Working with Natural Processes –
the evidence behind Natural Flood Management

Dr Lydia Burgess-Gamble – Principal Environmental Project Manager NEAS

But where's the leadership?

25 Year Environment Plan

We will take action to reduce the risk of harm from flooding and coastal erosion **including greater use of natural flood management solutions**

We will also focus on using more natural flood management solutions where appropriate

Chairman

'Natural flood management is an important part of our approach, alongside traditional flood defences and helping homeowners to improve their own property resilience'

Head of FCRM

'Natural Flood Management is part of our Nation's Flood Resilience'

Position Statement

Where NFM presents the most effective and viable approach to managing flood risk, **we will choose such measures over traditional defences…**

In all other circumstances, **we will seek to use them in combination with hard defences** …

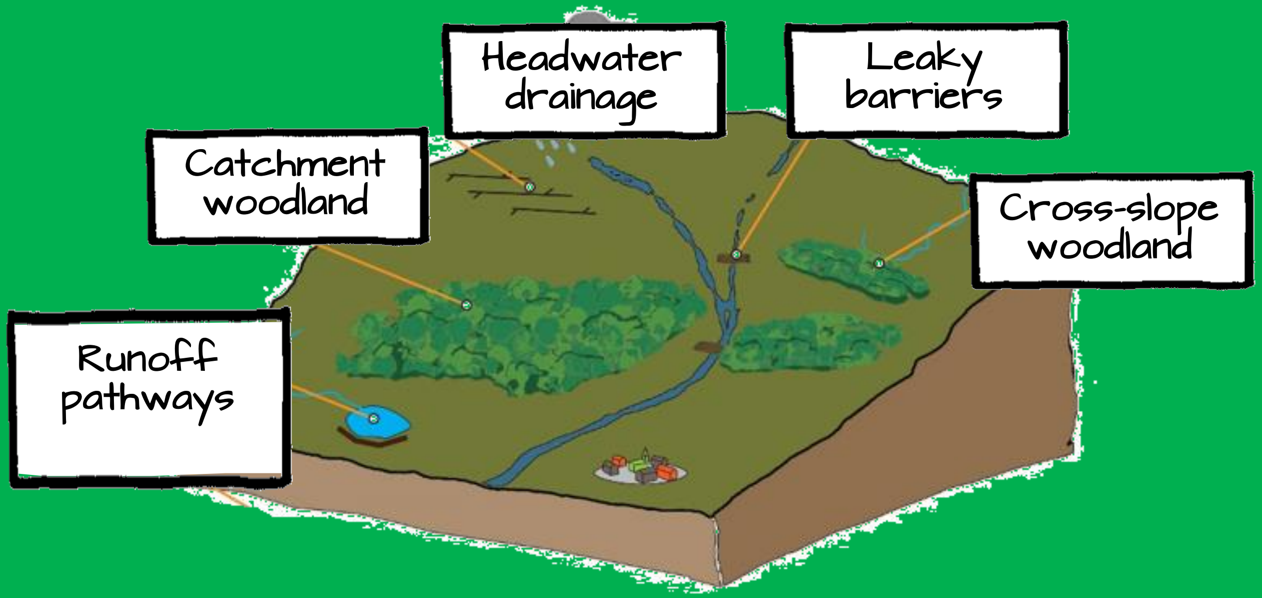
FCRM Managers

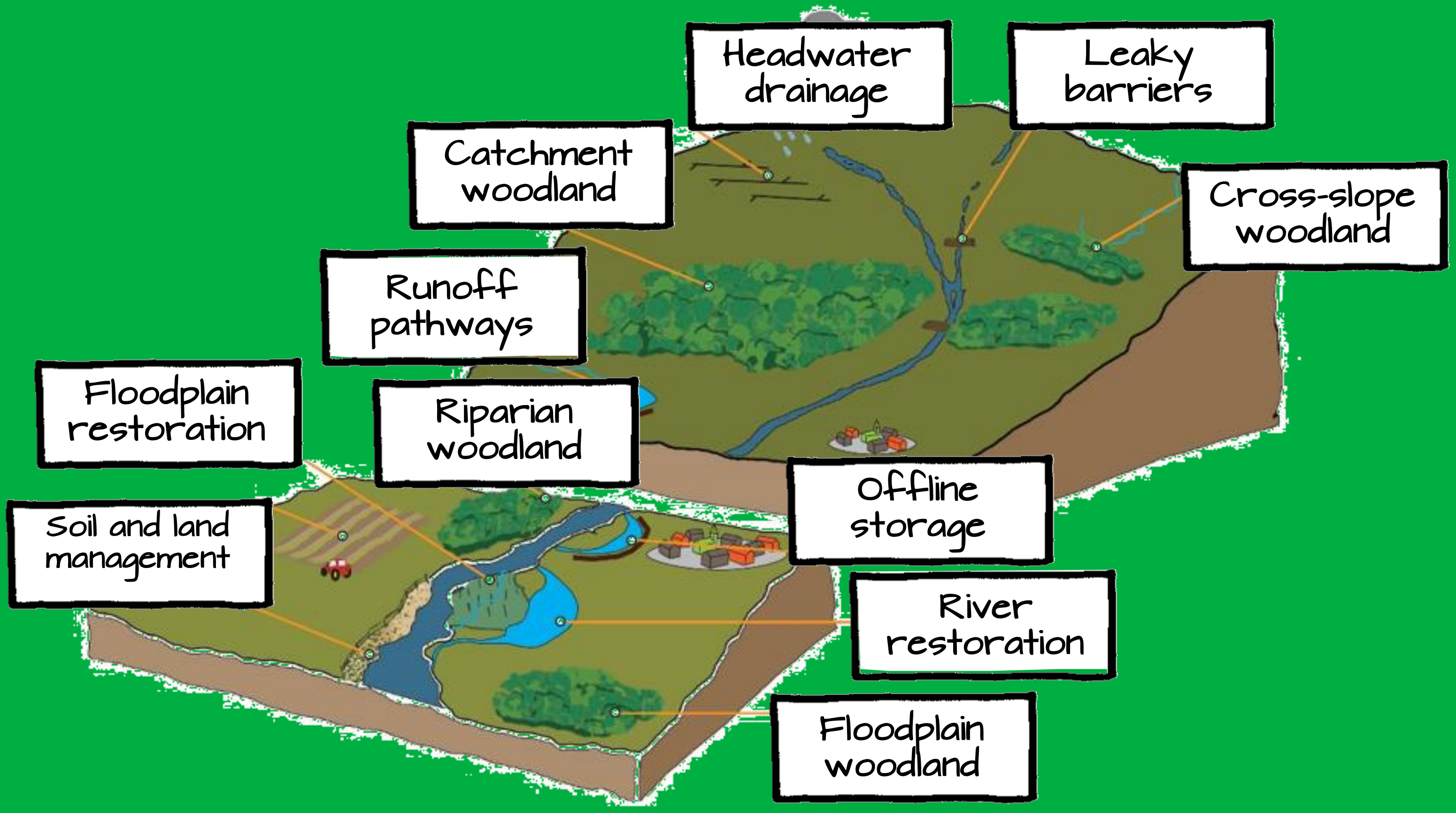
Natural flood management is supported by area FCRM managers where it is part of all of the solution to flooding

Staff

Amazing projects delivered by you, your colleagues, partners, communities and consultants

What is NFM


Headwater drainage
Leaky barriers
Catchment woodland
Cross-slope woodland
Runoff pathways



Headwater drainage
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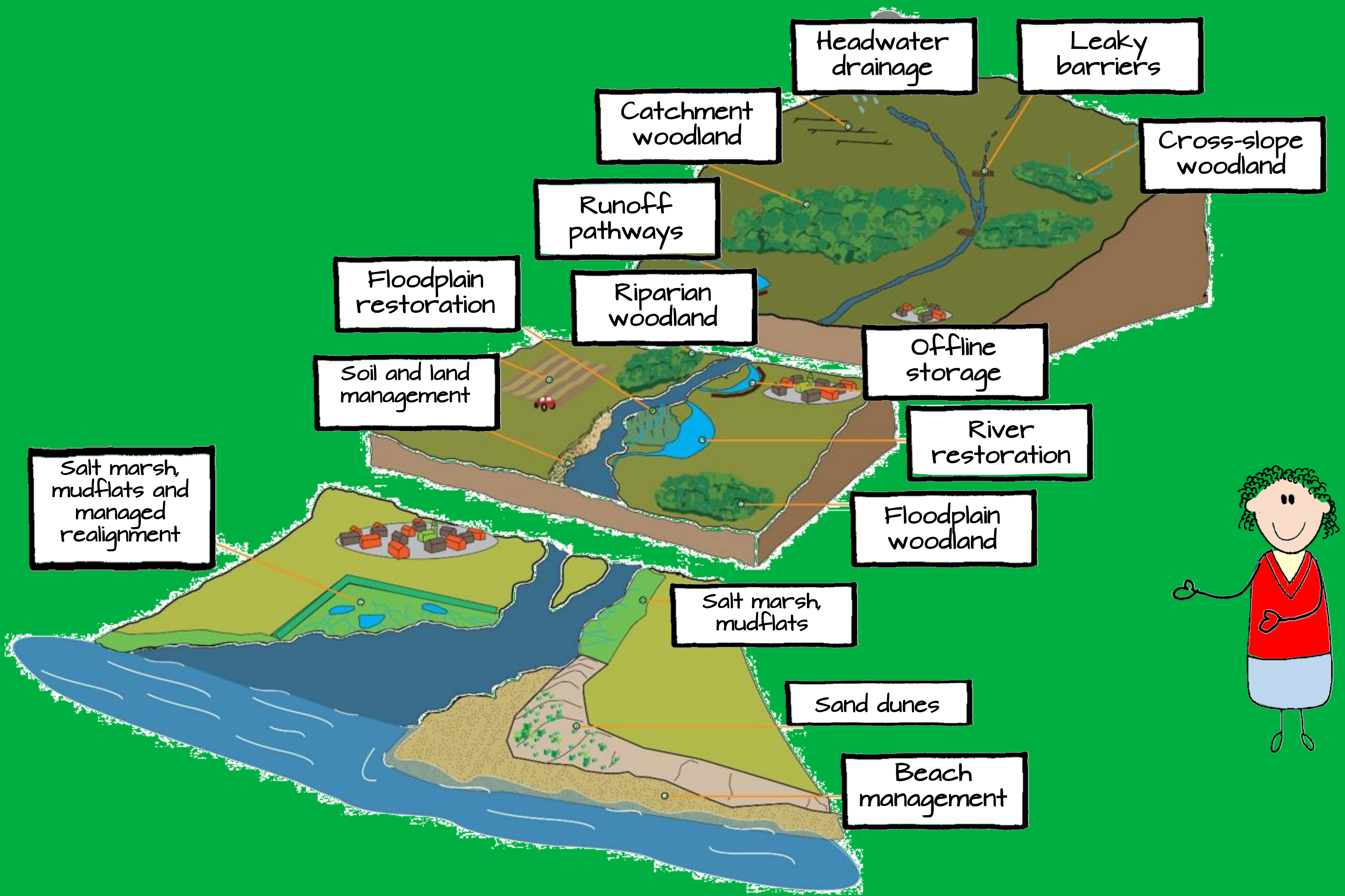
Floodplain restoration
Riparian woodland
Offline storage
Soil and land management
River restoration
Floodplain woodland


Headwater drainage
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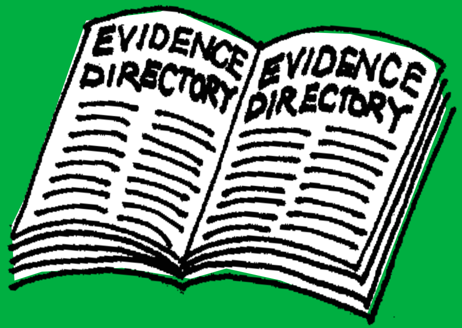
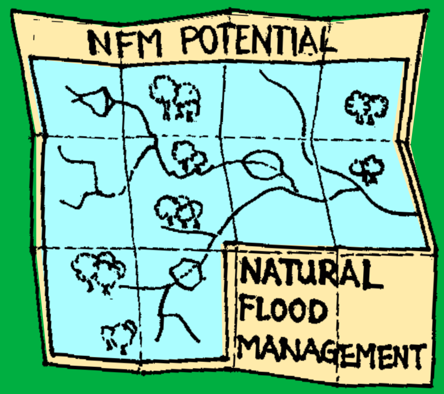
Riparian woodland
Offline storage
Soil and land management
River restoration
Salt marsh, mudflats and managed realignment
Floodplain woodland
Salt marsh, mudflats
Sand dunes
Beach management

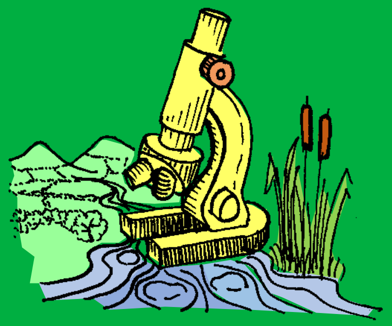
The Evidence Directory



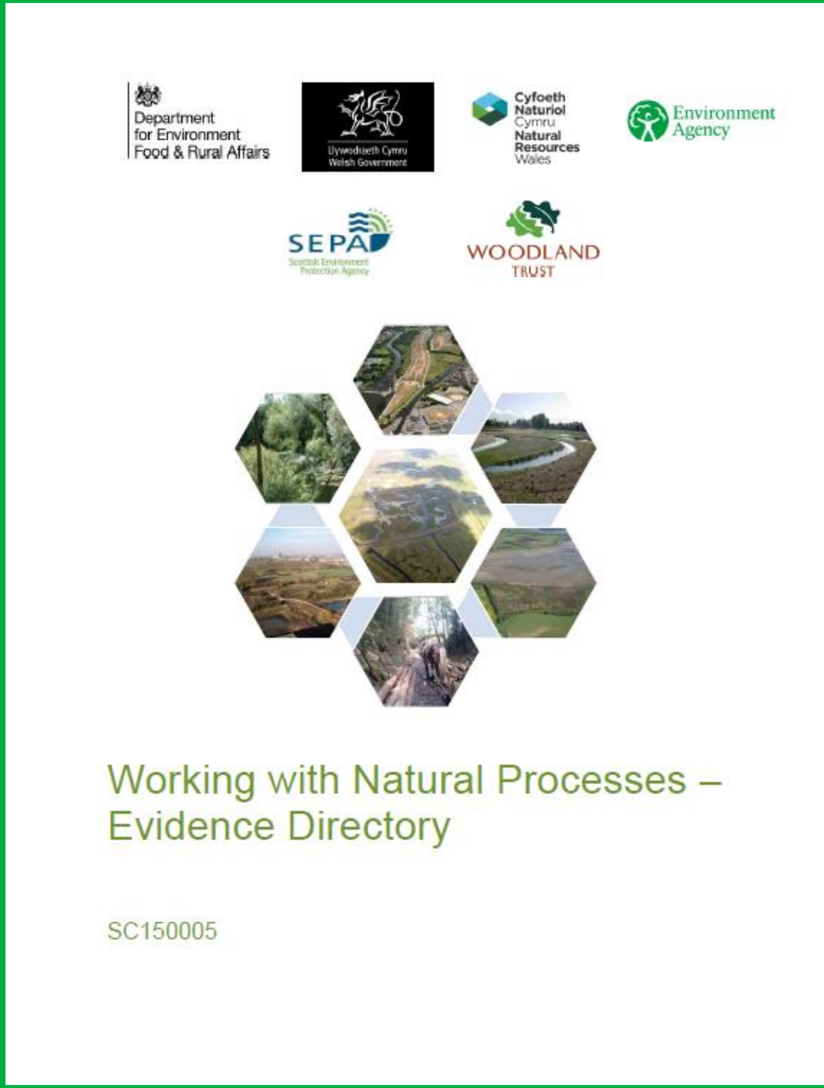
1. Evidence Directory

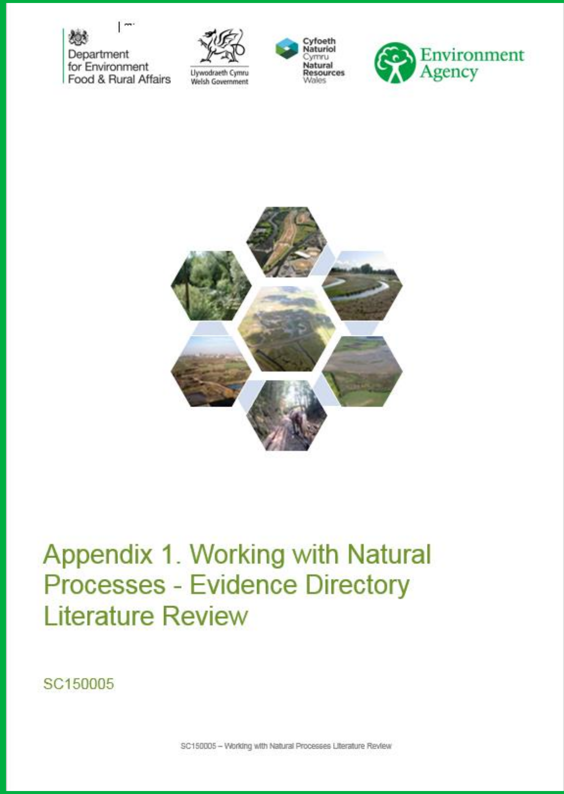


2. The Maps



3. The Gaps





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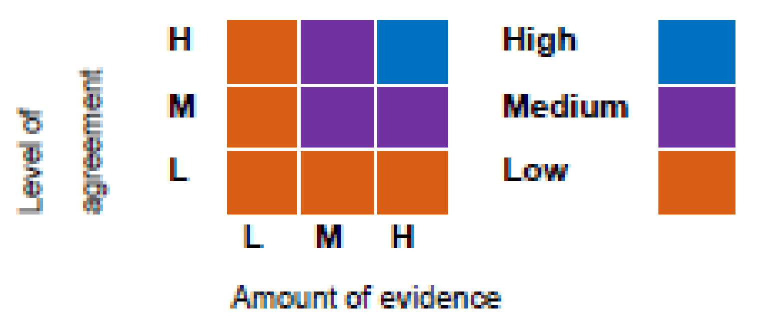
3.2.2 Flood risk evidence

This section sets out what we know in terms of the effectiveness of this measure from an FCRM perspective and the scientific confidence in what we know.

Effect on flood flows, peaks and storage M/H

Summary of the literature

- There is strong process understanding of the different ways that catchment woodland can affect flood generation processes.
  - The canopies of catchment woodland can typically intercept/evaporate more water than grass at a rate of 200–400 mm per year (Bosch and Hewlett 1982) or 1–8 mm per day (Calder et al. 2003), resulting in drier soils and less run-off contributing to flood flows.
  - Soil porosity has been found to be 15–55% greater under forest (Harrold et al. 1962, Wahren et al. 2012), resulting in higher soil infiltration rates (67 times; Marshall et al. 2014) and higher saturated hydraulic conductivities (2–140 times; Chandler and Chappell 2008, Alvarenga et al. 2011).
  - Longstanding but simplistic measures of surface/hydraulic roughness (Manning's n) that are available for catchment woodland and grassland (Chow 1959) indicate that the former maybe 5 times higher.



Confidence level is based on potential effectiveness of measure at reducing flood risk.

Degree of agreement of scientific studies, and amount of studies available

Chapter 3. Woodland management


3.1 Introduction


3.2 Catchment woodland


3.3 Cross-slope woodland


3.4 Riparian woodland


3.5 Floodplain woodland

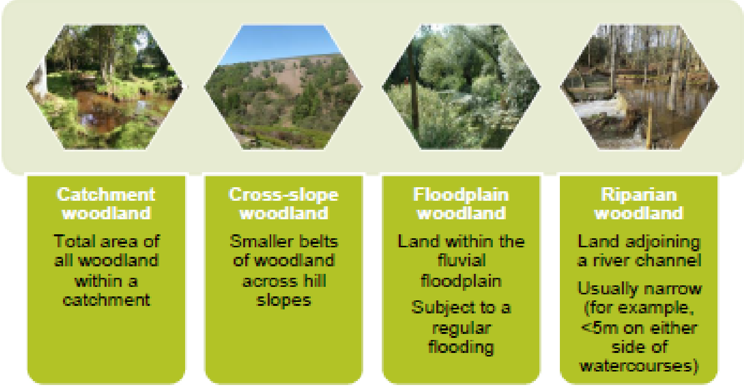
3 Woodland management

3.1 Introduction

This chapter summarises the evidence around the effectiveness of the following woodland management measures in reducing flood risk:

- Catchment woodland
- Cross-slope woodland
- Floodplain woodland
- Riparian woodland

The term 'woodland' is used to describe land predominantly covered in trees (with a canopy cover of at least 20%), whether in large tracts (generally called forests) or smaller areas known by a variety of terms (including woods, copses, spinneys or shelterbelts). The terms woodland and forest are used interchangeably throughout this chapter. Unlike the other types of measures covered in Chapters 2 to 5, the different types of woodland presented here do not fall on a spectrum whereby some are greener than others. The main difference throughout this chapter is the scale of the woodland and its location type, as illustrated below.



These different types of woodland WWNP measure reduce flood risk by:

- intercepting overland flow – by obstructing overland flow paths and physically slowing the rate at which water is delivered to rivers through increased hydraulic roughness
- encouraging infiltration and soil water storage – tree roots enable water to be delivered to the soil, which encourages infiltration and the storage of water within the soil.

Case study 6. Chelmer Valley Local Nature Reserve

Author: Trevor Bond

Main driver: Habitat improvement

Project stage: Completed spring 2016

Photo 1: River Chelmer, Chelmer Valley Local Nature Reserve (source: Chelmsford City Council)

Project summary:

The Chelmer Valley Local Nature Reserve (LNR) is a much loved open space situated to the north of Chelmsford city centre (Map 1). Approximately 2.5km long, the Chelmer Valley LNR consists of parkland, green spaces, unimproved grassland, ponds, wet margins, riparian woodland and the River Chelmer itself (Photo 1).

As part of this project, informal embankments created through years of dredging were lowered and the won material was used within the river to construct earth berms. This improved floodplain connectivity, created marginal habitat for plants and restricted the width of the active river channel, encouraging geomorphic processes. In addition, flood risk modelling of the scheme has shown flood risk benefits emerging from the project during particular flood frequencies.

Key facts:

Flood risk modelling indicated that the scheme would lead to a small, net decrease in lateral flood extent during both 10% and 1% annual exceedance probability (AEP) events. Modelling also suggests reduced flood depths of up to 0.3m in some locations during a 10% AEP event and reduced flood depths of 0.15m in some locations during a 1% AEP. The reduced flood risk is believed to be due to the improved connectivity between the main river channel and the floodplain, which means water evacuates onto the floodplain earlier and the flood peak is marginally reduced.

Case study 11. Low Stanger Floodplain Reconnection Project

Author: Ian Creighton

Main driver: Flood alleviation

Project stage: Completed 2015

Photo 1: Downstream breach, Low Stranger Farm (source: West Cumbria Rivers Trust)

Project summary:

There have been significant flooding issues in the town of Cockermouth in recent years. A new flood defence scheme was constructed in 2014, which was overtopped by Storm Desmond in December 2015. There is no single solution and it will need multiple and varied solutions working with landowners to help flatten the flood peak in order to reduce future flood risk. At Low Stanger Farm (see Map 1), the existing flood embankment was breached along 4 sections to increase flood storage when the River Cocker is out of channel (Photo 1).

Key fact:

Survived Storm Desmond intact! An additional flood storage area of 5ha was created.

Case study 12. Slowing the Flow at Pickering

Authors: Tom Nisbet, Huw Thomas, Philip Roe

Main driver: Flood risk management

Project stage: Multi-objective, long-term, demonstration study

Photo 1: Woody dams upstream of Pickering (source: Forest Research)

Project summary:

The project was established in April 2009 to look at how changes in land use and land management can help to reduce flood risk for the town of Pickering in North Yorkshire (Map 1). It was 1 of 3 pilot projects funded by Defra in response to Sir Michael Pitt's Review of the 2007 floods in England and Wales and his call for greater working with natural processes. The project's overall aim is to demonstrate how the integrated application of a range of land management interventions/measures can help reduce flood risk at the catchment scale, as well as providing wider multiple benefits for local communities. A strong local partnership was formed, which put in place an agreed set of measures designed to reduce the chance of flooding in the town from 25% to 4% or less in any given year. Initial results have been very positive and work continues to evaluate the effectiveness of the measures in reducing flood risk.

Key facts:

An analysis of flow measurements from the Boxing Day 2015 storm event, when 50mm of rain fell over a 36-hour period, concluded with a relatively high degree of certainty that the project measures prevented flooding to a small number of properties in the town. It was estimated that the measures reduced the flood peak by 15–20%, with around half of the reduction due to the upstream land management interventions and half due to the large flood storage bund. The results are consistent with other observations that show the measures to be working as expected in reducing flood generation by storing and slowing flood waters within the catchment.

Case study 16. Belford Natural Flood Management Scheme, Northumberland

Authors: Alex Nicholson (Arup), Paul Quinn (Newcastle University), Mark Wilkinson (James Hutton Institute)

Main driver: Flood risk management – repeated flooding in the community of Belford

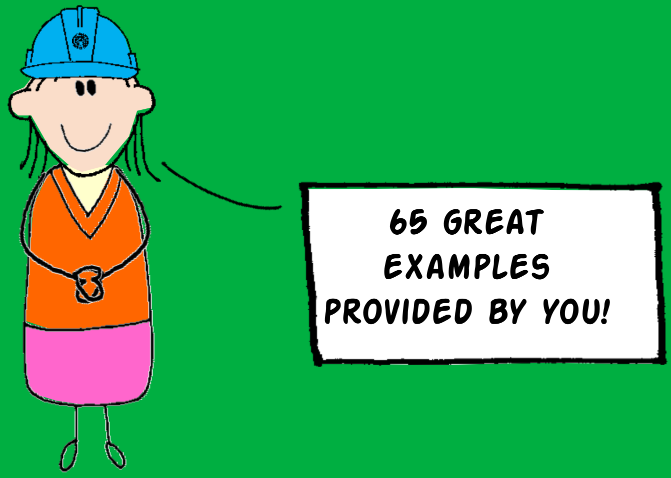
Project stage: Completed 2015

Photo 1: Belford Natural Flood Management project with pictures of some of its interventions (source: Newcastle University)

Project summary:

The Belford Burn is a small stream that runs through the centre of Belford village, hard up against garden boundaries and walls. The 6km² catchment is predominantly rural upstream of the village and is privately owned by 3 main landowners. Prior to the scheme, the burn presented a risk of flooding to 54 properties and a caravan park from a 1 in 100 year event. However, 25 properties were at risk from a 1 in 2 year event.

Belford village flooded 10 times between 1997 and 2007. The flood in 1997, which inundated the East Coast mainline railway, is estimated to have a return period of between 10 and 20 years. Traditional flood defences were not adopted owing to a lack of space between properties and the watercourse, and an unfavourable cost–benefit assessment at the project appraisal phase.



Case study 17. Blackbrook Slow the Flow, St Helens

Authors: Mike Norbury, Rick Rogers, David Brown

Main driver: Flood risk management – repeated flooding in the Blackbrook area of St Helens (October 2000, September 2012 and 26 December 2016)

Project stage: Seeking funding opportunities to implement a catchment-scale Natural Flood Management Plan

Photo1: Engineered dam 2 – attenuation and suspended sediment settlement during flood flows

Project summary:

Blackbrook in St Helens, Merseyside, experiences repeat flooding from a combination of main river and surface water sources. There are 18 properties at flood risk, 3 of which are businesses; a major truck A-road is also at risk. The current flood risk is high.

Blackbrook has a 5% chance of flooding in any given year and sits in a low-lying bowl at the confluence of 5 rapid response catchments whose upstream area is 21km². The property level protection put in place has had limited success, partly due to a failure in its operation at the time of the last flood (26 December 2016). Flooding also occurred on 28–29 October 2000 and 24–26 September 2012.

Capital solutions to reduce the flood risk are prohibitively expensive, as culvert enlarging would be required to reduce the flow constriction. Such considerable capital interventions do not qualify for full funding under HM Treasury rules on cost–benefitratios. Significant additional funding would therefore be required.

Case study 47. North Norfolk Coast

Authors: Sue Rees and Oli Burns

Main driver: Habitat creation, improved and more sustainable defences

Project stage: Constructed – several schemes in different years: Brancaster 2002; Holme Dunes 2004; River Glaven 2006; Cley to Salthouse 2007; Titchwell RSPB 2011 (Photo 1); Blakeney Freshes 2014

Photo 1. Titchwell (source: Mike Page RSPB)

Case study 50. Medmerry Managed Realignment

Author: Robert Harvey

Main driver: Improved defences and habitat creation

Project stage: Completed 2013

Photo 1: Medmerry managed coastal realignment site, 10 October 2013 (source: © Environment Agency and John Akerman ABPmer)

Project summary:

The Medmerry Managed Realignment scheme in West Sussex (Photo 1) was identified in the Pagham to East Head Coastal Strategy (2009). The project came about through a combination of the need to improve flood risk management and the requirement of the Environment Agency's Regional Habitat Creation Programme to create intertidal habitat. The Environment Agency purchased most of the land required for the project and constructed 6.2km of new retreated sea defences, tied into the existing shoreline with rock revetments. Additional land was contributed by RSPB.

The project provides a 1 in 100 year standard of defence in year 100 (increased from 1 in 1 year standard prior to implementation) to 348 properties, the road serving Selsey and a waste water treatment works. It has created 183ha of intertidal habitat and 80ha of transitional grassland. Mitigation was also provided for 50ha of freshwater Site of Special Scientific Interest (SSSI) within and around the realignment area. The project has increased recreation and tourism, creating new amenity and providing both new and replacement footpaths, cycleways and bridleways. Most of the land within the project area has been leased by the Environment Agency to RSPB for management as a nature reserve.

https://www.gov.uk/government/publications/working-with-natural-processes-to-reduce-flood-risk

The Evidence behind Working with N[atural] Processes to reduce flood and coast[al] erosion risk

What is it?

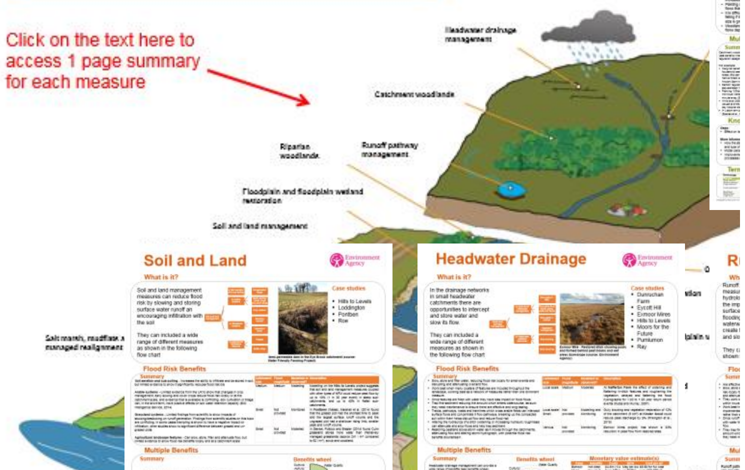
Working with Natural Processes to reduce flood and coastal erosion risk is about restoring and emulating the natural functions of catchments, floodplains, rivers and the coast (Environment Agency, 2012).

It is an approach which can be applied in urban and rural locations, on hill slopes, rivers, floodplain, estuaries and the coast.

It takes many different forms such as:

Rye Harbour Farm (source: Envir[onment Agency])

Click on the text here to access 1 page summary for each measure



River Restoration

Environment Agency

What is it?

Historically rivers have been modified for many reasons (e.g. navigation, development, flood risk management).

River restoration is the reinstatement of the natural physical processes and features (e.g. pools, riffles) that are characteristic of a river.

It can help reduce flood risk, by slowing the flow of water within the channel.

Mayes Brook river floodplain restoration post-construction (source: Environment Agency)

Case studies

- River Avon
- Dorset Frome
- Mayes Brook
- New Forest

Flood Risk Benefits

Summary

- Can slow flood flows and decrease conveyance through the reintroduction of features which encourages the river to reconnect with its floodplain where it can store water and attenuates peak flows d/s
- Can reduce flood risk, the extent of this effect depends on length of river restored relative to catchment size
- Once constructed should last forever, pace at which it becomes effective will vary between rivers, there can be delay whilst morphological adjustment occurs
- Should require limited maintenance

Catchment size	Flood magnitude	Modelled or observed?	Description
Medium	Small	Observed	In a 25 km² catchment in the New Forest Sear et al (2006) found river restoration led to a 21% reduction in flood peak and a 33% increase in peak travel (2year recurrence).
Small	Large	Modelled	Restoration reduced water velocities for a 1 in 100 year flood by 41% (Keesstra et al., 2012).
Local/ Small	Not provided	Modelled	Restoring reaches of 5-10 km can provide tangible attenuation of peak flows (Sholtes and Doyle, 2011).
Medium	Not provided	Modelled	Restoring 5km of the Cherwell's channel reduces peak flow by a 10-15% and increases peak floodplain water levels by 0.5-1.6m (Acreman et al., 2003).
Medium	Medium	Modelled	Restoring meanders in a 1km reach in a 17 km² catchment, reduced flood peaks by less than 1% for 2 to 50 year return period (Sholtes and Doyle, 2011).
Large	Not provided	Modelled	River restoration in headwaters of 400 km² catchment, reduced peak flow by 14% (Liu et al., 2004).

Multiple Benefits

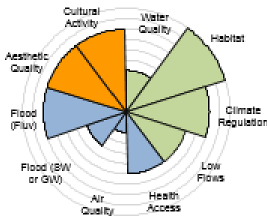
Summary

- River restoration can provide a wide range of benefits across most ecosystem services (see benefits wheel).

For example:

- Regeneration benefits of improving the river and surrounding park at Mayes Brook was valued at £7.8 million over 100 years, based on the uplift to property prices (Everard et al., 2011).
- On the River Frome (Dorset) river restoration is expected to also help manage diffuse pollution, accumulating silt on the floodplain.

Benefits wheel



Monetary value estimate(s)

Case study	Benefits	Costs	BCR
Mayes Brook	£245k	£750k + approx. £5k pa	7:1

Source: Eftec (2017)

River restoration benefits recreation and tourism, the estimated per person per trip value provided by rivers and floodplains is £3.35 (Sen et al., 2012).

Knowledge gaps

Gaps:

- Limited field-based evidence that demonstrate its flood risk benefit

More information needed on::

- Standard of flood protection provided by river restoration
- FCRM benefits of different types of river restoration at different spatial scales
- Conveyance capacity of restored rivers
- Water storage effects of restoration

Key reading and maps

Reading:

- Green approaches in river engineering
- Manual of River Restoration Techniques
- River restoration and biodiversity

Maps:

- Wetland vision
- Strategic National Opportunity Maps (England)
- NFM Opportunity Maps (Scotland)

Terms of reference

Terminology

Benefits wheels

For each measure we have summarised the multiple benefits which the measure could provide using a Benefits Wheel which covers 10 benefit indicators that have been ranked on a scale from 1 to 5 to give an indication of the relative contribution the measure can make to the provision of a certain benefit.

References

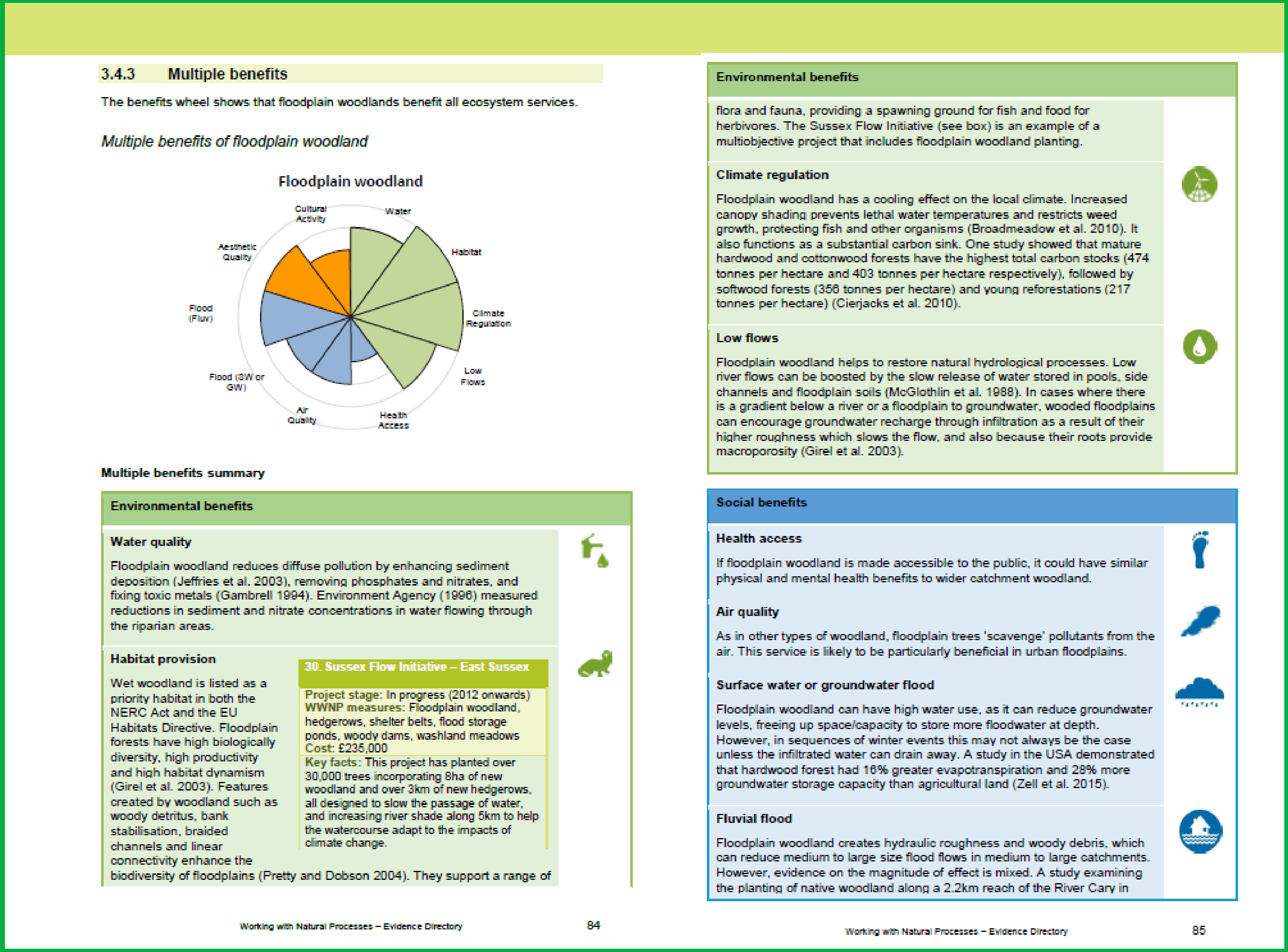
More details on the references and case studies discussed here can be found in the following documents:
SC150005 - Working with Natural Processes – Evidence Directory
SC150005 - Appendix 1. Evidence Directory Literature Review
SC150005 - 65 Individual case studies

HERE ARE THE 14 1 PAGE SUMMARIES

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/654440/Working_with_natural_processes_one_page_summaries.pdf

Multiple Benefits

Kate Kipling



3.4.3 Multiple benefits

The benefits wheel shows that floodplain woodlands benefit all ecosystem services.

Multiple benefits of floodplain woodland

Multiple benefits summary

Environmental benefits

Water quality

Floodplain woodland reduces diffuse pollution by enhancing sediment deposition (Jeffries et al. 2003), removing phosphates and nitrates, and fixing toxic metals (Gambrell 1994). Environment Agency (1996) measured reductions in sediment and nitrate concentrations in water flowing through the riparian areas.

Habitat provision

Wet woodland is listed as a priority habitat in both the NERC Act and the EU Habitats Directive. Floodplain forests have high biological diversity, high productivity and high habitat dynamism (Girel et al. 2003). Features created by woodland such as woody detritus, bank stabilisation, braided channels and linear connectivity enhance the biodiversity of floodplains (Pretty and Dobson 2004). They support a range of

30. Sussex Flow Initiative – East Sussex

Project stage: In progress (2012 onwards)
WWNP measures: Floodplain woodland, hedgerows, shelter belts, flood storage ponds, woody dams, washland meadows
Cost: £235,000
Key facts: This project has planted over 30,000 trees incorporating 8ha of new woodland and over 3km of new hedgerows, all designed to slow the passage of water, and increasing river shade along 5km to help the watercourse adapt to the impacts of climate change.

Environmental benefits

flora and fauna, providing a spawning ground for fish and food for herbivores. The Sussex Flow Initiative (see box) is an example of a multiobjective project that includes floodplain woodland planting.

Climate regulation

Floodplain woodland has a cooling effect on the local climate. Increased canopy shading prevents lethal water temperatures and restricts weed growth, protecting fish and other organisms (Broadmeadow et al. 2010). It also functions as a substantial carbon sink. One study showed that mature hardwood and cottonwood forests have the highest total carbon stocks (474 tonnes per hectare and 403 tonnes per hectare respectively), followed by softwood forests (356 tonnes per hectare) and young reforestations (217 tonnes per hectare) (Cierjacks et al. 2010).

Low flows

Floodplain woodland helps to restore natural hydrological processes. Low river flows can be boosted by the slow release of water stored in pools, side channels and floodplain soils (McGlothlin et al. 1988). In cases where there is a gradient below a river or a floodplain to groundwater, wooded floodplains can encourage groundwater recharge through infiltration as a result of their higher roughness which slows the flow, and also because their roots provide macroporosity (Girel et al. 2003).

Social benefits

Health access

If floodplain woodland is made accessible to the public, it could have similar physical and mental health benefits to wider catchment woodland.

Air quality

As in other types of woodland, floodplain trees 'scavenge' pollutants from the air. This service is likely to be particularly beneficial in urban floodplains.

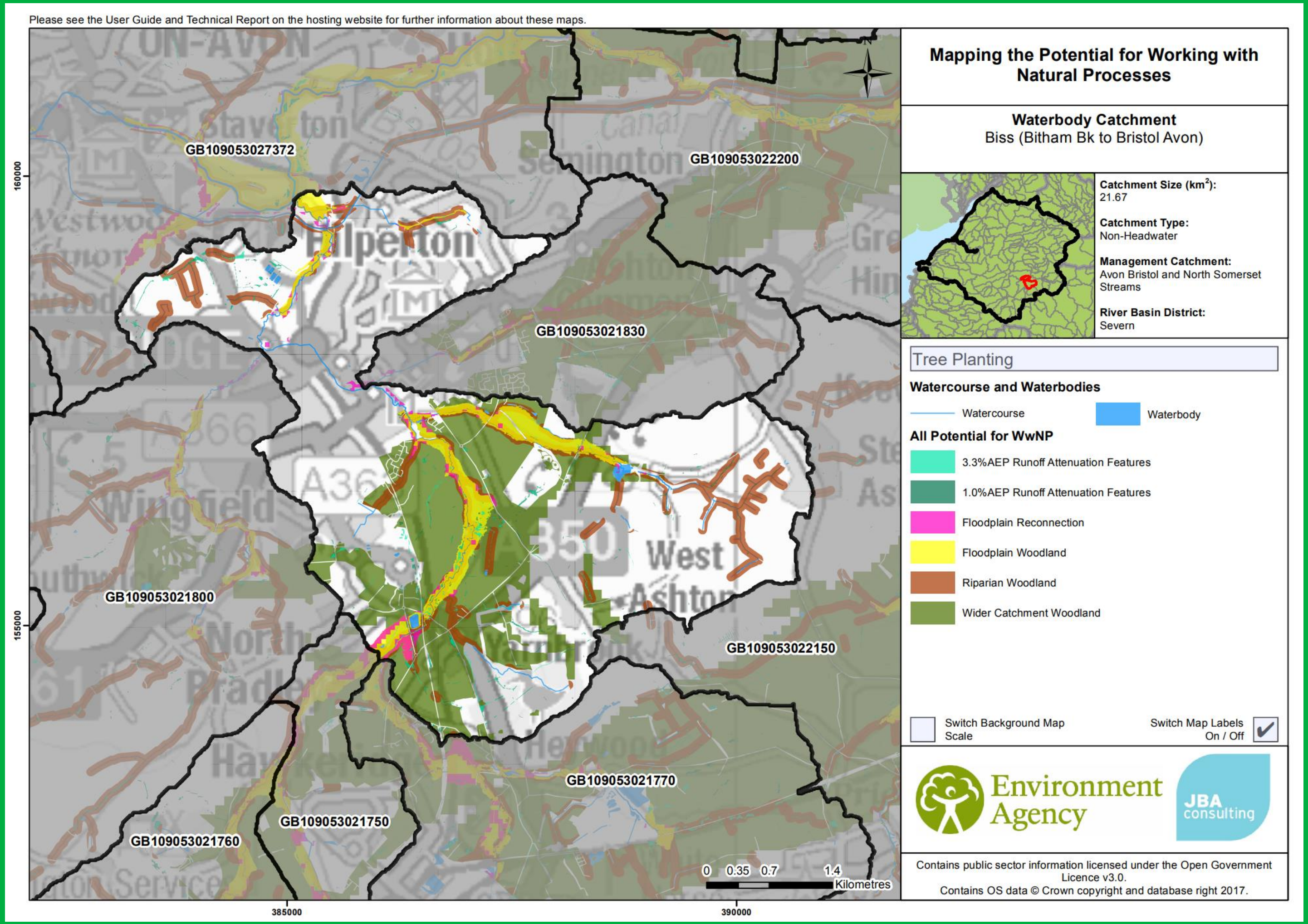
Surface water or groundwater flood

Floodplain woodland can have high water use, as it can reduce groundwater levels, freeing up space/capacity to store more floodwater at depth. However, in sequences of winter events this may not always be the case unless the infiltrated water can drain away. A study in the USA demonstrated that hardwood forest had 16% greater evapotranspiration and 28% more groundwater storage capacity than agricultural land (Zell et al. 2015).

Fluvial flood

Floodplain woodland creates hydraulic roughness and woody debris, which can reduce medium to large size flood flows in medium to large catchments. However, evidence on the magnitude of effect is mixed. A study examining the planting of native woodland along a 2.2km reach of the River Cary in

The Maps



http://naturalprocesses.jbahosting.com We have recently updated this so people can add spatial edits & comments: http://wwnp-dev.jbahosting.com/Map

The Gaps

Chapter 6. Research gaps and monitoring

Mayes Brook restoration – explaining ecological monitoring to local school children (source: Environment Agency)

What’s happening in my area?

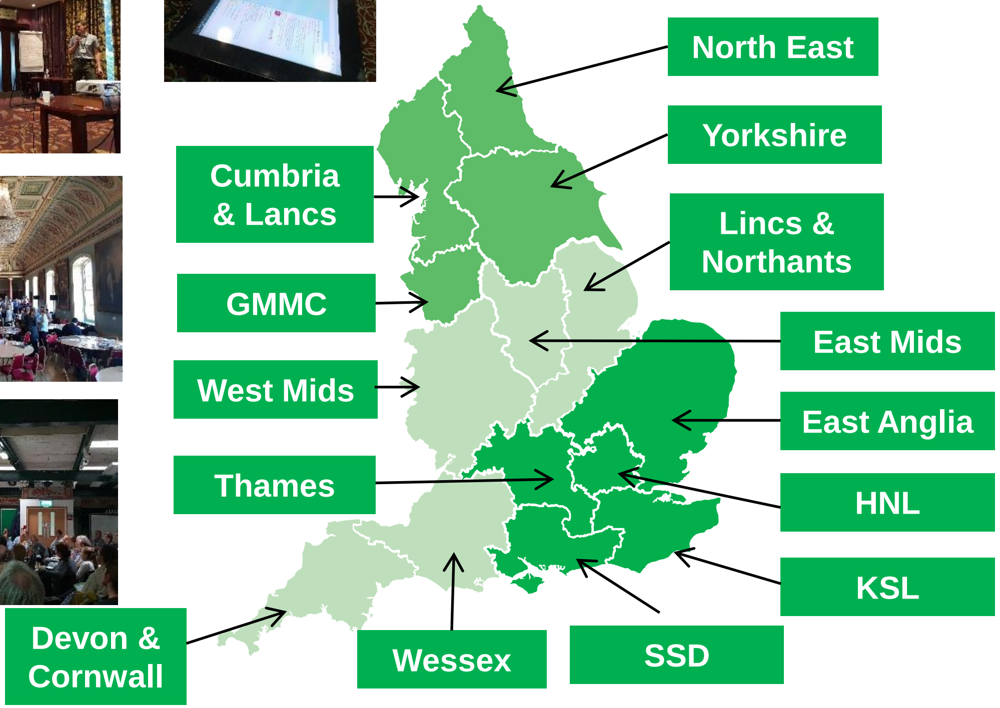
We ran 14 NFM roadshows & reached 1400 people!

Click on labels below to find out more about a specific area. Then visit the slide pack for more details







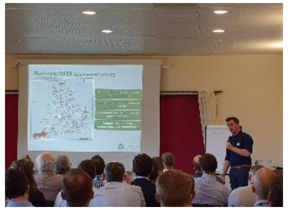














East Midlands

Message from Paul Lockhart – Area FCRM Manager

My goal for future East Midlands' flood alleviation schemes is that, when thinking about potential solutions, the *starting* point will be using natural processes and identifying multiple benefits with partners. It is only then that we will really be creating a better place for our communities and getting the best value for the taxpayer from our investment.

Internal contacts:
- Andy Disney – FCRM
- Karen Carter – FCRM
- Julia Toone – Geomorphologist
- Alison Baker – Environment Programme Manager
- Alex McDonald – NEAS

External contacts:
- David Bole – Forestry Commission
- David Parker – Natural England

Main NFM projects:
- iWait River Torne
- Lowdham NFM
- Moors for the future partnership
- Soar Tributaries
- Southwell

The Evidence Base:
www.gov.uk/government/publications/working-with-natural-processes-to-reduce-flood-risk

Prezi summary of Evidence Base:
https://prezi.com/view/0kkkS47snB1ah7gGMavN/

Email:
wwnp@environment-agency.gov.uk