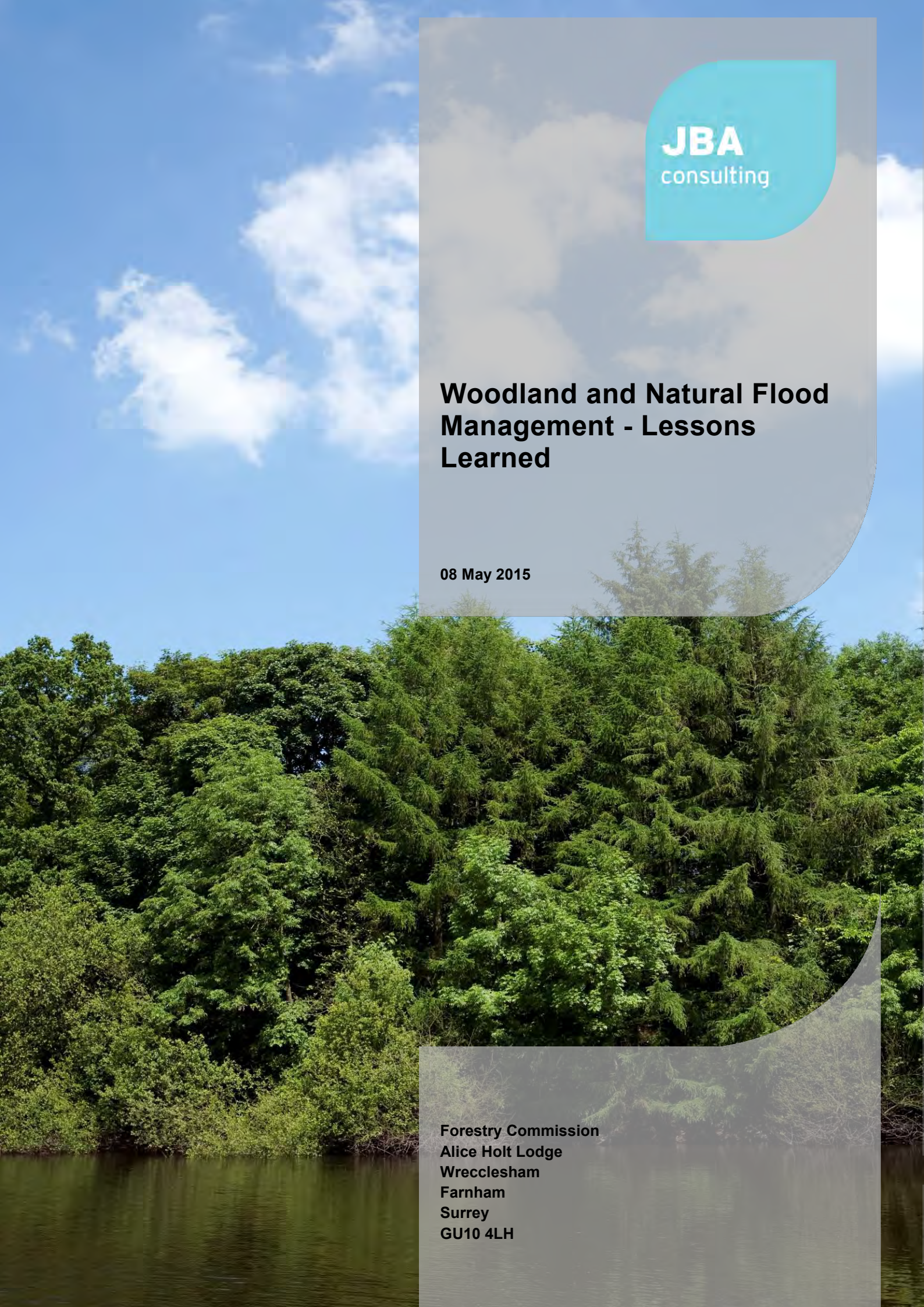

Woodland and Natural Flood Management - Lessons Learned

08 May 2015

Forestry Commission
Alice Holt Lodge
Wrecclesham
Farnham
Surrey
GU10 4LH

JBA Project Manager

Janet Spence
JBA Consulting
Salts Mill
Victoria Road
Saltaire
Shipley BD18 3LF

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Contract

This report describes work commissioned by Vince Carter on behalf of the Forestry Commission. Marie Lagerwall and Steve Rose of JBA Consulting carried out this work.

Prepared by ..... Marie Lagerwall BA MSc MA
Assistant Landscape Architect

Reviewed by ..... Steve Rose BSc MSc FRGS CGeog
Technical Director

Purpose

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1 Introduction

1.1 Background

JBA Consulting was commissioned by Forestry Commission to carry out a review to identify research, demonstration and monitoring projects undertaken in the United Kingdom since the year 2000 that have involved the implementation of woodland measures taken in the context of natural flood management (NFM) or as part of a natural processes approach to flood risk management and other water objectives.

Despite pre-dating the year 2000, the Coalburn project in the Kielder Forest which was initiated in the late 1960s was included in the review as it is ongoing and continues generating relevant data, with the woodland planted on site in the 1970s due for felling starting this year.

The review incorporates two elements, namely:

- a database of projects identified, and
- an associated summary report focused on drawing out lessons learned from the various projects.

1.2 Methodology

The research took place over approximately 4 weeks starting on Thursday 5 March 2015. It was entirely desk-based and iterative, with email and/or phone contact with individuals involved in or aware of woodland and NFM projects feeding into web-based research and *vice versa*.

1.2.1 Sources

Information for the project was collected from two source types:

- individuals involved in or aware of NFM and/or woodland projects, and
- online literature, or in some cases hard-copy documents, regarding woodland NFM projects identified.

One online resource of particular note for information on NFM projects was the collection of case studies made available on the Centre of Expertise for Waters website at http://www.crew.ac.uk/NFMcasestudies.

The following documents have proved seminal since their publication and should therefore also be highlighted in this introduction as they effectively underpin and form the backdrop to this review:

- The *Pitt Review* was undertaken following the devastating floods the UK experienced in summer 2007. It drew together lessons learned from the events and response to the floods, and made recommendations to help prevent and better manage future events - see Pitt, M. (2008), *The Pitt Review - learning lessons from the 2007 floods: full report*, The Cabinet Office.
- In 2011, Forest Research published the *Woodland for water* report which looked at the use of woodland measures, in particular woodland creation, to facilitate Water Framework Directive objectives - see Nisbet, T., M. Silgram, N. Shah, K. Morrow and S. Broadmeadow (2011), *Woodland for water: woodland measures for meeting Water Framework Directive objectives*, Forest Research Monograph: 4, Forestry Commission.
- In 2014, the Environment Agency published its report on *working with natural processes* in relation to managing flood risk - see Barlow, J., F. Moore, L. Burgess-Gamble (2014), *Delivering benefits through evidence: working with natural processes to reduce flood risk*, Environment Agency Flood and Coastal Erosion Risk Management Research and Development Programme.

2 Findings

2.1 Data collection

A total of 53 projects were identified through the research. These are listed under appendix 5.1 and mapped under appendix 5.2, with:

- 36 projects in England (refs. E1-E36),
- 13 projects in Scotland (refs. S1-S13),
- 3 projects in Wales (refs. W1-W3), and
- 1 project in Northern Ireland (ref. NI1).

	No. of projects	10 to 15 (of 15) cells filled	5 to 9 cells filled	0 to 4 cells filled
ENGLAND	36	9	13	14
SCOTLAND	13	1	5	7
WALES	3	0	1	2
N. IRELAND	1	0	1	0
Total	53	10	20	23

For 10 of the 53 projects, a good to very good amount of data were identified, with over 10 of the 15 cells populated in the database specified. These instances largely correlate with well-documented projects and/or projects where data were not only sourced from the literature available but also directly from individuals involved with the projects and able to set time aside to answer questions through email or over the phone.

For 20 of 53 projects, a reasonable amount of data were collected through the research, with up to 9 of 15 cells populated.

For the remaining 23 of 53 projects, only a limited amount of data were identified, with fewer than 5 of the 15 cells populated. The main reason for this is that a good number of relatively new or small projects were flagged by individuals contacted through the course of the research, with little or no corresponding information to be found online for these projects, and a failure to source information by other means within the timeframe of the project.

2.1.1 Highlights

Of particular note with regards quantity and quality of data gathered within the database, and included under appendix 5.3, are the following projects:

- rSuDS Project, Stroud (E8),
- SOURCE, Upper Calder & Aire catchment (E21),
- Slowing the Flow at Pickering, North Yorkshire (E31),
- Eddleston Water Project, Scottish Borders (S3),
- Bowmont-Glen catchment (S6),
- Spey Catchment Initiative, North East Scotland (S10), and
- Pontbren Project (W3).

Indeed, these projects display most if not all of the following characteristics:

- Broad scale or range of woodland interventions in place or planned.
- Good funding sources and budgets with long-term continuity.
- Partnership projects, mostly including research/academic interests, and in the case of Pontbren, driven by a group of farmers.

- Some form(s) of monitoring and/or a modelling element.
- NFM as key aim within multiple objectives.

2.2 Background

Where information regarding the background to projects listed was identified, by far the most significant driver were recent flood events and associated damage to settlements and properties. Indeed, such events are known to have informed the commissioning of the following 6 projects:

- Slowing the Flow at Pickering, North Yorkshire (E31),
- Lustrum Beck Flood Alleviation Project, Stockton-On-Tees (E32),
- Belford Catchment Solutions Project, Northumberland (E36),
- rSuDS Project, Stroud (E8),
- River Derwent catchment, North West Cumbria (E26), and the
- Bowmont-Glen catchment (S6).

In the case of the SOURCE project (E21), the background to the project is the significant flood risk level identified in the upper Calder catchment rather than any particular flood event. And in the case of the Ripon Multi-Objective Project (Ripon MOP) and associated River Laver demonstration project (E29), the main driver was the realisation that the relationship between land use and flood management was not being adequately considered or realised.

2.3 Partners

Some agencies and organisations that appear in at least 4 projects reviewed and are therefore of note include (with number of projects in brackets):

- the Environment Agency (16),
- Natural England (10),
- the Woodland Trust (9),
- the Forestry Commission or Forest Research (9),
- the Wildlife Trust (6),
- the RSPB (4),
- the Scottish Environment Protection Agency (4),
- Scottish Natural Heritage (4),
- misc. local authorities (14),
- misc. universities (10), and
- misc. national park authorities (5).

Many projects also form partnerships with or otherwise involve local communities: typically including landowners, land managers and tenants.

2.4 Funding

2.4.1 Funding partners

The following organisations recurred across at least 4 projects, as funding partners or providers of in-kind support (with number of projects in brackets):

- the Environment Agency (6),
- Defra (5),
- Natural England (5),
- the Woodland Trust (5), and
- the Forestry Commission (4).

2.4.2 Funding streams

While details of specific funding streams were not available for all projects, the following streams or funds featured in the research (with associated funder in brackets):

- Flood and Coastal Erosion Risk Management Grant in Aid / Innovation Fund (the Environment Agency / Defra),
- Water Framework Directive Grant in Aid (the Environment Agency),
- Catchment Restoration Fund (the Environment Agency),
- Regional Flood and Coastal Committee (the Environment Agency),
- Community Resilience Pathfinder (Defra),
- Innovation funding (Defra),
- Higher Level Stewardship Scheme (Natural England),
- Woodlands for Water / Woodland Creation Grant / English Woodland Grant Scheme (Forestry Commission),
- the Landscape Partnership Scheme (the Heritage Lottery Fund),
- Restoration Fund (Scottish Environment Protection Agency),
- Water Environment Fund (Scottish Environment Protection Agency), and
- Green Stimulus Peatland Restoration Fund (Scottish Natural Heritage).

2.5 Technical details

Given how variable the amount, comprehensiveness and precision of the technical data collected under the following headings, it ought to be borne in mind the summaries below, based entirely on this data, may not in every case constitute a fully accurate representation of known projects focused on or involving woodland measures for NFM benefits. The summaries are thus only as representative as the technical data collected for the projects.

2.5.1 Woodland NFM type

Woodland type	Equivalent woodland creation category as defined in Broadmeadow & Nisbet (2010)	No. of projects
Woody debris dams	N/A	16
Gully woodland	Wider planting	10
Riparian woodland	Riparian	9
Floodplain woodland	Floodplain	7
Upland woodland	Wider planting	7
Cross-slope woodland	Wider planting	1

The above table shows the number of instances encountered in the projects reviewed for each of the woodland types specified in this project, namely: upland woodland, gully woodland, cross-slope woodland, floodplain woodland, riparian woodland and woody debris dams. The data are based on 28 of the 53 projects reviewed as no such data were found for the remaining 27 projects.

By far the largest woodland NFM type encountered were woody debris dams, with over half of the projects where such data were collected having planned or implemented such structures. At the other end of the spectrum, the least common woodland type was found to be cross-slope woodland, cited only in the context of the Pontbren Project in Wales (W3). The upland, gully, riparian, floodplain and upland woodland types recurred throughout the research, with between 7 to 10 instances noted for each.

The high recurrence of woody debris dams may be explained by the relative ease and speed with which such structures can be built: using local materials sourced from existing woodland, and with construction not overly demanding in terms of manpower or technical skill set.

The scarcity of cross-slope woodland instances found in the research may be explained by the potential loss of farming land such woodland can result or be perceived to result in, a known issue of concern to the farming community.

In most cases, projects deployed either a single woodland NFM type or a combination of two:

No of woodland measures	No. of projects	Woodland type pairing	No. of projects with this pairing
1	11	N/A	
2	10	Upland + gully	4
		Floodplain + woody debris	2
		Floodplain + riparian	2
		Gully + woody debris	1
		Riparian + woody debris	1
3	4	N/A	
4	2	N/A	

No single pairing occurred significantly more than any other pairing, with the slightly higher number of instances found for the combination of upland and gully woodland understood to be due to those 4 projects all occurring in Cumbria and 3 of the projects involving the same officer, from whom the data were sourced, namely for:

- Kinniside Common (E25),
- Tebay Common (E30) and
- Duddon upper catchment (E24).

Only in a small number of projects was a combination of 3 or more measures recorded, these instances were at:

- Slowing the Flow, Pickering (E31),
- the Lustrum Beck Flood Alleviation Project, Stockton-On-Tees (E32),
- the Eddleston Water Project, Scottish Borders (S3),
- the Bowmont-Glen catchment (S6),
- the River Devon Natural Flood Management Demonstration Project, Clackmannanshire (S8), and
- the Upper Clyde Natural Flood Management Scoping Study, Upper Clyde Valley (S1).

This may be explained by the following factors: the source and level of funding made available to these projects having been on a greater scale than for other projects reviewed and the activities involved in these projects better documented as a result, with more comprehensive data regarding woodland type available, as well as the scale of these projects possibly entailing areas of more varied topography and terrain and thus resulting in a wider range of woodland measures available for implementation.

2.5.2 Extent

The data gathered highlights the range of scales of the projects reviewed, with an overall area of 20,000 hectares in the case of the Sustainable Catchment Management Programme (SCaMP) in North West England (E19), and individual woodland blocks recorded within the database ranging between under 1 ha, as with the Holnicote Multi-Objective Flood Management Demonstration Project in Somerset (E3), and 188 ha, as with the Rydal Valley project in Cumbria (E23).

The same variation is observed with woody debris dam numbers: a project such as Slowing the Flow at Pickering in North Yorkshire (E31) saw the construction of 100 such structures, with other projects such as the one on Cunsey Beck in Cumbria (E22) involving just 6 structures.

2.5.3 Woodland management and creation

Further details than the data recorded under woodland NFM type were found on woodland management and creation for a small number of the projects identified. It is worth noting that aside from woody debris dam construction, other management measures include thinning, forest drain blocking and fencing erection to keep grazers from accessing areas of newly created woodland.

Though this information was only collected for a small number of projects, the most salient data found on woodland creation were details of tree species planted.

2.5.4 Catchment monitoring and modelling

Limited information on modelling or catchment monitoring was identified for the following projects only:

- Ripon Multi-Objective Project (Ripon MOP) and associated River Laver demonstration project (E29),
- Slowing the Flow at Pickering, North Yorkshire (E31),
- Coalburn, Kielder Forest (E34),
- Lustrum Beck Flood Alleviation Project, Stockton-On-Tees (E32), and in the
- Bowmont-Glen catchment (S6).

3 Conclusions

3.1 Lessons learned

The main lessons learned from this commission have to do with the research process. Indeed, the database population achieved within the timescale of this project has proven too limited to enable the sort of in-depth review and analysis that could draw out broad lessons on implemented woodland NFM measures within funded projects.

With regards to the research process and data collection more specifically; it is clear there are difficulties with sourcing relevant literature and publications. While grey literature might be abundant, it may not necessarily be indexed or made available in a way conducive to retrieval. Project documentation is extremely variable: there may be little or none generated or available online, or where there is, it may not provide information that is detailed enough to start building a broader understanding of how and, perhaps, with what success woodland NFM measures have been or are being planned or implemented in the UK.

Unsurprisingly, the richest information was very often found to result from direct communication with individuals involved in delivering woodland NFM projects, whether via email or over the phone, along with data gathered from project documentation.

3.2 Monitoring

There is a general absence of monitoring measures in place from a significant number of projects. This absence, if it is indeed representative of projects on the ground rather than issues of data collection, may be understood as pointing to the difficulty with 'before' and 'after' monitoring: with no-woodland data collection prior to woodland creation especially problematic given the forward drive often associated with such projects. In the case of woody debris dams, the methodological difficulties of collecting data after the erection of an essentially dynamic structure may equally explain the relative scarcity of monitoring measures in place.

Monitoring of either woodland management or creation measures in a NFM context also suffers from a difficulty of scale: measuring effects upstream and downstream of the location of a particular woodland measure is especially complex given the number of additional factors needing to be considered with every increment of the monitoring area.

3.3 Coalburn, Kielder Forest

In this context, the longest running UK afforestation research project at Coalburn (E34) is worth mentioning: the huge dataset built up since the project began within the Kielder Forest in the North of England in the late 1960s, if incomplete, is a reminder of the essential value of monitoring. The historic dataset has enabled research to be undertaken that could not have been foreseen let alone anticipated at the time monitoring was planned or data collected.

Coalburn may also serve as a reminder of how transformed forestry/woodland establishment and management practices have become since the late 1960s and early 1970s when this particular scheme was initiated, with deep ploughing preceding planting of the coniferous woodland standard practice at the time and far removed from current Forests and Water guidelines.

4 Recommendations

4.1 A comprehensive inventory

The main recommendation would thus be to build on the research carried out so far and further populate the database, with a view to creating a comprehensive inventory of woodland NFM projects in the UK on the basis of:

- a more comprehensive and systematic literature review than was possible within this commission, and
- a programme of in-depth interviews with managers, officers or other representatives of woodland NFM projects.

A longer timescale would be necessary for the above processes to result in optimal information yields. Sourcing data from people in particular requires a relatively long timescale, possibly spanning months rather than weeks to allow for communication to follow its course. The seven projects highlighted under section 2.1.1 and in appendix 5.3 could be prioritised within this research, or focused on solely if resources for a comprehensive inventory or a long timescale cannot be secured.

4.2 A web interface

A related recommendation would be for the resulting database or inventory to have a web interface, whereby the data could be viewed, the database queried, and which could also allow for new data contribution, thus keeping the database live. While relatively small-scale, the collection of case studies made available on the Centre of Expertise for Water website (http://www.crew.ac.uk/content/natural-flood-management-database) could be used as precedent, as could the River Restoration Centre's interactive project map (http://www.therrc.co.uk/uk-projects-map).

4.3 A stand-alone literature review

A final recommendation would be for the literature review to not only assist with developing the database but also result in a more definitive report, compiled with a view to the broadest possible dissemination in the UK.

5 Appendices

5.1 List of identified projects

ENGLAND

E1 - Helston, Cornwall

E2 - Buckfastleigh, Devon

E3 - Holnicote Multi-Objective Flood Management Demonstration Project, Somerset

E4 - Parrett Catchment Project

E5 - River Lyd/Lydbrook Scheme, Forest of Dean

E6 - Upper Lydbrook Scheme, Forest of Dean

E7 - River Frome, Stroud

E8 - rSuDS Project, Stroud

E9 - Berkshire Downs

E10 - Aldingbourne Rife catchment, Sussex

E11 - South Downs National Park Authority, West Sussex

E12 - Upper Thames tributaries, Wallingford

E13 - Sussex Flow Initiative - River Ouse East Sussex, formerly Trees on the River Uck (TrUck)

E14 - River Leam, Warwickshire

E15 - Farming Floodplains for the Future, Stafford

E16 - Knowledge Transfer Partnership

E17 - Roding catchment, Chipping Ongar

E18 - South West Peak Landscape Partnership

E19 - Sustainable Catchment Management Programme (SCaMP), North West England

E20 - Clough Woodland Project, Peak District

E21 - SOURCE, Upper Calder & Aire catchment

E22 - Cunsey Beck, Cumbria

E23 - Rydal Valley, Cumbria

E24 - Duddon upper catchment, Cumbria

E25 - Kinniside Common, Cumbria

E26 - River Derwent catchment, North West Cumbria

E27 - Dearne Valley, South Yorkshire

E28 - White Rose Forest, Yorkshire

E29 - Ripon Multi-Objective Project (Ripon MOP) and associated River Laver demonstration project

E30 - Tebay Common, Cumbria

E31 - Slowing the Flow at Pickering, North Yorkshire

E32 - Lustrum Beck Flood Alleviation Project, Stockton-On-Tees

E33 - Saltholme, Tyneside

E34 - Coalburn, Kielder Forest

E35 - River Till Wetland Restoration Project, Northumberland

E36 - Belford Catchment Solutions Project, Northumberland

SCOTLAND

S1 - Upper Clyde Natural Flood Management Scoping Study, Upper Clyde Valley

S2 - Craik Forest/Borthwick Water, Scottish Borders

S3 - Eddleston Water Project, Scottish Borders

S4 - Ettrick Water, Scottish Borders

S5 - Bowanhill Farm, Teviot, Scottish Borders

S6 - Bowmont-Glen catchment

S7 - Inner Forth FutureScapes

S8 - River Devon Natural Flood Management Demonstration Project, Clackmannanshire

S9 - Allan Water NFM Techniques and Scoping Study, and associated Allan Water NFM Project

S10 - Spey Catchment Initiative, North East Scotland

S11 - Tarland Burn

S12 - Stonehaven/Cowie Water

S13 - Aberdeenshire Land Use strategy Pilot (RLUP), Aberdeenshire

WALES

W1 - Natural Resource Management Trials

W2 - Great Triley Wood, Abergavenny

W3 - Pontbren Project

NORTHERN IRELAND

NI1 - Lagan River/Ulster Canal, Belfast

5.2 Location map

5.3 Seven projects of note

It should be noted that within this section, "No data" appears where data were either not available or not obtained.

5.3.1 rSuDS Project, Stroud (E8)

Contact details

Chris Uttley - Stroud District Council, chris.uttley@stroud.gov.uk.

Dates

May 2014-May 2017

Summary

The project is focused on measures to slow the flow and reduce siltation throughout the River Frome catchment. Measures include those aimed at woodland and agricultural land.

Background

Like other parts of Gloucestershire, the Stroud Valleys suffered extensive flooding during the summer of 2007. Every year since has seen flooding in some parts of the Stroud Valleys, including most recently Chalford on the middle Frome, and Bridgend and Eastington on the lower Frome. Of particular concern to residents and the District Council is the designation by the Environment Agency of the Slad Valley as at risk of destructive flash flooding, of a similar type to the event that destroyed parts of Boscastle in Cornwall. In 2012, the Environment Agency commissioned a report into the feasibility and potential benefits of implementing Natural Flood Management (also called Rural Sustainable Drainage - RSuDS) throughout the catchment of the Frome and associated tributaries. Acting on findings of the study, the Severn and Wye Regional Flood and Coastal Committee (RFCC) agreed to fund a project officer to implement and promote rural sustainable drainage in the Frome catchment.

Selected findings

No data.

Partners

A formal partnership between Gloucestershire County Council, the Environment Agency, the RFCC and Stroud District Council was established to implement the work, and under a collaborative agreement, Stroud District Council agreed to employ the Project Officer for three years. The project has also involved Gloucestershire Wildlife Trust and several landowners within the Slad and Toadsmoor Valleys.

Funding

£150,000 revenue funding from the RFCC over 3 years (May 2014-May 2017). Capital funds supplied by Gloucestershire County Council, Stroud District Council and funding in kind from the National Trust and Gloucestershire Wildlife Trust. Further capital funding secured for next year financial year from Gloucestershire County Council, the Environment Agency and Stroud District Council.

NFM type

Hydraulic roughness; Surface runoff interception

Woodland type

Woody debris dams (artificial) and other timber structures

Extent

Slad Valley - 21 medium-large woody debris dams in all within Slad Valley riparian woodland: 5 within a 50m stretch at the confluence of two streams, 16 at Snows Farm Nature Reserve on Dillay Brook, with another 7 very large floodplain attenuation timber structures. Workmans Wood - 12 large woody debris dams along Sheepscombe Brook in all: 11 along channel with base flow and 1 upstream in the dry channel with seasonal flow; 4 large timber deflectors or flood

attenuation structures; 8 woody debris structures to slow down water flow from culverts built underneath woodland tracks to downstream outlet and 8ft soakaway. Toadsmoor Wood - 18 medium woody debris dams.

Location

Slad Valley - approximate coordinates for Snows Farm Nature Reserve: 388714, 208098. Workmans Wood (within the Painswick Valley in the Cotswold Commons and Beechwoods NNR) - approximate coordinates for the wood: 390000, 210900. Toadsmoor Wood, Toadsmoor Valley - approximate coordinates: 388270, 204462. (Location on map: 388714, 208098).

Woodland management - further details

Slad Valley - Woody debris dams are artificially constructed with materials sourced from the streamside, typically Ash, Alder and other hardwoods, with Hazel also along Dillay Brook. Reinforced steel bars are used to hold main logs in place. The floodplain attenuation structures are experimental and built of Poplar and/or Alder, 18ft long, and placed to divert water away from the watercourse to the floodplain at times when river flow is increased significantly. Workmans Wood - Woody debris dams are artificially constructed with local materials, with reinforced steel bars used to hold main logs in place. Large poplar trees used to deflect flow from the channel to adjacent woodland to facilitate infiltration. The culverts constructed underneath woodland tracks and associated woody debris structures and soakaways are also designed to collect silt. Toadsmoor Wood - Thinning is taking place within this deciduous broadleaf woodland of Hazel coppice, Beech and Douglas Fir, in order to provide materials for the woody debris dams which are designed to slow water flow and trap sediment along unnamed watercourse that feeds Toadsmoor Pond. The 30 ha woodland is otherwise privately owned and commercially managed for firewood, with a 40% contribution in time and labour from the landowner towards the construction of the woody debris structures.

Woodland creation - further details

N/A

Catchment monitoring

No data.

Modelling

No data.

5.3.2 SOURCE, Upper Calder & Aire catchment (E21)

Contact details

Charles Foreman - Environment Agency, charles.forman@environment-agency.gov.uk.

Dongria Kondh - Treesponsibility, treesponsibility@yahoo.co.uk, 07847 815926.

Dates

Summer 2011 (formal launch)

Summary

The project deploys land management approaches, including woodland measures, aimed at reducing local flood risk by minimising surface water run-off and reducing hillside erosion and sediment deposits following heavy rainfall. The project is also involved with moorland restoration and river ecology as well as educational and volunteer activities across the spectrum of project activities.

Background

The project is informed by the significant flood risk level in the upper Calder catchment due to rapid run-off from the land, and the Calder and Colne water bodies failing WFD standards due to sediment levels.

Selected findings

A model was developed as part of PhD research carried out by Dr Gao at the University of Leeds, also part of the water@leeds centre, to assess the impacts of land use management on floods in the Upper Calder catchment, with findings on the Colden Water modelling study made public in September 2014 (although these have not been sourced so far in the context of this project). Monitoring also in place on erosion control programme and river invertebrate.

Partners

"The project is an environmental partnership between the Calder and Colne Rivers Trust, Calder Valley Wildlife Group, Todmorden Moor Restoration Trust, Calder Futures, Calderdale Council (Countryside Department), the Environment Agency, Treesponsibility, White Rose Forest, BlackBark Woodland Management, Moors for the Future, National Trust, Trees for Yorkshire, Upper Calderdale Wildlife Group. The project also contributes to broader strategic activities and contributes to the Leeds City Region green infrastructure investment programme Rivers For Life, the work of the local regeneration company Pennine Prospects and their South Pennine Landscapes work in the Dark Peak Nature Improvement Area. SOURCE has also worked with a large number of volunteers from diverse community groups (too numerous to list comprehensively), for eg. St. Josephs RC Primary School, Manchester Quakers, Liverpool Woodcraft Folk."

Funding

Woodlands for Water funding received from the Forestry Commission and in-kind contributions from the Woodland Trust and Yorkshire Water. Funding also received from the Coal Authority, Cooperative Community Fund and Calderdale Council for volunteer training on invertebrate monitoring, from Calderdale Council through the Defra Community Resilience Pathfinder to enable a range of project-related events, from Calderdale Council Cleaner Greener with private match funding from SUMA Wholefoods, and from Hebden Bridge Town Council.

NFM type

Hydraulic roughness; Surface runoff interception

Woodland type

Gully woodland; Woody debris dams

Extent

44,000 trees planted to date across all sites: c. 10,000 trees and 800m of hedging over a 8 ha site at Warland Farm. The extent of the site near Blackshawhead is 2.5 ha. No other data gathered.

Location

Headwaters of the River Calder catchment near Todmorden: at Gorpley Clough within Inchfield Pasture Common (391900, 423500), Warland Farm (394656, 420329), Calf Lee, South Grain and Sagar Lane. Also upper Derwent catchment within Dark Peak Improvement Area. Headwaters of the River Calder catchment near Blackshawhead. (Location on map: 391900, 423500).

Woodland management - further details

At Gorpley Clough: fencing installed to exclude sheep and cattle. Woody debris dam or 'leaky dam' construction near Blackshawhead.

Woodland creation - further details

Warland Farm: ash, oak, sweet chestnut, hazel and willow coppice as well as blackthorn hedgerow. Gorpley Clough: hedge and trees planted.

Catchment monitoring

No data.

Modelling

No data.

5.3.3 Slowing the Flow at Pickering, North Yorkshire (E31)

Contact details

Tom Nisbet - Forest Research, tom.nisbet@forestry.gsi.gov.uk, 0300 067 5600 / 0300 067 5697.

Dean Hamblin - Environment Agency, dean.hamblin@environment-agency.gov.uk.

Richard Pow - Yorkshire & North East Forestry Commission Area Team, Forestry Commission, Richard.Pow@forestry.gsi.gov.uk, 01670381005 / 07831216024.

Paul Murby - Defra, paul.murby@defra.gsi.gov.uk.

Dates

01.06.2009-31.03.2015

Summary

Project focused on the Pickering catchment looking at a range of NFM techniques.

Background

The long history of flooding in Pickering and the damage these floods caused to properties form the context for this project.

Selected findings

Placement of only the 100 large woody debris dams resulting in a peak flow reduction of between 3.5% and 7.5%.... NFM measures can sometimes increase flood risk, especially when implemented close to flood prone sites. (Mouchel, 2013)

Partners

Forest Research, Forestry Commission England, the Environment Agency, Natural England, Durham University, North York Moors National Park, Ryedale District Council, North Yorkshire Moors Railway, Sinnington Parish Council, North Yorkshire County Council

Funding

Defra project cost of £247,000. Woodland Creation Grant received under the English Woodland Grant Scheme to meet the costs of tree planting, totalling just over £15,500.

NFM type

Hydraulic roughness; Surface runoff interception

Woodland type

Floodplain woodland; Riparian woodland; Woody debris dams

Extent

Floodplain woodland extent was 30 ha, riparian woodland 50 ha, with 100 large woody debris dams constructed.

Location

(Location on map, for Pickering: 480522, 483447).

Woodland management - further details

No data.

Woodland creation - further details

No data.

Catchment monitoring

No data.

Modelling

Opportunity mapping identified approximately 400 ha of riparian land comprising 96 individual stream reaches as potential for woodland creation. The 'Overflow' model from Durham University was used to assess potential sites and identify locations for woodland creation that would contribute the most to reducing flood risk.

5.3.4 Eddleston Water Project, Scottish Borders (S3)

Contact details

Luke Comins - Tweed Forum, luke.comins@tweedforum.org, 01896 849723.

Chris Spray - UNESCO Centre for Water, 01382 388362.

Tom Ball - Dundee University, t.ball@dundee.ac.uk, 01382 385116.

Huw Thomas - Forest Research, huw.thomas1@forestry.gsi.gov.uk, 07810 863799.

Nadeem Shah - Forest Research, Nadeem.Shah@forestry.gsi.gov.uk.

Dates

2009 (scoping study) on-going

Summary

Project aimed at finding out whether land use management changes and natural habitat restoration can assist in improving river ecology and minimise flooding risk to Eddleston and Peebles. The project also has a more general remit to restore the Eddleston Water for the benefit of the local community and wildlife.

Background

No data.

Selected findings

A range of monitoring equipment, including rain gauges, groundwater and river level gauges, are in place to ensure the effects of the measures deployed as part of the project are measured and assessed for impact on river flows and flood frequencies.

Partners

Project led by Tweed Forum in partnership with: Scottish Environment Protection Agency, the Scottish Government and the University of Dundee. Other key partners include: British Geological Survey, Scottish Borders Council, Scottish Natural Heritage, the Forestry Commission, National Farmers Union, Forest Carbon and the Woodland Trust. Finally, the project works with local schools and other educational organisations to spread the word on river restoration and natural flood management.

Funding

Over £300k

NFM type

Hydraulic roughness; Surface runoff interception

Woodland type

Gully woodland; Riparian planting; Woody debris dams (artificial)

Extent

50,000 trees planted over an area of 35 ha.

Location

Approximate centre of gully and riparian woodland planting on the Longcote Burn: 325690, 646525. Approximate centre of riparian woodland planting on the Shiplaw Burn: 323161, 651164. Approximate centre of area for 10 woody debris dams installed on the Middle Burn: 322315, 650254. (Location on map: 325690, 646525).

Woodland management - further details

No data.

Woodland creation - further details

No data.

Catchment monitoring

A large array of hydrometric instrumentation has been deployed across the study area to enable the quantification of the impacts of NFM implementation on flood attenuation: monitoring equipment including rain gauges, groundwater and river level gauges, are in place to ensure the effects of the measures deployed as part of the project are measured and assessed for impact on river flows and flood frequencies.

Modelling

No data.

5.3.5 Bowmont-Glen catchment (S6)

Contact details

Luke Comins - Tweed Forum, luke.comins@tweedforum.org, 01896 849723.

Dates

2010-on-going

Summary

The project aimed to develop a sustainable catchment management plan for the catchment through a participatory process between land managers and regulatory agencies. The project involved planting woodlands, creating woody debris dams, restoring wetlands and allowing certain areas to flood. Alongside other demonstration projects, work within the Bowmont-Glen catchment forms part of Cheviot Futures.

Background

The project emerged following the major floods of 2008 and 2009 in the Bowmont-Glen catchment which caused significant damage to farmland. Disagreement between land managers and regulatory bodies on how to reduce future flood risk further contributed to the creation of the project.

Selected findings

Partners

Overseen by Tweed Forum, in partnership with land managers, regulatory and administrative bodies.

Funding

No data.

NFM type

Hydraulic roughness; Surface runoff interception

Woodland type

Gully woodland; Riparian woodland; Woody debris dams

Extent

70m of hedgerow

Location

(Location on map, for Bowmont Water: 390703, 630825).

Woodland management - further details

Woodland creation - further details

The project involved some woodland creation, including the planting of 70m of new hedgerow to assist with stabilising the riverbank and intercept surface water runoff, and the planting of gully and riparian woodland to assist natural flood management.

Catchment monitoring

Monitoring work on the woody debris dam structures carried out by the James Hutton Institute to clarify the impact of such structures on the local and catchment scale.

Modelling

No data.

5.3.6 Spey Catchment Initiative, North East Scotland (S10)

Contact details

Liz Henderson - Spey Catchment Initiative, l.henderson@speyfisheryboard.com, 01479 810477 / 07534 174992.

Duncan Ferguson, d.ferguson.spey@btconnect.com, 07823 334747.

Mark Wilkinson - James Hutton Institute, Marl.Wilkinson@hutton.ac.uk.

Dates

2010-2013 (inception); 2014-2016 (current 3-year phase)

Summary

The project is currently focused on 4 priority themes: planting and safeguarding riparian woodlands and enhancing wetlands; demonstrating natural flood management techniques; understanding how the river works and education, awareness raising and getting people involved in the catchment.

Background

No data.

Selected findings

Partners

Scottish Natural Heritage, Cairngorms National Park Authority, Diageo, Spey Fishery Board, Moray Council, Scottish Environment Protection Agency, Forestry Commission Scotland and the Highland Council.

Funding

£2.5million of Heritage Lottery Funding earmarked for the Tomintoul & Glenlivet Landscape Partnership (TGLP); £200,000 in funding from the Scottish Government via Cairngorms National Park Authority for Aviemore Riverside Park; support from the Woodland Trust; support from Water Environment Fund and the Green Stimulus Peatland Restoration Fund on peatland restoration work at Allt a'Mharcaidh

NFM type

Hydraulic roughness; Surface runoff interception

Woodland type

Riparian woodland; Woody debris dams

Extent

10,000 riparian trees planted across several sites and several woody debris dams at Allt a'Mharcaidh.

Location

Allt a'Mharcaidh river. (Location on map, for Auchlean: 284853, 797353).

Woodland management - further details

No data.

Woodland creation - further details

No data.

Catchment monitoring

No data.

Modelling

No data.

5.3.7 Pontbren Project (W3)

Contact details

Neil McIntyre - Sustainable Minerals Institute, University of Queensland, n.mcintyre@uq.edu.au.

Dates

1997: Pontbren farmers start coming together; 2004-2012: intensive hydrological research programme.

Summary

The project was primarily aimed at improving livestock production through woodland management and tree planting.

Background

No data.

Selected findings

The project observed that a major secondary benefit was that woodland measures also help reduce water run-off. Hydrological research carried out as part of the project found that "... infiltration rates were up to 60 times higher in woodland areas compare to grazed pasture" (Environment Agency, 2012), "woodland planting across a whole catchment could reduce peak flows by 10-54%..." (Environment Agency, 2012) and "(planted) trees begin to have this effect (improved soil structure) as early as two years after planting" (Woodland Trust).

Partners

Environment Agency.

Funding

No data.

NFM type

Surface runoff interception

Woodland type

Cross-slope woodland

Extent

No data.

Location

(Location on map, approximate: 304708, 306741).

Woodland management - further details

No data.

Woodland creation - further details

No data.

Catchment monitoring

A large array of hydrometric instrumentation was deployed at various scales across the Pontbren study area to study both in-field processes and effects, and hydrological responses in the arterial stream network to rainfall events.

Modelling

A physics-based, distributed model, capable of representing soil heterogeneity was used to characterise hydrological processes at the hillslope scale. Meta modelling techniques were then used to upscale through the development of a semi-distributed catchment-scale model.

References

GENERAL

Barlow, J., F. Moore, L. Burgess-Gamble (2014), *Delivering benefits through evidence: working with natural processes to reduce flood risk*, Environment Agency Flood and Coastal Erosion Risk Management Research and Development Programme.

Broadmeadow, S., H. Thomas and T. Nisbet (2014), *Opportunity mapping for woodland creation to reduce diffuse water pollution and flood risk in England and Wales*, Forest Research, Forestry Commission (available at http://www.forestry.gov.uk/pdf/FR_Broadmeadow_NOM_EW_2014.pdf/$FILE/FR_Broadmeadow_NOM_EW_2014.pdf, last accessed 06.05.2015).

Broadmeadow, S. and T. Nisbet (2010), *Opportunity mapping for woodland to reduce flooding in the Yorkshire & the Humber Region*, Forest Research Monograph: 1, Forestry Commission (available at http://www.forestry.gov.uk/pdf/York_and_Humber_flooding_final_report_2009.pdf/$FILE/York_and_Humber_flooding_final_report_2009.pdf, last accessed 09.04.2015).

Centre of Expertise for Waters (?), *NFM case studies*, Centre of Expertise for Waters (available at http://www.crew.ac.uk/NFMcasestudies, last accessed 09.04.2015).

Forestry Commission (2011), *Forests and water: UK forestry standard guidelines*, Forestry Commission (available at http://www.forestry.gov.uk/pdf/FCGL007.pdf/$FILE/FCGL007.pdf, last *accessed 09.04.2015).*

Nisbet, T., M. Silgram, N. Shah, K. Morrow and S. Broadmeadow (2011), *Woodland for water: woodland measures for meeting Water Framework Directive objectives*, Forest Research Monograph: 4, Forestry Commission (available at http://www.forestry.gov.uk/pdf/FRMG004_Woodland4Water.pdf/$FILE/FRMG004_Woodland4Water.pdf, last accessed 09.04.2015).

Pitt, M. (2008), *The Pitt Review - learning lessons from the 2007 floods: full report*, The Cabinet Office (available at http://webarchive.nationalarchives.gov.uk/20100807034701/http:/archive.cabinetoffice.gov.uk/pittreview/thepittreview/final_report.html, last accessed 06.05.2015).

Woodland Trust (?), *Planting trees to protect water*, Woodland Trust (available at https://www.woodlandtrust.org.uk/mediafile/100083903/Planting-trees-to-protect-water-RBC-Bluewater-farming-report-evidence.pdf, last accessed 09.04.2015).

SCIENTIFIC PUBLICATIONS

E22 - Cunsey

Clarke, R. and M. Anteric (2014*), Final evaluation of the Windermere Reflections Landscape Partnership: report to the Heritage Lottery Fund prepared on behalf of Windermere Reflections*, Centre for European Protected Area Research (available at http://eprints.bbk.ac.uk/11639/1/2014_WindermereReflections-FinalEvaluation_Main.pdf, last accessed 18.03.2015).

E34 - Coalburn

Robinson, M. (1998), "30 years of forest hydrology changes at Coalburn: water balance and extreme flows", *Hydrology and Earth System Sciences*, 2(2), pp. 233-238.

Robinson, M., R.E. Moore, T.R. Nisbet and J.R. Blackie (1998), "From moorland to forest: the Coalburn catchment experiment", Report No. 133, Institute of Hydrology (available at http://nora.nerc.ac.uk/7372/1/IH_133.pdf, last accessed 07.04.2015).

E36 - Belford

Nicholson, A.R., M.E. Wilkinson, G.M. O'Donnell and P.F. Quinn (2012), "Runoff attenuation features: a sustainable flood mitigation strategy in the Belford catchment, UK", *Area*, 2012, pp. 1-7.

Wilkinson, M.E., P.F. Quinn, N.J. Barber and J. Jonczyk (2014), "A framework for managing runoff and pollution in the rural landscape using a Catchment Systems Engineering approach", *Science of the Total Environment*, 2014: 468-469, pp. 1245-1254.

Wilkinson, M.E and P.F. Quinn (2010), "Belford catchment proactive flood solutions: a toolkit for managing runoff in the rural landscape", Proceedings of the SAC and SEPA Biennial Conference, Edinburgh (available at https://research.ncl.ac.uk/proactive/belford/papers/SAC2010.pdf, last accessed 23.03.2015).

Wilkinson, M.E., P.F. Quinn and P. Welton (2010), "Runoff management during the September 2008 floods in the Belford catchment, Northumberland", *Journal of Flood Risk Management*, 2010:3, pp. 285-295.

Wilkinson, M.E., P.F. Quinn, I. Benson and P. Welton (2010), "Runoff management: mitigation measures for disconnecting flow pathways in the Belford Burn catchment to reduce flood risk", British Hydrological Society Third International Symposium: Managing Consequences of a Changing Global Environment, Newcastle 2010, pp.1-6.

Wilkinson, M.E., P.F. Quinn and P. Welton (2008), "Belford catchment proactive flood solutions: storing and attenuating runoff on farms", British Hydrological Society 10th National Hydrology Symposium, Exeter 2008, pp. 327-332.

REPORTS

E3 - Holnicote

Rose, S., Z. Rosolova, R. Lamb, P. Worrall, G. Hammond and N. Hester (22 November 2011), *Holnicote Multi-Objective Flood Management Demonstration Project: an analysis of the impacts of rural land management change on flooding and flood risk - a position paper*, Penny Anderson Associates (available from http://www.pennyanderson.com/case-studies/defra-multi-objective-flood-management-demonstration-project, last accessed 11.03.2015).

E15 - Farming Floodplains

Jones, M. (2010), *Farming floodplains for the future: final report*, Staffordshire Wildlife Trust (available at http://www.staffs-wildlife.org.uk/sites/default/files/files/Publications/Farming%20Floodplains%20for%20the%20Future%20Final%20Report.pdf, last accessed 25.03.2015).

E21 - SOURCE

SOURCE (2014), *The SOURCE report Summer 2014: river and land stewardship in the headwaters of the river Calder*, Treesponsibility (available at http://www.treesponsibility.com/wp-content/uploads/2014/06/source-report-2014.pdf, last accessed 23.03.2015).

SOURCE (2013), *The SOURCE report Summer 2013: river and land stewardship in the headwaters of the river Calder*, Treesponsibility (available at http://www.treesponsibility.com/wp-content/uploads/2013/09/SOURCE-REPORT-SUMMER-2013.pdf, last accessed 23.03.2015).

SOURCE (2012), *The SOURCE report Spring/Summer 2012*, Treesponsibility (available at http://www.treesponsibility.com/wp-content/uploads/2013/09/Source-Booklet-Print.pdf, last accessed 23.03.2015).

E29 - Ripon

Forest Research (?), *Flood risk management through land use and land-use change: Ripon Multi-Objective Pilot project*, Forestry Commission (available at http://www.forestry.gov.uk/pdf/urgp_case_study_019_Ripon_MOP.pdf/$file/urgp_case_study_019_Ripon_MOP.pdf, last accessed 24.03.2015).

Murphy, D. (2007), *Ripon Multi-Objective Project: final report*, Defra (available at http://archive.defra.gov.uk/environment/flooding/documents/manage/riponfr.pdf, last accessed 24.03.2015).

Nisbet, T.R. and H. Thomas (2008), *Project SLD2316: restoring floodplain woodland for flood alleviation*, Forestry Commission (available at http://www.forestry.gov.uk/pdf/defra_floodplain_report_15june2008.pdf/$file/defra_floodplain_report_15june2008.pdf, last accessed 24.03.2015).

E31 - Pickering

Defra (April 2011), *Project RMP5455: slowing the flow at Pickering: final report*, Defra (available at http://www.forestry.gov.uk/pdf/stfap_final_report_Apr2011.pdf/$file/stfap_final_report_Apr2011.pdf, last accessed 09.03.2015).

E36 - Belford

Quinn, P., G. O'Donnell, A. Nicholson, M. Wilkinson, G. Owen, J. Jonczyk, N. Barber, M. Hardwick and G. Davies (2013), *June 2013 National Flood Management Runoff Attenuation Features report: potential use of runoff attenuation features in small rural catchments for flood mitigation*, Newcastle University (available at https://research.ncl.ac.uk/proactive/belford/newcastlenfmrafreport/reportpdf/June%20NFM%20RAF%20Report.pdf, last accessed 23.03.2015).

S8 - River Devon

WWF (?), *Slowing the flow: a natural solution to flooding problems*, WWF (available at http://www.wwf.org.uk/filelibrary/pdf/slowingflow_web.pdf, last accessed 09.03.2015).

S9 - Allan Water

SEPA (2011), *Allan Water Natural Flood Management techniques and scoping study*, SEPA (available at http://www.cress.stir.ac.uk/allanwater/documents/R001.Allan_Water_NFM.pdf, last accessed 09.03.2015).

S13 - Aberdeenshire

Misc. project reports (available at http://www.aberdeenshire.gov.uk/energy/AberdeenshireLandUseStrategyPilot.asp, last accessed 30.03.2015).

W3 - Pontbren

Wheater, H., B. Reynolds, N. Mcintyre, M. Marshall, B. Jackson, Z. Frogbrook, I. Solloway, O. Francis and J. Chell (2008), *Impacts of upland land management on flood risk: multi-scale modelling methodology and results from the Pontbren experiment*, Flood Risk Management Research Consortium (available at http://web.sbe.hw.ac.uk/frmrc/downloads/ur16_impacts_upland_land_management_wp2_2_v1_0.pdf, last accessed 06.05.2015).

Woodland Trust (?), *The Pontbren Project: a farmer-led approach to sustainable land management in the uplands*, Woodland Trust (available at http://www.coedcymru.org.uk/images/user/5472%20Pontbren%20CS%20v12.pdf, last accessed 30.03.2015).

OTHER PROJECT OUTPUT OR CITATIONS

E3 - Holnicote

JBA (?2014), *Holnicote - Defra Multi-Objective Flood Management Demonstration Project JBA*, JBA (available online at http://www.jbaconsulting.com/project/holnicote-defra-multi-objective-flood-management-demonstration-project-jba, last accessed 11.03.2015).

National Trust (2011), *Multi-Objective Flood Management Demonstration Scheme: project factsheet 1 - the National Trust Holnicote Projects*, Defra (available online at http://archive.defra.gov.uk/environment/flooding/documents/manage/multi-objective-fm-scheme-factsheet1.pdf, last accessed 11.03.2015).

Rose, S. (?2014), *Holnicote Multi-Objective Flood Management Demonstration Project*, the River Restoration Centre (available at http://www.therrc.co.uk/Workshops/RRC/2014_A_NFM/Holnicote_SR2.pdf, last accessed 11.03.2015).

E4 - Parrett

Broadley, R. (?), *Natural Flood Management: working with nature to innovate? The sustainable approach to Flood Risk Management*, Falkirk Council (available at http://www.keepscotlandbeautiful.org/media/120109/Falkirk-Presentation_SSN-Adaptation-Programme-Consultation-Event.pdf, last accessed 20.03.2015), slide 16.

E6 - Upper Lydbrook

Environment Agency (2015), *English Severn and Wye Regional Flood and Coastal Committee: Tuesday, 13 January 2015*, Environment Agency, pp.45-46 (available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/390692/MIDS_ESW_13_January_2015_2.pdf, last accessed 23.03.2015).

E8 - rSuDS Stroud

Environment Agency (2015), *English Severn and Wye Regional Flood and Coastal Committee: Tuesday, 13 January 2015*, Environment Agency, p.26, pp.44-45 (available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/390692/MIDS_ESW_13_January_2015_2.pdf, last accessed 23.03.2015).

E15 - Farming Floodplains

Jones, M. (2010), *Farming Floodplains for the Future*, Sussex Wildlife Trust (available at http://www.ciwem.org/media/97461/1610_Matt_Jones_2010.pdf, last accessed 25.03.2015).

E19 - SCaMP

National Assembly of Wales (?), *Case study 4: SCaMP - Sustainable Catchment Management Programme*, National Assembly for Wales (available at http://www.assembly.wales/en/bus-home/committees/sustainable-land-management/Pages/scamp.aspx, last accessed 30.093.2015).

E20 - Clough Woodland

Moors for the Future Partnership (?), *Clough Woodland Project*, Moors for the Future (available from http://www.moorsforthefuture.org.uk/sites/default/files/20140516_CLW-A0-PosterV2_Web.pdf, last accessed 23.03.2015).

SOURCE (2014), *The SOURCE report Summer 2014: river and land stewardship in the headwaters of the river Calder*, Treesponsibility (available at http://www.treesponsibility.com/wp-content/uploads/2014/06/source-report-2014.pdf, last accessed 23.03.2015), p.8.

E21 - SOURCE

SOURCE (2013), *Understanding the Hebden Water Catchment*, Treesponsibility (available at http://www.treesponsibility.com/wp-content/uploads/2014/01/Hebden-Water-Catchment-Booklet.pdf, last accessed 23.03.2015).

E26 - River Derwent

Woodland Trust (?), *Tree planting partnerships in the River Derwent catchment: working with landowners on floodplain and riparian planting projects*, The Wild Trout Trust (available at http://www.wildtrout.org/sites/default/files/library/Woodland%20Trust%20Case%20Study%20-%20Derwent.pdf, last accessed 30.03.2015).

E27 - Dearne

Broadley, R. (?), *Natural Flood Management: working with nature to innovate? The sustainable approach to Flood Risk Management*, Falkirk Council (available at http://www.keepscotlandbeautiful.org/media/120109/Falkirk-Presentation_SSN-Adaptation-Programme-Consultation-Event.pdf, last accessed 20.03.2015), slide 14.

E33 - Saltholme

Broadley, R. (?), *Natural Flood Management: working with nature to innovate? The sustainable approach to Flood Risk Management*, Falkirk Council, slide 13 (available at http://www.keepscotlandbeautiful.org/media/120109/Falkirk-Presentation_SSN-Adaptation-Programme-Consultation-Event.pdf, last accessed 20.03.2015).

E34 - Coalburn

Birkingshaw, S., J. Bathurst and M. Robinson (?), *45 years of non-stationary hydrology over the Coalburn upland forest catchment: what happens to the river discharge when you plant trees*, Newcastle University.

E35 - River Till

Broadley, R. (?), *Natural Flood Management: working with nature to innovate? The sustainable approach to Flood Risk Management*, Falkirk Council, slide 15 (available at http://www.keepscotlandbeautiful.org/media/120109/Falkirk-Presentation_SSN-Adaptation-Programme-Consultation-Event.pdf, last accessed 20.03.2015).

E36 - Belford

Newcastle University and Environment Agency (April 2010), *Runoff attenuation features: a guide for all those working in catchment management*, Newcastle University (available at https://research.ncl.ac.uk/proactive/belford/papers/Runoff_Attenuation_Features_Handbook_final.pdf, last accessed 23.03.2015).

SOURCE (2014), *The SOURCE report Summer 2014: river and land stewardship in the headwaters of the river Calder*, Treesponsibility (available at http://www.treesponsibility.com/wp-content/uploads/2014/06/source-report-2014.pdf, last accessed 23.03.2015), p.7.

S1 - Upper Clyde

Forest Research (?), *Climate change adaptation in the Glasgow and Clyde Valley: opportunity mapping for woodland creation to reduce flood risk (report prepared for the GCV Green Network Partnership)*, GCV Green Network, pp.22-24.

S3 - Eddleston

Tweed Forum (?), *The Eddleston Water Project*, Tweed Forum (available at http://tweedforum.org/publications/Leaflet_2013.pdf, last accessed 17.03.2015),

S8 - River Devon

Natural Rivers (?), *The River Devon project: slowing the flow*, WWF (available at http://assets.wwf.org.uk/downloads/river_devon_leaflet_a.pdf?_ga=1.244474176.438973446.1425916444, last accessed 30.03.2015).

S9 - Allan Water

Allan Water NFM scoping study (2011), *Natural Flood Management: factsheet*, CRESS (available at http://www.cress.stir.ac.uk/allanwater/documents/FactsheetRev2.pdf, last accessed 24.03.2015).

Belleni, L. (?), *Natural Flood Management on the Allan Water*, Communities Along the Carron Association (available at http://www.catca.org.uk/talks/NFMonAllanWater.pdf, last accessed 24.03.2015).

W3 - Pontbren

Environment Agency (2012), *Greater working with natural processed in flood and coastal erosion risk management: a response to Pitt Review Recommendation 27* (available at file:///C:/Users/marielagerwall/Downloads/Pitt_Report_on_Natural_Processes_Flood_Risk_Management.PDF, last accessed 30.03.2015), p. 15.

Reynolds B, M. Marshall, Z. Frogbrook, I. Solloway, N. McIntyre and H. Wheater (2012), *The Pontbren Hydrological Database FRMRC Research Report SWP5.1* (available at http://web.sbe.hw.ac.uk/frmrc/downloads/Data/FRMRC_Deliverable5.2.pdf, last accessed 30.03.2015).

Various

Broadley, R. (?), *Natural Flood Management: working with nature to innovate? The sustainable approach to Flood Risk Management*, Falkirk Council, slide 15.

Forbes, H. (?), *Working with natural processes to help manage flooding in Scotland*, SEPA, pp. 6-10, p.18.

Mouchel (2013), *Callander River Teith Optioneering and Benefit / Cost Appraisal*, Mouchel, pp.3-6 of Appendix I.

Nutt, N. (?), *Natural flood management within the Flood Risk Management (Scotland) Act*, Halcrow/CH2M Hill, p.8.

WEB MATERIAL

E8 - rSuDS Stroud

Centre of Expertise for Waters (?), *Stroud RSuDS project*, CREW (available at http://www.crew.ac.uk/casestudies/stroud-rsuds-project, last accessed 18.03.2015).

Cotswold Lion (2015), "Managing water flow", *Cotswold Lion*, Issue 32, Spring-Summer 2015 (available at http://www.cotswoldsaonb.org.uk/userfiles/file/publications/cotswold%20lion/cotswold-lion-spring_autumn-2015.pdf, last accessed 18.03.2015).

Project Twitter Feed (available at https://twitter.com/stroud_rsuds, last accessed 30.03.2015).

E13 - Sussex Flow

Former project website (available at http://www.treesontheriveruck.org.uk/, last accessed 30.03.2015).

E16 - Knowledge Transfer

Project website (available at http://www.waterco.co.uk/nfm-ktp-research, last accessed 18.03.2015).

E18 - South West Peak

Project website (available at http://www.southwestpeak.co.uk/, last accessed 30.03.2015).

E19 - SCaMP

United Utilities (?), *SCaMP*, United Utilities (available at http://corporate.unitedutilities.com/scamp-index.aspx, last accessed 19.03.2015).

E20 - Clough Woodland

Project website (available at http://www.moorsforthefuture.org.uk/clough-woodland-project, last accessed 30.03.2015).

E21 - SOURCE

Pennines Prospects YouTube channel (available at https://www.youtube.com/user/penninesprospects, last accessed 23.03.2015).

E30 - Tebay

Project video (available at https://www.youtube.com/watch?v=UpXMYawQ7vI, last accessed 30.03.2015).

E31 - Pickering

Centre of Expertise for Waters (?), *Pickering (woodland creation)*, CREW (available at http://www.crew.ac.uk/casestudies/pickering-woodland-creation, last accessed 18.03.2015).

E22 - Cunsey

WindermereReflections Facebook page (available at https://www.facebook.com/WindermereReflections, last accessed 18.03.2015).

Windermere Reflections website (available at http://www.windermere-reflections.org.uk/, last accessed 18.03.2015).

E26 - River Derwent

Centre of Expertise for Waters (?), *Stroud RSuDS project*, CREW (available at http://www.crew.ac.uk/casestudies/river-derwent-catchment-paplava-farm, last accessed 20.03.2015).

E32 - Lustrum Beck

Stockton-On-Tees Borough Council (June 2014), *Final approval for Lustrum Beck Flood Defence scheme*, Stockton-On-Tees Borough Council (available at http://www.stockton.gov.uk/news/localnews/year2014/june/lustrumapproval#sthash.2cwhlUId.dpbs, last accessed 11.03.2015).

E34 - Coalburn

Newcastle University (2013), *Case study 6-45 years of changes in forest hydrology at the experimental Coalburn catchment*, Newcastle University (available at http://research.ncl.ac.uk/shetran/CaseStudy6.htm, last accessed 27.03.2015).

E36 - Belford

Belford project website (available at https://research.ncl.ac.uk/proactive/belford/ last accessed 23.03.2015).

S3 - Eddleston

Project website (available at http://www.tweedforum.org/projects/current-projects/Eddleston, last accessed 30.03.2015).

S5 - Bowanhill

Tweed Forum (2013), "Cheviot Futures*", Tweedmatters: the newsletter of the Tweed Forum*, Summer 2013: no.15 (available at http://www.tweedforum.org/publications/tweed_matters_15_web.pdf, last accessed 24.03.2015), pp. 8-9.

S6 - Bowmont-Glen

Tweed Forum (2013), "Cheviot Futures", *Tweedmatters: the newsletter of the Tweed Forum*, Summer 2013: no.15 (available at http://www.tweedforum.org/publications/tweed_matters_15_web.pdf, last accessed 24.03.2015), pp. 9-10.

S10 - Spey

Project website (available at http://www.speyfisheryboard.com/the-spey-catchment-initiative-intro/, last accessed 30.03.2015).

Spey Catchment Initiative (December 2014), *Spey Catchment Initiative: update December 2014,* Spey Catchment Initiative (available at http://www.speyfisheryboard.com/wp-content/uploads/downloads/2014/12/SCI-Briefing-December-2014.pdf, last accessed 17.03.2015).

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BD23 3AE

t:+44(0)1756 799919
e:info@jbaconsulting.com

Jeremy Benn Associates Ltd
Registered in England
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Visit our website
www.jbaconsulting.com