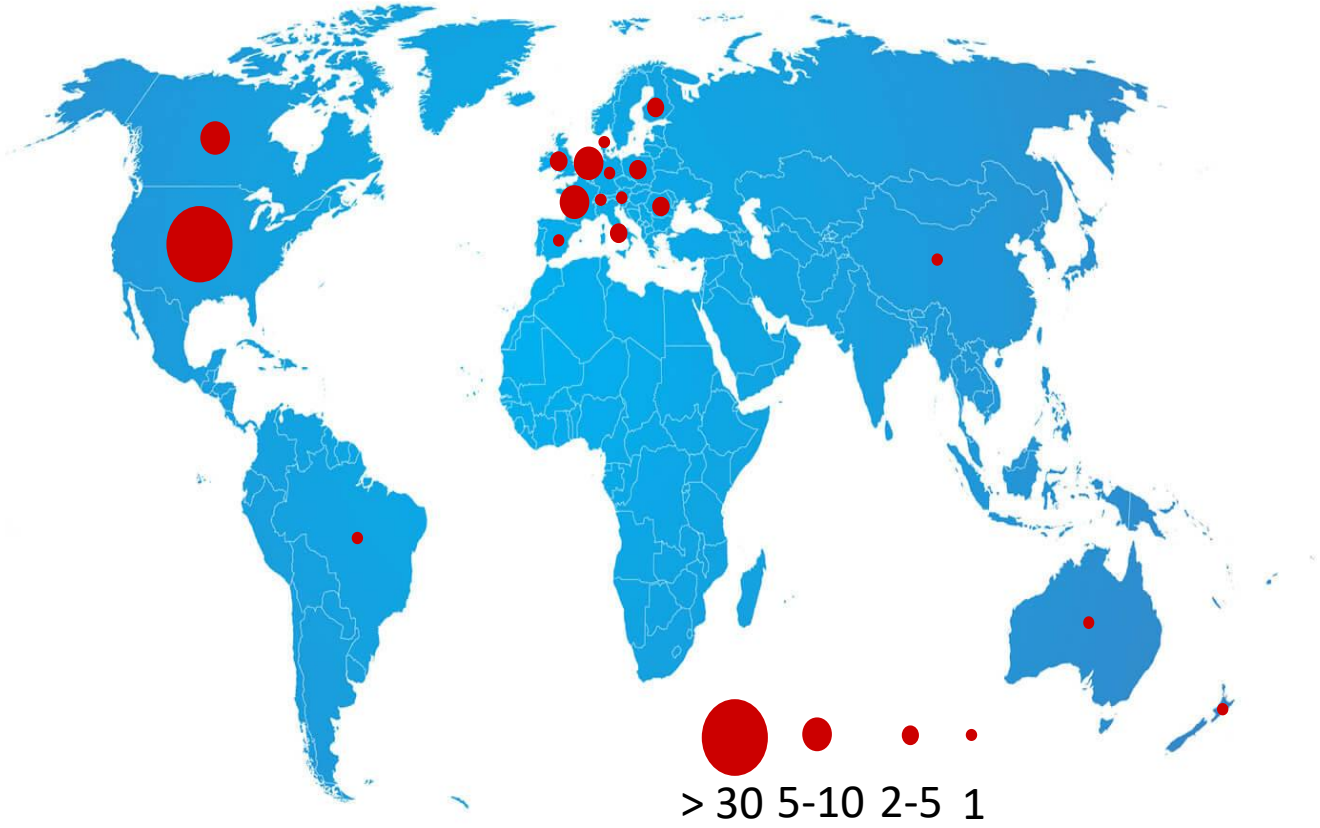
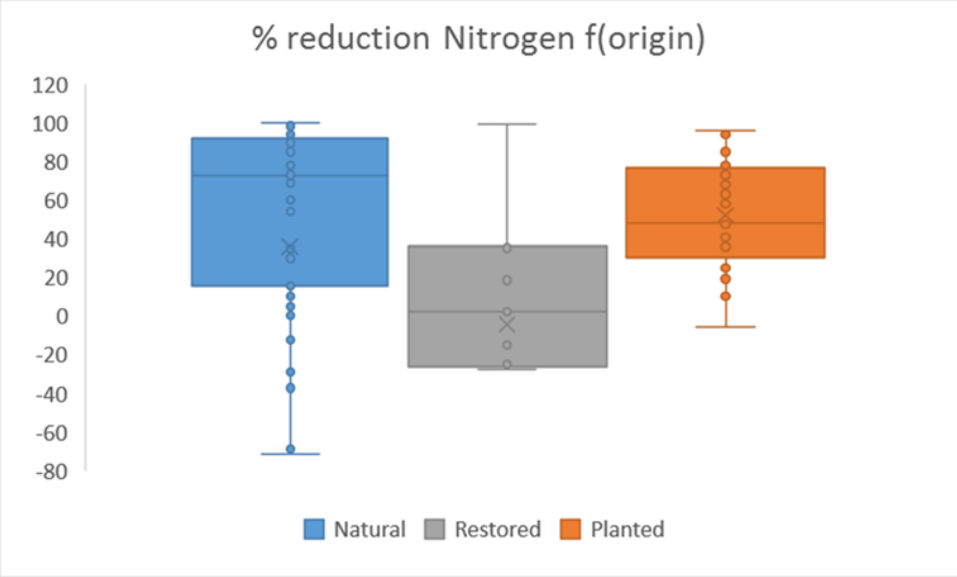


Nitrate-N

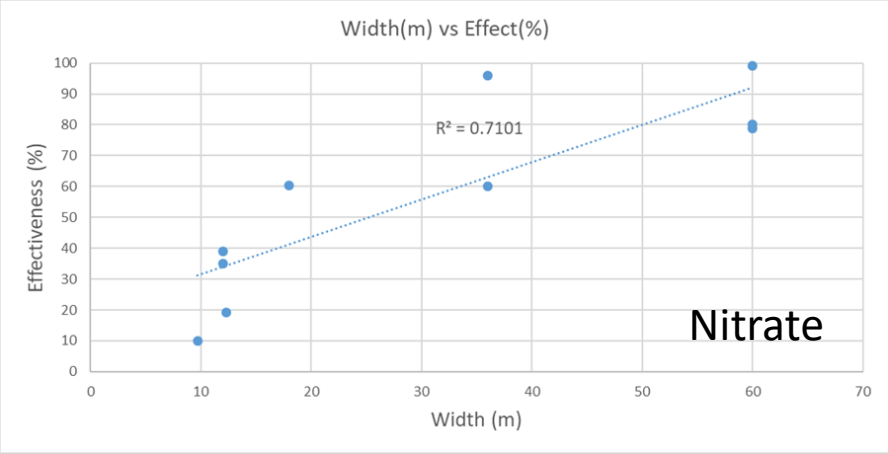
Concentration of NO_3-N (mg/l) in surface runoff									
Climate	n	max[Initial]	min[Initial]	Av. Effect.(%)	Q1	Q2	Q3	Type of plantation/forest	n	Av. Effect.(%)
Continental	17	46.8	0.4	84.8 [18.4 - 100.0]	82	98	99	Hillside woodland	6	88.6 [64.0 - 100.0]
								Riparian woodland	9	79.8 [18.4 - 99.9]
								Shrub	2	96.0 [94.0 - 98.0]
Oceanic	8	32.5	0.1	74.2 [32.0 - 98.0]	60	77	95	Riparian woodland	7	73.9 [32.0 - 98.0]
								Shrub	1	76.0
Subtropical humid	13	13.5	1.3	82.5 [35.0 - 99.0]	80	92	96	Riparian woodland	10	89.7 [39.0 - 100.0]
								Shrub	3	58.3 [35.0 - 80.0]

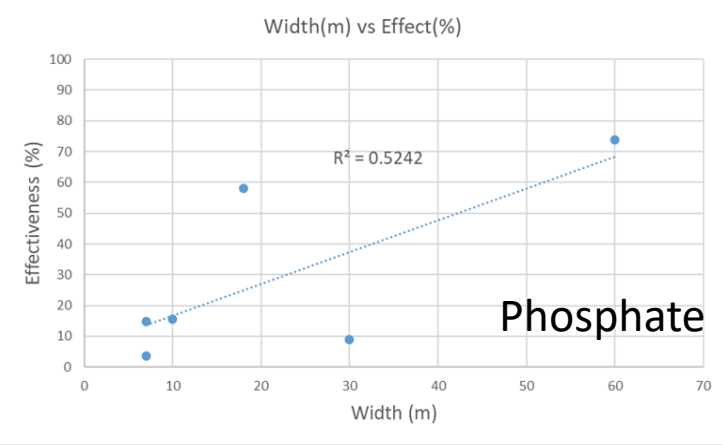
Climate and woodland type appeared relatively unimportant factors



Buffer width is a critical factor influencing effectiveness for pollutant removal:

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%





Limitations of Woodland Buffers

- Slow establishment delays water and other benefits
- Potential for pollutants to bypass buffer via field drains or in groundwater
- Deflection of stream flows and disruption of drains increases soil wetness
- Need for fencing to protect woodland buffer where livestock present
- Reduced access to watercourse for livestock and maintenance work
- Potential for nutrient saturation and excessive shading.

Conclusions

- The water environment remains severely impacted by agriculture, with limited progress made in controlling diffuse pollution.
- Woodland creation offers much scope to reduce pollutant delivery to watercourses and aid ecological recovery.
- Spatial data can be used to identify priority catchments and target areas for woodland creation for water benefits.
- Woodland provides an effective 3D buffer, supported by a substantial body of evidence – buffer width is a key factor.
- Potential dis-benefits such as increased water use can be controlled by site selection, woodland type and design – planting the right tree in the right place for the right reason.
- There is a strong case for woodland creation to be delivered through catchment level planning supported by appropriate incentives/payments.

Any Questions?