

## How trees, woodlands and forests can contribute to flood risk management - a review of the evidence

Dr T R Nisbet





## Woodland can reduce flood risk by:

- Reducing the volume of flood water at source by increasing evaporation;
- Slowing the rate of runoff from the land by increasing soil infiltration;
- Enhancing floodplain storage and delaying the flood peak by increasing hydraulic roughness;
- Reducing sediment delivery and siltation, increasing conveyance.









# By reducing flood volume, extending response or desynchronising flows:



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## Flood mitigation by reduced run-off:



Annual interception loss: 32-45% for conifers, 17-23% for broadleaves





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### **Role of Soil Moisture Deficit**



Figure 42. Water content in the uppermost 2 m under each land cover (12th February 1998 to 23rd April 2002) as measured by the neutron probe.

Calder et al. (2002)



## Flood mitigation by `sponge effect':

The open structure and high organic content of woodland soil aids water infiltration and storage, reducing the risk of rapid surface runoff.



## Flood mitigation by physical barrier:

Floodplains	Min	Normal	Max
a. Pasture no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Trees			
1. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
2. Same as above but heavy sprouts	0.050	0.060	0.080
3. Heavy stand of timber, few downed trees, little	0.080	0.100	0.120
undergrowth, flow below branches			
4. Same as above but with flow into branches	0.100	0.150	0.200
5. Dense willows, summer, straight	0.110	0.150	0.300

rest Research



**Table 1** Typical Manning's n values for floodplains, after Chow (1959)

Hydraulic roughness (x5) creates a barrier effect, slowing river flows, pushing water onto floodplains and temporarily increasing flood storage (100 m<sup>3</sup> to 100,000+ m<sup>3</sup>).



## Delaying the passage of flood flows:



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Establishing 130 ha of floodplain woodland along a 2.2 km reach of the River Cary in Somerset increased the flood level for a 1-in-100 year event by 50-270 mm (~120,000 m<sup>3</sup>) and delayed the flood peak by 140 min in an 80 km<sup>2</sup> catchment (Thomas & Nisbet, 2006).



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## Flood mitigation by reduced siltation:

- By providing physical shelter
- By reducing water runoff
- By improving soil strength/stability
- By protecting river banks





Well managed woodland is usually associated with low sediment losses, helping to maintain slope stability and channel conveyance (Collins and Walling, 2006)



## However, woodland can increase flood risk by:

- The backing-up of flood water upstream of floodplain and riparian woodland;
- The washout of large woody debris blocking downstream structures;
- The synchronisation of flood flows within catchments.







## Factors influencing effectiveness:

- Scale and location of woodland within catchment in relation to assets at risk;
- Nature of existing land use and management practices;
- Woodland design, e.g. in terms of type, age, shape and structure;
- Woodland management, including scale and timing of practices such as felling;
- Site vulnerability to potential dis-benefits.



## Long-term study at Coalburn, N England



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## Longer-term changes in annual rainfall:



Standard gauge 15%

YEAR

Figure 3 Quality controlled time series of the annual precipitation at Coalburn.

(From Robinson, 2015)



## **Correcting for changes in rainfall: effect of forest growth on peak flows at Coalburn**



S.J. Birkinshaw et al./Journal of Hydrology 519 (2014) 559-573

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### Changes in peak flows due to forest felling:



Proportion of basin area cut or volume harvested (%)

Fig. 20 A review of changes in river peak-flow following forest cutting in boreal and temperate regions by Guillemette et al. (2005 J. Hydrol. 302: 137-153).

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## Predicting the impact of soil infiltration and water use effects at Pontbren, Wales

 Table 2.7
 Summary of changes in peak streamflow for three land use change scenarios during a synthetic extreme rain storm event at gauge 6 in the Pontbren catchment. 95 per cent confidence intervals are in parenthesis

Land use change	Area affected (%)	Mean change in peak flow (%)	Normalised change in peak flow <sup>[1]</sup> (-)
Remove trees	7	+5 (3 to 7)	+73 (42 to 100)
Add tree strips	7	-5 (-2 to -11)	-71(-29 to -157)
Full afforestation	93	-36 (-10 to -54)	-39 (-11 to -58)

#### Note

1 This is the mean change in peak flow divided by the area affected expressed as a percentage.

(From McIntyre & Thorne, 2013)



## Impact of tree planting in 25 km<sup>2</sup> Hodder sub-catchment (using physicsbased, Runoff Generating Model):

## Table 2.8 Examples of scenario effects for a 25 km² Hodder sub-catchment. 95 per cent confidence intervals are in parenthesis

Scenario (% of catchment)	Area affected 10 largest peak flows (%)	Increase in mean of increase (∆flow/area)	Normalised
Full coniferous planting of mineral soils	29	-7 (-3 to -13)	-24 (-46 to -10)
Full deciduous planting of mineral soils	29	-4 (0 to -9)	-15 (-2 to -32)
Deciduous riparian planting	9	-2 (0 to -3)	-17 (-1 to -36)

(From McIntyre & Thorne, 2013)



## Modelling studies demonstrate:

- Adjusting model parameters in line with process understanding shows woodland can reduce downstream flood levels and delay peak flows;
- Woodland creation predicted to reduce catchment flood peaks by 4-8% (Pickering, 68 km<sup>2</sup>), 0-13% (Hodder, 25 km<sup>2</sup>) -3 to 27% (River Tone) 2-54% (Pont Bren, 6 km<sup>2</sup>) and 6-19% (New Forest);
- Ability of woodland to reduce flood flows declines with flood size, although modelling suggests can influence 1 in 100 year or larger events;
- Scope to alleviate flooding decreases with increasing catchment size (greatest for <100 km<sup>2</sup>).



### **Overview of Defra Projects**



#### An appraisal of the Defra Multi-Objective Flood Management Projects, December 2015

As part of its response to the Pitt Review<sup>1</sup>, Defra invested  $\pounds1.7m$  in three Demonstration Projects. The stated brief for these projects was to:

"Generate hard evidence to demonstrate how integrated land management change, working with natural processes and in partnership, can contribute to reducing local flood risk while producing wider benefits for the environment and communities."

In achieving this brief, two of the projects also engaged to a significant extent with local communities and land-holders both of whom provided additional anecdotal evidence about the impact of land management change on flood risk.

The Demonstration Projects

- The three projects date from 2009 in Somerset, Derbyshire and North Yorkshire.
- Catchment sizes ranged from 18-90 km<sup>2</sup>.
- All three projects were within or bordered on upland areas, with high rainfall and rapid runoff.
- The project in Derbyshire was located in a catchment dominated by blanket bog, much of which was severely degraded.
- The catchments in North Yorkshire and Somerset included areas of moorfand, woodland, improved grassland and arable land.

#### Natural Flood Management

Natural Flood Management (NFM) involves implementing a range of land management interventions with the aim of decreasing peak flood levels experienced by properties and other assets downstream. The aim is to slow the rate of flow and / or store more flood water in the upstream catchment. Between them, a range of NFM measures was implemented in the three demonstration catchments, including:

- Establishing flood storage areas formed by clay or earth banks ("bunds") or by timber walls. The capacity of these bunded areas ranged from 1,300 m<sup>3</sup> to 120,000 m<sup>3</sup>
- Creating 'leaky' woody dams both within channels and in woodland areas alongside streams
- Planting riparian and farm woodland
- Restoring degraded moorland by blocking gullies and drainage ditches, by stabilisation and re-vegetation of bare peat, and by establishing no-bum buffer zones alongside watercourses
- Diverting water away from moorland paths and tracks and onto the rough moorland surface, so slowing rapid surface runoff

### Headline findings:

NFM techniques can reduce flood risk

NFM techniques provide a wide range of additional benefits

NFM techniques can be effective in catchments up to 100 km<sup>2</sup>

Local communities can become powerful advocates of NFM techniques

NFM requires careful planning and would benefit from 'priority mapping'



<sup>&</sup>lt;sup>1</sup> Pitt, M. 2008. The Pitt review: learning lessons from the 2007 floods. <u>http://webarchive.nationalarchives.gov.uk/20100807034701/http://archive.cabinetoffice.gov.uk/pittreview/</u> /media/assets/www.cabinetoffice.gov.uk/flooding\_review/pitt\_review\_full%20pdf.pdf



### **CEH Systematic Review**



### DO TREES IN UK-RELEVANT RIVER CATCHMENTS **INFLUENCE FLUVIAL FLOOD PEAKS?**

#### A SYSTEMATIC REVIEW

Stratford, C., Miller, J., House, A., Old, G., Acreman, M., Dueñas-Lopez, M. A., Nisbet, T., Newman, J., Burgess-Gamble, L., Chappell, N., Clarke, S., Leeson, L., Monbiot, G., Paterson, J., Robinson, M., Rogers, M. and Tickner, D.

Issue Number 1 Date 07/08/2017 Environment Agency Forest Research

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### Headline findings:

There is broad support for the conclusion that increased tree cover in catchments results in decreasing flood peaks, while decreased tree cover results in increasing flood peaks.

While there is strong evidence of an influence during small floods, only a few observational studies have assessed large floods and the majority of these found no influence on flood peak.



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CIWEM Events

### Working with Natural Processes: The Evidence Behind Natural Flood Management

31 October 2017 | CIWEM One-Day Conference

Coin Street Conference Centre, London, SE1 9NH

#ciwemevents @CIWEM

Working with Natural Processes: The Evidence Behind Natural Flood Management

**CIWEM** Events

#### Speaker Agenda

Session 1: The         Registration Registration           59:30 - 09:30         Welcome           99:40 - 09:55         Keynote Address: John Curtin, Executive Director of Flood and Coastal Risk Management. Environment Agency           09:55 - 10:00         High Water Common Ground Trailer           10:00 - 10:15         Introduction/Overview/self the scene of the Evidence base Lydia Burges-Gamble, Principal Scientist Flood & Coastal Risk Management Research. Environment Agency           10:15 - 10:25         Short Break           Session 1: The         10:25 - 10:45           Evidence Base         10:45 - 11:00           Natural England         Tim Collins, Principal Specialist - Coasts & Flood Management, Natural England           11:00 - 11:10         Case study 1: Hawswater and Yorkshire Washlands           11:10 - 11:20         Cast study 3: Stroud           11:20 - 11:30         Cast study 3: Stroud           11:20 - 11:30         Liscussion and Q&A           12:20 - 13:30         Linch Break and Networking           13:30 - 13:40         Liscussion and Q&A           12:00 - 13:30         Linch Break and Networking           13:30 - 13:40         Case study 1: North Norfolk           01:8 Barry Hankin, Head of Environmental Modelling, BA           Nikel Pheter, Sussex Wildlife Trust           13:50 - 14:00         Case study 1: North Norf		00.00 00.20	Perintration and Refreshments
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I1.00 - 11.10       Case study 1: Hawswater and Yorkshire Washlands         Simon Wightman, RSPB         I1.10 - 11.20       Case study 2: (invited)         I1.20 - 11.30       Case study 3: Stroud         Chris Uttley, Stroud District Council       I1.30 - 12.00         I1.20 - 13.00       Luck heads and Q&A         I2.00 - 13.10       Luck heads and Q&A         I2.00 - 13.10       Luck heads and Q&A         I3.00 - 13.15       Introducing the NFM maps & modelling guide         Barry Hankin, Head of Environmental Modelling, JBA         NFM       I3.15 - 13.30         I3.30 - 13.40       Case study 1. North Norfolk         OII Burns, Environment Agency and Sue Rees, Natural England         I3.40 - 13.50       Case study 2. Sussex Flow Initiative         Fran Southgate, Sussex Wildlife Trust         I3.50 - 14.00       Case study 2. Sussex Wildlife Trust         I3.50 - 14.00       Case study 3: Sussex Wildlife Trust         I3.50 - 14.00       Refreshments and Networking         Istudo - 15.15       Introducing the R&D gaps that we still need to fill and introducing the monitoring guide         Tom Dauben, Environment Agency and Morag Angus, South West Water       I5.25 - 15.35         Case study 3: Bornont       Mark Wilkinson, The James Hutton Institute         I5.45 - 16.15       Dis			England
Simon Wightman, RSPB           11.10 - 11.20         Cast study 2: (invited)           11.20 - 11.30         Cast study 2: (invited)           11.20 - 11.30         Cast study 2: (invited)           11.20 - 11.30         Cast study 2: (invited)           11.30 - 12.00         Discussion and Q&A           12.00 - 13.00         Lunch Break and Networking           Making the case         Barry Hankin, Head of Environmental Modelling, JBA           13.15 - 13.30         NFM on the coast           Nigel Pontee, CH2M         13.30 - 13.40           13.30 - 13.40         Case study 1. North Norfolk           0li Burns, Environment Agency and Sue Rees, Natural England         13.40 - 13.50           13.40 - 13.50         Case study 2: Sussex Violatifier Trust           13.50 - 14.00         Case study 3: Clywd/Barrog           Jacques Sisson 3: Filing paps 8:         Discussion and Q&A           14.30 - 15.00         Refreshments and Networking           15.15 - 15.25         Case study 1: Mires           Tom Nisbet, Head Physical Environment Agency and Morag Angus, South West Water           15.25 - 15.35         Case study 2: Eventode           Joanne Old, Environment Agency         15.45 - 16.30           15.45 - 16.30         Wrap up		11.00 - 11.10	Case study 1: Hawswater and Yorkshire Washlands
11.10 - 11.20       Cast study 2: (invited)         11.20 - 11.30       Case study 3: Stroud         Chris Uttley, Stroud District Council       11.30 - 12.00         11.30 - 12.00       Discussion and Q&A         12.00 - 13.00       Lunch Break and Networking         Making the case       13.10 - 13.15         for NFM       13.15 - 13.30         13.30 - 13.40       Case study 1: North Norfolk         Oil Burns, Environment Agency and Sue Rees, Natural England         13.40 - 13.50       Case study 2: Sussex Vilou Initiative         Fran Southgate, Sussex Wildlife Trust         13.50 - 14.00       Case study 2: Sussex Wildlife Trust         13.50 - 14.00       Case study 3: Clywd/Barrog         Jacques Sisson, Natural Resources Wales         14.40 - 14.30       Discussion and Q&A         14.40 - 15.15       Introducing the R&D gaps that we still need to fill and introducing the monitoring guide         Session 3: Filling gaps & monitoring       15.15 - 15.25         Case study 1: Mires       Torn Dauben, Environment Agency and Morag Angus, South West Water         15.25 - 15.35       Case study 3: Bownont         Mark Wilkinson, The James Hutton Institute       15.45 - 16.15         Discussion and Q&A       16.15 - 16.30         Wrap up       CIWEM Events <th></th> <th></th> <th>Simon Wightman, RSPB</th>			Simon Wightman, RSPB
11:10 - 11:20       Case study 2: (Initial Council         11:20 - 11:30       Case study 3: Stroud         11:20 - 11:30       Case study 3: Stroud         11:20 - 11:30       Case study 3: Stroud         11:20 - 11:30       Discussion and Q&A         12:20 - 13:30       Lunch Break and Networking         Session 2:       13:00 - 13:15       Introducing the NFM maps & modelling guide         Barry Hankin, Head of Environmental Modelling, JBA       Barry Hankin, Head of Environmental Modelling, JBA         13:15 - 13:30       Nigel Pontee, CH2M         13:30 - 13:40       Case study 1. North Norfolk         01i Burns, Environment Agency and Sue Rees, Natural England         13:40 - 13:50       Case study 2: Sussex Flow Initiative Fran Southgate, Sussex Wildlife Trust         13:50 - 14:00       Case study 2: Sussex Wildlife Trust         13:50 - 14:00       Case study 2: Sussex Wildlife Trust         13:50 - 14:30       Discussion and Q&A         14:00 - 14:30       Discussion and Q&A         14:00 - 15:15       Introducing the RAD gaps that we still need to fill and introducing the monitoring guide         Session 3: Filling paps & monitoring       Tom Dauben, Environment Agency and Morag Angus, South West Water         15:25 - 15:25       Case study 1: Mires         Tom Dauben, Envinonment Agency       Sis - 15:45 <th></th> <th>11 10 11 20</th> <th>Cast study 2: //ouited)</th>		11 10 11 20	Cast study 2: //ouited)
Session 2: Filing pape & monitoring Session 2: 15.25 - 15.35 Session 2: 15.25 - 15.35 Session 3: 15.25 - 15.45 Session 3: 15.25 - 15.45 Session 3: 15.25 - 15.35 Session 3: 15.25 - 15.45 Session 3: 15.25 - 15.45 Session 3: 15.25 - 15.35 Session 3: 15.25 - 15.45 Session 3: Session		11.10 - 11.20	Case study 2: (Invited)
Session 3: Filing paps & monitoring Session 3: Filing paps & Session 3: Setter 1: Session 3: Setter 1: Session 3: Setter 2: Seter 1: Setter 1: Seter 1: Setter 1: Setter 1:		11.20 - 11.50	Case study 5. Stroud Chris Uttley, Stroud District Council
11.30 - 12.00       Discussion and Q&A         12.00 - 13.00       Lunch Break and Networking         13.00 - 13.15       Introducing the NFM maps & modelling guide         Barry Hankin, Head of Environmental Modelling, JBA         13.10 - 13.30       NFM on the coast         13.30 - 13.40       Case study 1. North Norfolk         0Ii Burns, Environment Agency and Sue Rees, Natural England         13.40 - 13.50       Case study 3. Clywd/Barrog         13.50 - 14.00       Case study 3. Clywd/Barrog         14.00 - 14.30       Discussion and Q&A         14.30 - 15.00       Refreshments and Networking         Session 3: Filling       Isco - 15.15         Session 3: Filling       Isco - 15.15         15.15 - 15.25       Case study 2: Very Northing         15.25 - 15.25       Case study 2: Evenlode         15.35 - 15.45       Discussion and Q&A         15.45 - 16.15       Discussion and QAA         15.45 - 16.15 <t< th=""><th></th><th></th><th>Chris Ottiey, stroud District Council</th></t<>			Chris Ottiey, stroud District Council
Session 2:         13.00 - 13.10         Lunch Break and Networking           Making the case         Barry Hankin, Head of Environmental Modelling. JBA           for NFM         13.15 - 13.30         NFM on the coast           13.30 - 13.40         Case study 1. North Norfolk           13.30 - 13.40         Case study 2. Sussex Flow Initiative           Fran Southgate, Sussex Violatilie Trust         13.50 - 14.00           13.50 - 14.00         Case study 3. Clywa/Barrog           Jacques Sisson, Natural Resources Wales         14.30 - 15.00           14.30 - 15.00         Refrestments and Networking           Session 3: Filling gaps & monitoring public         15.00 - 15.15           Session 4: Filling size study 2: Clywa/Barrog         Jacques Sisson, Natural Resources Wales           15.00 - 15.15         Introducing the RAD gaps that we still need to fill and introducing the monitoring guide           Tom Nisbet, Head Physical Environment Research, Forest Research           15.25 - 15.25         Case study 1: Mires           Tom Dauben, Environment Agency         15.35 - 15.45           15.45         Case study 3: Bowmont           Mark Wilkinson, The James Hutton Institute         15.45 - 16.30           16.15 - 16.30         Wrap up		11.30 - 12.00	Discussion and Q&A
Session 2: Making the case for NFM       13.00 - 13.15       Introducing the NFM maps & modelling guide Barry Hankin, Head of Environmental Modelling. JBA         13.15 - 13.30       NFM on the coast Nigel Pontee, CH2M       13.30 - 13.40       Case study 1. North Norfolk Oil Burns, Environment Agency and Sue Rees, Natural England         13.40 - 13.50       Case study 2. Sussex Flow Initiative Fran Southgate, Sussex Wildlife Trust       13.40 - 13.50         13.50 - 14.00       Case study 2. Sussex Wildlife Trust         13.50 - 14.00       Case study 3. Clywd/Barrog Jacques Sisson, Natural Resources Wales         14.40 - 14.30       Discussion and Q&A         14.40 - 15.00       Referentments and Networking         Session 3: Filling paps & monitoring       15.00 - 15.15         Introducing the R&D gaps that we still need to fill and introducing the monitoring guide Tom Nisbet, Head Physical Environment Research, Forest Research         15.15 - 15.25       Case study 1: Mires Tom Dauben, Environment Agency and Morag Angus, South West Water         15.25 - 15.35       Case study 3: Bowmont Mark Wilkinson, The James Hutton Institute         15.45 - 16.15       Discussion and Q&A         16.15 - 16.30       Wrap up		12.00 - 13.00	Lunch Break and Networking
Making the case         Barry Hankin, Head of Environmental Modelling, JBA           for NFM         13.15 - 13.30         NFM on the coast           13.30 - 13.40         Case study 1. North Norfolk         01           13.30 - 13.40         Case study 1. North Norfolk         01           13.40 - 13.50         Case study 2. Suscer How Initiative Fran Southgate, Sussex Wildlife Trust         13.50 - 14.00           13.50 - 14.00         Case study 3. Clywd/Barrog Jacques Sisson, Natural Resources Wales         14.00 - 14.30           14.00 - 14.30         Discussion and Q&A         14.30 - 15.00           14.30 - 15.00         Refreshments and Networking         15.00 - 15.15           Session 3: Filling spas & monitoring         15.00 - 15.15         Introducing the R&D gaps that we still need to fill and introducing the monitoring guide           15.15 - 15.25         Case study 1: Mires         Tom Nisbet, Head Physical Environment Research, Forest Research           15.25 - 15.35         Case study 2: Evenlode         Joanne Old, Environment Agency           15.35 - 15.45         Case study 2: Evenlode         Joanne Old, Environment Agency           15.35 - 15.45         Discussion and Q&A         16.15 - 16.30           15.45 - 16.15         Discussion and Q&A         16.15 - 16.30	Session 2:	13.00 - 13.15	Introducing the NFM maps & modelling guide
for NFM         13.15 - 13.30         NFM on the coast Nigel Pontee, CH2M           13.30 - 13.40         Case study 1. North Norfolk Oli Burns, Environment Agency and Sue Rees, Natural England           13.40 - 13.50         Case study 2. Sussex Flow Initiative Fran Southgate, Sussex Villdlife Trust           13.50 - 14.00         Case study 3. Clywd/Barrog           14.40 - 14.30         Discussion and Q&A           14.30 - 15.00         Refrestments and Networking           14.30 - 15.00         Refrestments and Networking           15.00 - 15.15         Introducing the R&D gaps that we still need to fill and introducing the monitoring guide Tom Nisbet, Head Physical Environment Research, Forest Research           15.15 - 15.25         Case study 1: Mires Tom Dauben, Environment Agency           15.25 - 15.35         Case study 2: Eventode Joanne Old, Environment Agency           15.35 - 15.45         Case study 3: Bowmont Mark Wilkinson, The James Hutton Institute           15.45 - 16.15         Discussion and Q&A           16.15 - 16.30         Wrap up	Making the case		Barry Hankin, Head of Environmental Modelling, JBA
Nigel Pontee, CH2M         13.30 - 13.40       Case study 1. North Norfolk         Oli Burns, Environment Agency and Sue Rees, Natural England         13.40 - 13.50       Case study 2. Sussex Flow Initiative Fran Southgate, Sussex Wildlife Trust         13.50 - 14.00       Case study 2. Sussex Wildlife Trust         13.50 - 14.00       Case study 3. Clywd/Barrog Jacques Sisson, Natural Resources Wales         14.30 - 14.30       Discussion and Q&A         14.30 - 15.00       Refershments and Networking         Session 3: Filling paps & monitoring       15.00 - 15.15         Introducing the R&D gaps that we still need to fill and introducing the monitoring guide Tom Nisbet, Head Physical Environment Research, Forest Research         15.15 - 15.25       Case study 1: Mires Tom Dauben, Environment Agency and Morag Angus, South West Water         15.25 - 15.35       Case study 2: Evenlode Joanne Old, Environment Agency         15.45       Case study 3: Bowmont Mark Wilkinson, The James Hutton Institute         15.45 - 16.15       Discussion and Q&A         16.15 - 16.30       Wrap up	for NFM	13.15 - 13.30	NFM on the coast
13.30 - 13.40       Case study 1. North Norfolk         Oli Burns, Environment Agency and Sue Rees, Natural England       13.40 - 13.50         13.40 - 13.50       Case study 3. Scywd/Barrog         13.50 - 14.00       Case study 3. Clywd/Barrog         13.60 - 14.30       Discussion, Natural Resources Wales         14.00 - 14.30       Discussion and Q&A         14.30 - 15.00       Refreshments and Networking         Session 3: Filing       15.00 - 15.15         Introducing the R&D gaps that we still need to fill and introducing the monitoring guide         Tom Nisbet, Head Physical Environment Research, Forest Research         15.15 - 15.25       Case study 2: Evenlode         Joanne Old, Environment Agency         15.35 - 15.45       Case study 2: Evenlode         Joanne Old, Environment Agency         15.45 - 16.15       Discussion and Q&A         16.15 - 16.30       Wrap up			Nigel Pontee, CH2M
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13.40 - 13.50       Case study 2. Sussex Flow Initiative Fran Southgate, Sussex Wildlife Trust         13.50 - 14.00       Case study 3. Cywyd/Barrog Jacques Sisson, Natural Resources Wales         14.40 - 14.30       Discussion and Q&A         14.30 - 15.00       Refershments and Networking         Session 3: Filling paps & monitoring       15.00 - 15.15         Introducing the R&D gaps that we still need to fill and introducing the monitoring guide Tom Nisbet, Head Physical Environment Research, Forest Research         15.15 - 15.25       Case study 1: Mires Tom Dauben, Environment Agency and Morag Angus, South West Water         15.25 - 15.35       Case study 2: Evenlode Joanne Old, Environment Agency         15.45       Case study 3: Bowmont Mark Wilkinson, The James Hutton Institute         15.45 - 16.15       Discussion and Q&A         16.15 - 16.30       Wrap up			Oli Burns, Environment Agency and Sue Rees, Natural England
Fran Southgate, Sussex Wildlife Trust         13.50 – 14.00       Case study 3: Clywd/Barrog         Jacques Sisson, Natural Resources Wales         14.00 – 14.30       Discussion and Q&A         14.30 – 15.00       Refreshments and Networking         Session 3: Filing paps & monitoring       15.00 – 15.15         15.15 – 15.25       Case study 1: Mires         15.15 – 15.25       Case study 1: Mires         15.25 – 15.35       Case study 2: Evenlode Joanne Old, Environment Agency         15.35 – 15.45       Case study 2: Evenlode Joanne Old, Environment Agency         15.45 – 16.15       Discussion and Q&A         16.15 – 16.30       Wrap up		13.40 - 13.50	Case study 2. Sussex Flow Initiative
13.50 - 14.00     Case study 3: Clywd/Barrog Jacques Sisson, Natural Resources Wales       14.00 - 14.30     Discussion and Q&A       14.30 - 15.00     Refreshments and Networking       15.00 - 15.15     Introducing the R&D gaps that we still need to fill and introducing the monitoring gives       15.15 - 15.25     Case study 1: Mires Tom Dauben, Environment Agency and Morag Angus, South West Water       15.25 - 15.35     Case study 2: Eveniced Joanne Old, Environment Agency       15.35 - 15.45     Case study 3: Bowmont Mark Wilkinson, The James Hutton Institute       15.45 - 16.15     Discussion and Q&A       16.15 - 16.30     Wrap up			Fran Southgate, Sussex Wildlife Trust
Jacques Sisson, Natural Resources Wales           14.00 – 14.30         Discussion and Q&A           14.30 – 15.00         Referentments and Networking           Session 3: Filling paps & monitoring guide monitoring guide Tom Nisbet, Head Physical Environment Research, Forest Research           15.15 – 15.25         Case study 1: Mires Tom Daubent, Environment Agency and Morag Angus, South West Water           15.25 – 15.35         Case study 2: Wirronment Agency           15.35 – 15.45         Case study 3: Bowmont Mathematication Mark Wilkinson, The James Hutton Institute           15.45 – 16.15         Discussion and Q&A           16.15 – 16.30         Wrap up		13.50 - 14.00	Case study 3: Clywd/Barrog
14.00 - 14.30         Discussion and Q&A           14.30 - 15.00         Refreshments and Networking           14.30 - 15.01         Introducing the R&D gaps that we still need to fill and introducing the monitoring guide           monitoring         Tom Nisbet, Head Physical Environment Research.           15.15 - 15.25         Case study 1: Mires           Tom Dauben, Environment Agency and Morag Angus, South West Water           15.25 - 15.35         Case study 2: Evenlode           Joanne Old, Environment Agency           15.45 - 16.15         Discussion and Q&A           15.45 - 16.30         Wrap up			Jacques Sisson, Natural Resources Wales
Session 3: Filling paps & monitoring         14.30 – 15.00         Refreshments and Networking           15.00 – 15.15         Introducing the R&D gaps that we still need to fill and introducing the monitoring gide Tom Nisbet, Head Physical Environment Research, Forest Research           15.15 – 15.25         Case study 1: Mires Tom Dauben, Environment Agency and Morag Angus, South West Water           15.25 – 15.35         Case study 2: Eveniced Joanne Old, Environment Agency           15.35 – 15.45         Case study 3: Bowmont Mark Wilkinson, The James Hutton Institute           15.45 – 16.15         Discussion and Q&A           16.15 – 16.30         Wrap up		14.00 - 14.30	Discussion and Q&A
Session 3: Filling paps 8 monitoring       15.00 – 15.15       Introducing the R&D gaps that we still need to fill and introducing the monitoring guide Tom Nisbet, Head Physical Environment Research, Forest Research         15.15 – 15.25       Case study 1: Mires Tom Dauben, Environment Agency and Morag Angus, South West Water         15.25 – 15.35       Case study 2: Environment Agency         15.35 – 15.45       Case study 3: Bowmont         15.45 – 16.15       Discussion and Q&A         16.15 – 16.30       Wrap up		14.30 - 15.00	Refreshments and Networking
gaps & monitoring         monitoring guide Tom Nisbet, Head Physical Environment Research, Forest Research           15.15 - 15.25         Case study 1: Mires Tom Dauben, Environment Agency and Morag Angus, South West Water           15.25 - 15.35         Case study 2: Evenlode Joanne Old, Environment Agency           15.35 - 15.45         Case study 2: Bowmont Mark Wilkinson, The James Hutton Institute           15.45 - 16.15         Discussion and Q&A           16.15 - 16.30         Wrap up	Session 3: Filling	15.00 - 15.15	Introducing the R&D gaps that we still need to fill and introducing the
Tom Nisbet, Head Physical Environment Research, Forest Research           15.15 – 15.25         Case study 1: Mires           Tom Dauben, Environment Agency and Morag Angus, South West Water           15.25 – 15.35         Case study 2: Evenlode           Joanne Old, Environment Agency           15.35 – 15.45         Case study 3: Bowmont           Mark Wilkinson, The James Hutton Institute           15.45 – 16.15         Discussion and Q&A           16.15 – 16.30         Wrap up	gaps &		monitoring guide
15.15 - 15.25       Case study 1: Mires         Tom Dauben, Environment Agency and Morag Angus, South West Water         15.25 - 15.35       Case study 2: Evenlode         Joanne Old, Environment Agency         15.35 - 15.45       Case study 3: Bowmont         Mark Wilkinson, The James Hutton Institute         15.45 - 16.15       Discussion and Q&A         16.15 - 16.30       Wrap up	monitoring		Tom Nisbet, Head Physical Environment Research, Forest Research
Tom Dauben, Environment Agency and Morag Angus, South West Water           15.25 - 15.35         Case study 2: Evenlode Joanne Old, Environment Agency           15.35 - 15.45         Case study 3: Bowmont Mark Wilkinson, The James Hutton Institute           15.45 - 16.15         Discussion and Q&A           16.15 - 16.30         Wrap up		15.15 - 15.25	Case study 1: Mires
15.25 - 15.35       Case study 2: Evenlode Joanne Old, Environment Agency         15.35 - 15.45       Case study 3: Bowmont Mark Wilkinson, The James Hutton Institute         15.45 - 16.15       Discussion and Q&A         16.15 - 16.30       Wrap up			Tom Dauben, Environment Agency and Morag Angus, South West Water
Joanne Old, Environment Agency  15.35 – 15.45 Case study 3: Bowmont Mark Wilkinson, The James Hutton Institute  15.45 – 16.15 Discussion and Q&A 16.15 – 16.30 Wrap up  CIWEM Events		15.25 - 15.35	Case study 2: Evenlode
15.35 - 15.45     Case study 3: Bowmont       Mark Wilkinson, The James Hutton Institute       15.45 - 16.15     Discussion and Q&A       16.15 - 16.30     Wrap up			Joanne Old, Environment Agency
Mark Wilkinson, The James Hutton Institute          15.45 – 16.15       Discussion and Q&A         16.15 – 16.30       Wrap up		15.35 - 15.45	Case study 3: Bowmont
15.45 - 16.15         Discussion and Q&A           16.15 - 16.30         Wrap up           CIWEM Events			Mark Wilkinson. The James Hutton Institute
16.15 - 16.30 Wrap up CIWEM Events		15.45 - 16.15	Discussion and O&A
CIWEM Events		16.15 - 16.30	Wrap up
CIWEM Events			
			CIWEM Events



- There is strong understanding of the different processes by which trees, woodlands and forests can affect flood flows.
- An increasing number of modelling studies suggest that woodland creation has the potential to reduce flood flows, typically in the range of 5-20%.
- 'Hard' evidence of forestry reducing flood flows in larger catchments remains 'light' and difficult to prove.
- The amount, location, type and way forests are managed all influence the ability to affect flood flows.
- Risk factors such as the backing-up of floodwaters and the wash-out of woody debris can be controlled by site selection and woodland design.