

Rural Flooding: The Potential Role of Forestry

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Structure

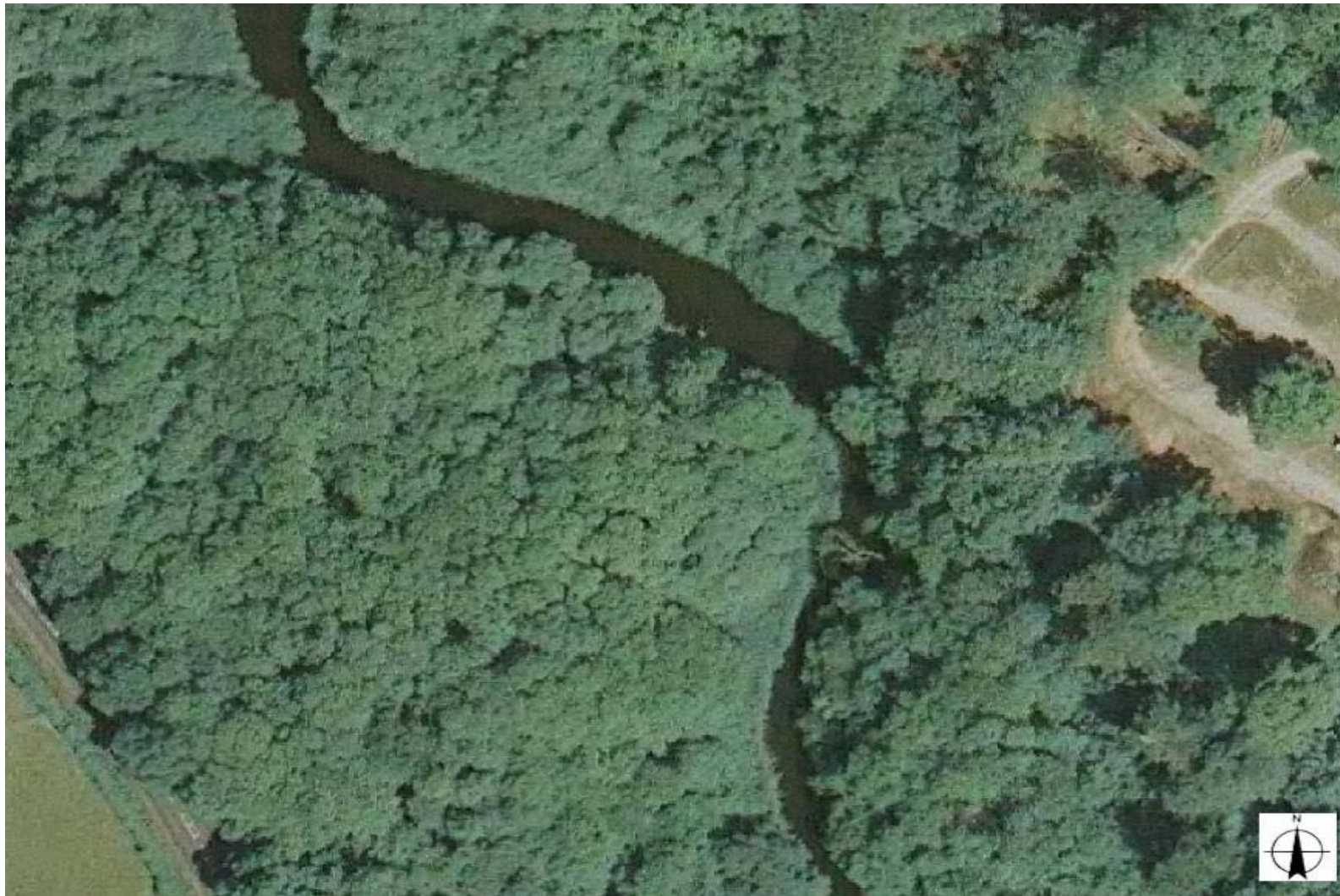
- Background
- Woodland and Flood Alleviation – The Theory.
- Studies on Woodland and Flood Alleviation

Flooding

- Recent flooding events imply that storm generated river flow peaks are increasing in magnitude and frequency.
- If climate change predictions are correct we will have increased precipitation and more flood events.
- Increased interest in whole-catchment approaches to flood alleviation, drawing on opportunities provided by rural land use and land management practices.

Floodplain and Riparian Woodland

- One land management option is the use of woodland to attenuate floodwater propagation.
- Trees are the natural vegetation type of most floodplain land; in the past floodplain and riparian woodland were found extensively on land adjacent to rivers.



River Beaulieu, New Forest

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River Lyon, Scotland

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River Almond, Scotland

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Floodplain Woodland

- We've lost up to 90% of floodplain forests in Europe.
- Since the latter part of the 20th Century interest has grown in the protection and restoration of floodplain forests – multiple benefits.
- In terms of flood alleviation, trees can aid the downstream flood defence by delaying and reducing the size of the flood peak.

How can trees 'slow the flow'?

- Hydraulic roughness - vegetation provides resistance to flowing water.
- The frictional effects vary depending on the type of vegetation.
- Using Manning's formula we can determine the roughness coefficient for different vegetation types.
- Roughness coefficients in the following table represent the resistance to flood flows in flood plains.

Table 1 Hydraulic roughness values (Manning's coefficient) of floodplains¹.

Channel	Hydraulic Roughness (Manning's n)
Pasture (no scrub) – short grass (long grass)	0.030 (0.035)
Mature field crops	0.040
Scattered scrub, heavy weeds	0.050
Medium to dense scrub in winter (summer)	0.070 (0.100)
Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.100
As above but with flood stage reaching branches	0.120
Dense willows, straight, summer	0.150

¹ Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains, United States Geological Survey Water-supply Paper 2339, and Hydraulics manual (1995) Oregon Department of Transport Highways Division.

- Thus, trees create more of a physical barrier than other vegetation types. Partly because the latter can flatten during high flows whereas trees, in general, do not.
- Other factors that influence the hydraulic roughness in trees are:
 - spacing and layout of trees
 - smoothness of trunks
 - presence of lower branches
 - level of undergrowth and amount of dead wood on the woodland floor
- The net effect of these factors is to reduce flow velocities, enhance out of bank flows, and increase water storage on the floodplain, resulting in an overall smaller downstream flood event.
- By varying these factors, woodland management and design can exert an influence on woodland roughness and thus on the capacity of floodplain woodland to impede flood flows.

Debris Dams

Fallen logs, branches and leaf litter collect to form debris dams, which act to hold back and slow down flood flows by:

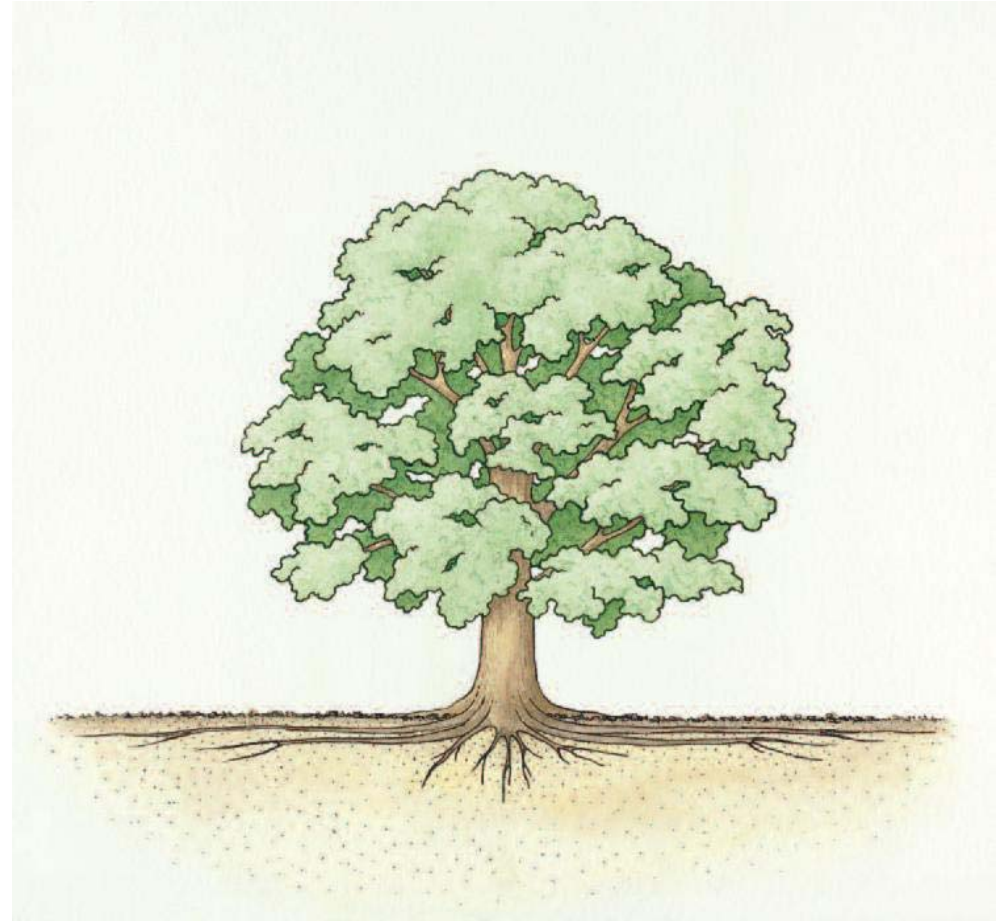
- Reducing water velocity along reach.
- Increasing channel width and water depth.
- Raising water levels, promoting overbank flows.
- Increasing water storage



Roots and Water Infiltration

The rooting structure of trees can provide macro-porosity and allow better infiltration and storage of water.

Trees help improve soil structure - prevents erosion and improves water infiltration.



Potential Disadvantages of Woodland Planting

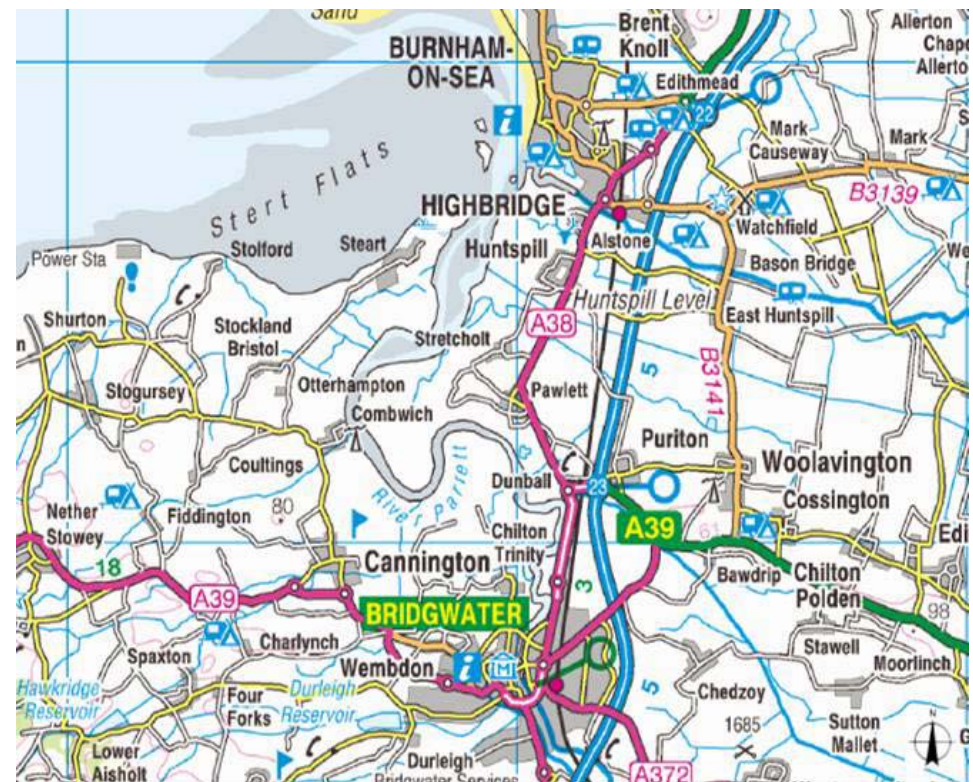
- Debris movement downstream.
- May be ineffective against large floods.
- Land use costs - replacing another land use option.

Wider Benefits

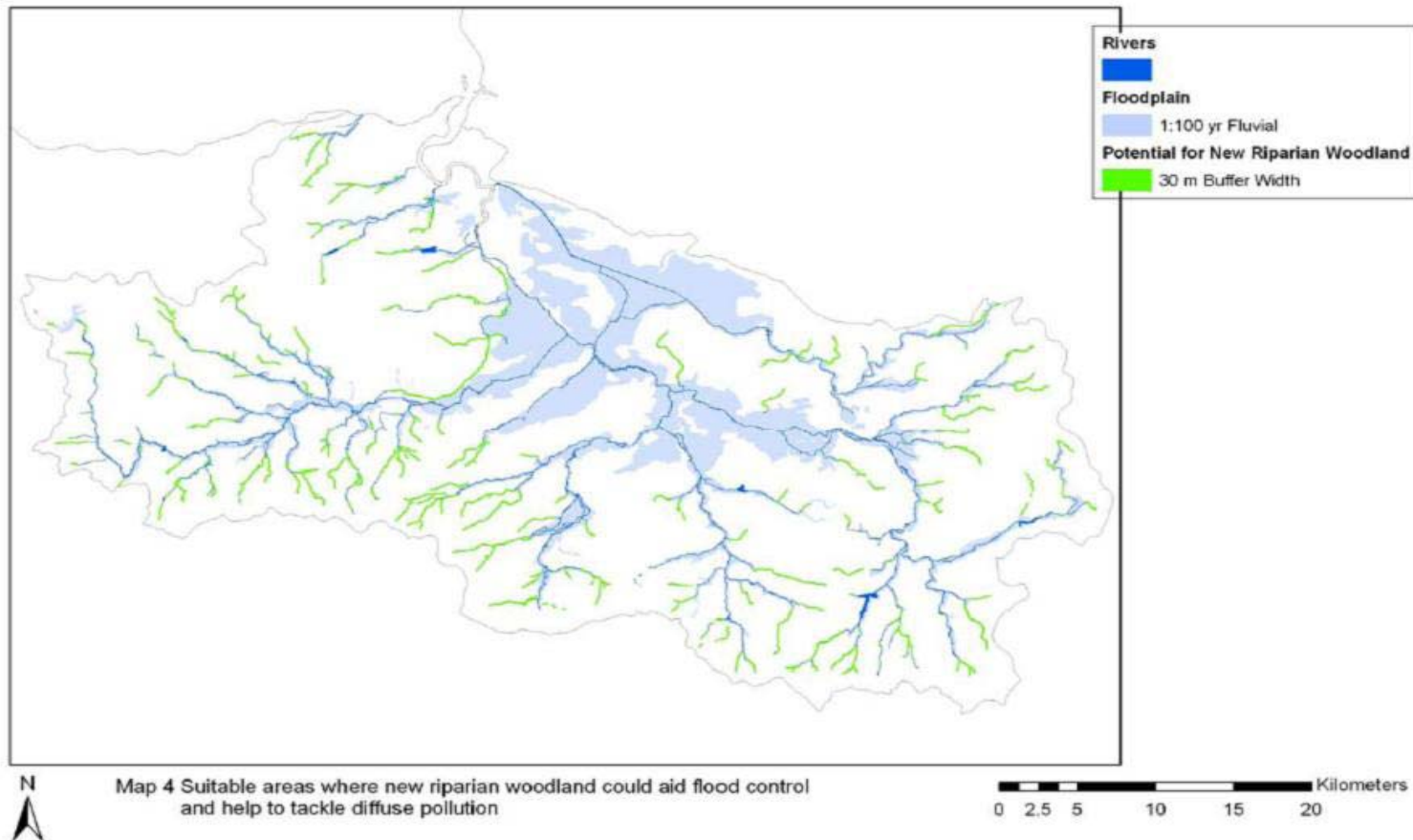
- Biodiversity - A floodplain/riparian forest area provides a rich and diverse range of aquatic and terrestrial habitats.
- Forest Habitat Network - linking habitats for wildlife
- Carbon storage and nutrient retention – climate change mitigation
- Pollution control and remediation – WFD objectives
- Sediment retention – improved river morphology (WFD)

Floodplain Woodland and Flood Alleviation: River Parrett Catchment

- Drains 1690 km² (50% of the land area of Somerset)
- A number of towns face a serious and recurrent flooding problem
- Key objective of study was to explore how woodland could help alleviate downstream flooding.



Opportunity mapping to find suitable areas for restoration of floodplain woodland²



² Nisbet and Broadmeadow (2003). Opportunity mapping for trees and floods.

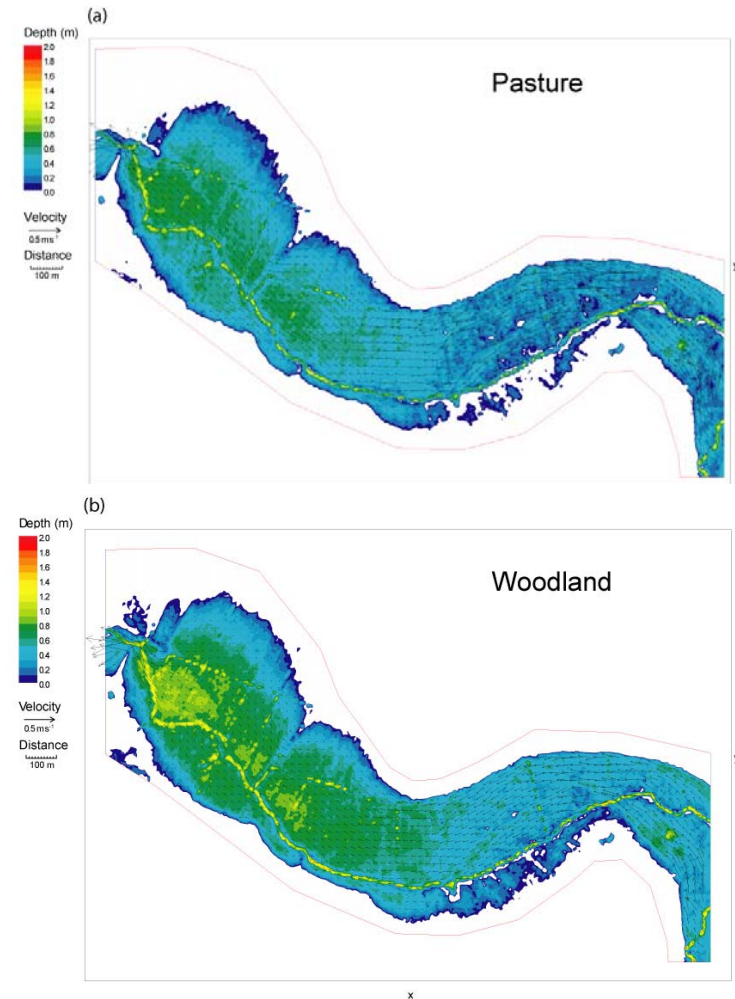
Suitability maps used to select a site for modelling study³

- 1D and 2D models applied to investigate effects of floodplain woodland on flood flows, using available data for River Cary reach.
- Appropriate hydraulic roughness values selected from literature to simulate the effect of floodplain woodland restoration on a 1 in 100 year flood event.

³ Thomas, H. and Nisbet, T. R. 2007. An assessment of the impact of floodplain woodland on flood flows. Water and Environment Journal, 1747-6585.

Hydraulic Impact of Floodplain Woodland

- Reduced velocity and increased depth.
- Establishing woodland along 2.2 km reach increased flood level up to 270 mm and delayed flood peak by 140 min in 80 km² catchment.

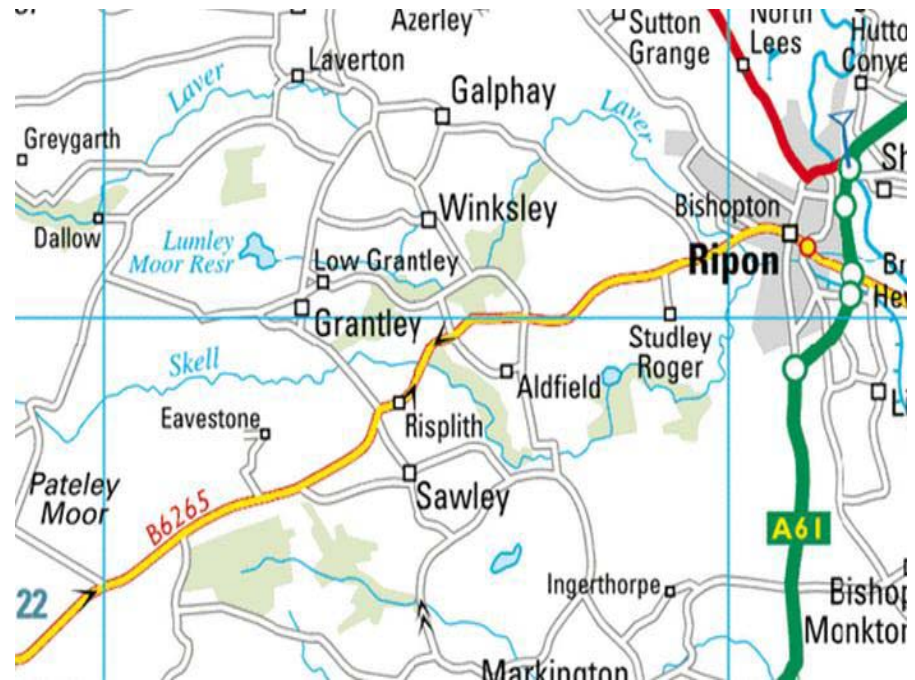


Parrett Catchment

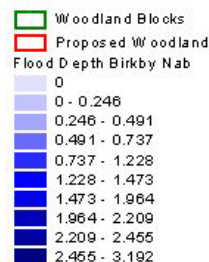
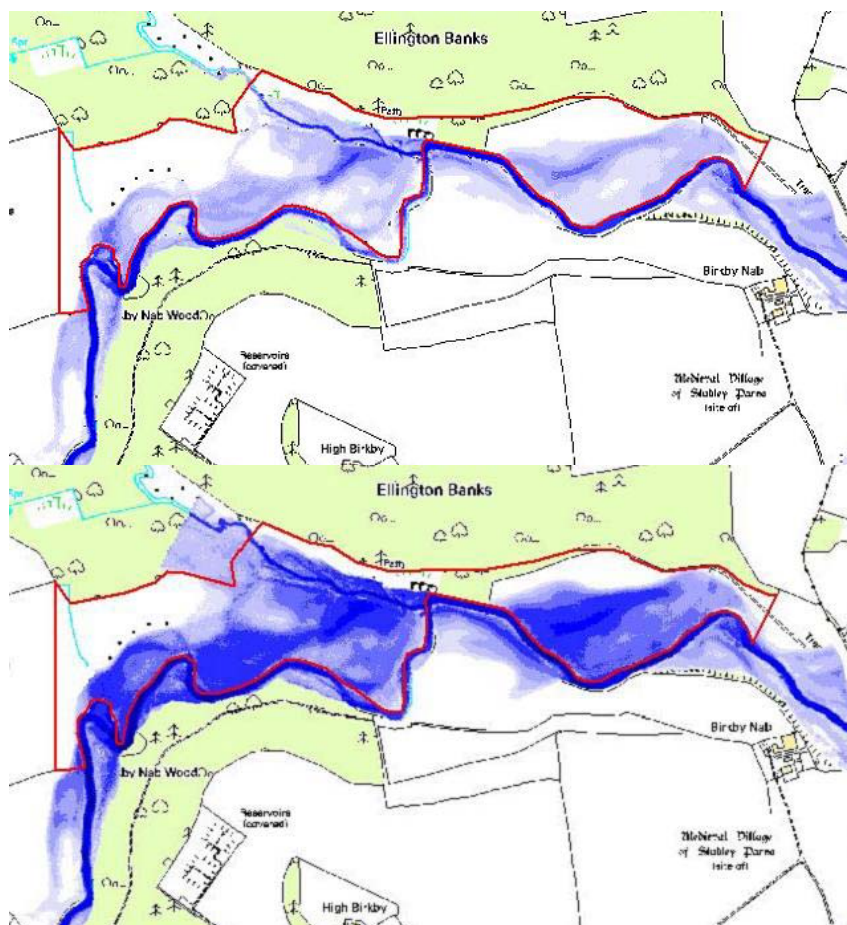
- Monitoring continues.
- Native broadleaved riparian woodland has been planted in a previously arable field in the floodplain of the River Parrett.
- Trees were planted with the support of the Forestry Commission under the Woodland Grant Scheme and Farm Woodland Premium Scheme.

Restoring Floodplain Woodland for Flood Alleviation – River Laver Catchment

- Three-year study, started Feb 2007
- Aim to create up to 15 ha of floodplain woodland to reduce flood risk at Ripon
- Model impact of woodland on flood flows to evaluate potential sites and the effect of varying the design and management of the woodland on flood velocity, depth, storage volume and peak travel time.



Model Results: Birkby Nab

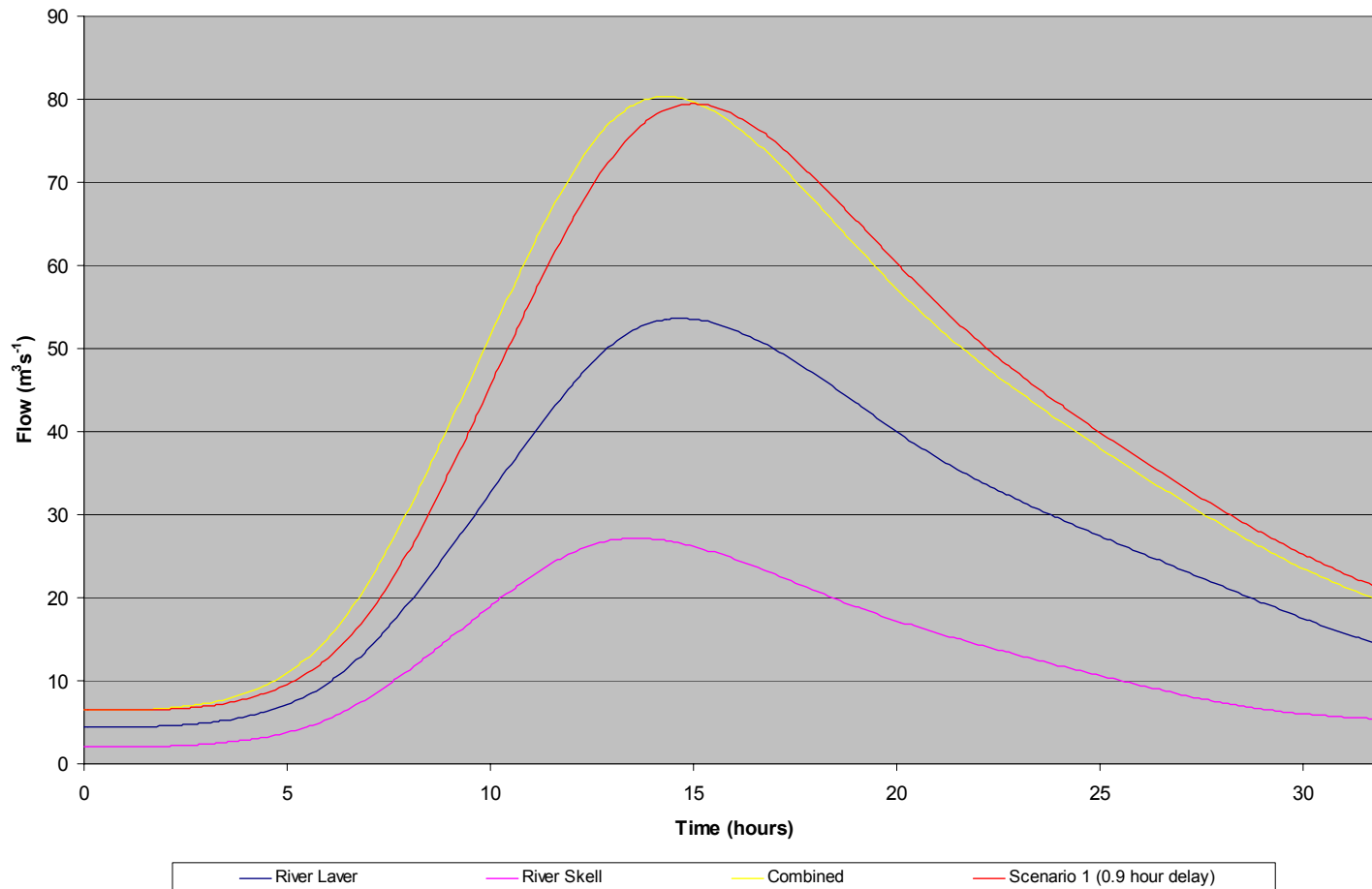


Modelled impact of planting 19.3 ha of floodplain woodland

- Reduction in flood velocity up to 1.8 m s^{-1}
- Mean flood depth predicted to increase by 44 cm within woodland
- Backwater effect extending to 170 m.

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Impact of Floodplain Woodland on Peak Flow Synchronisation

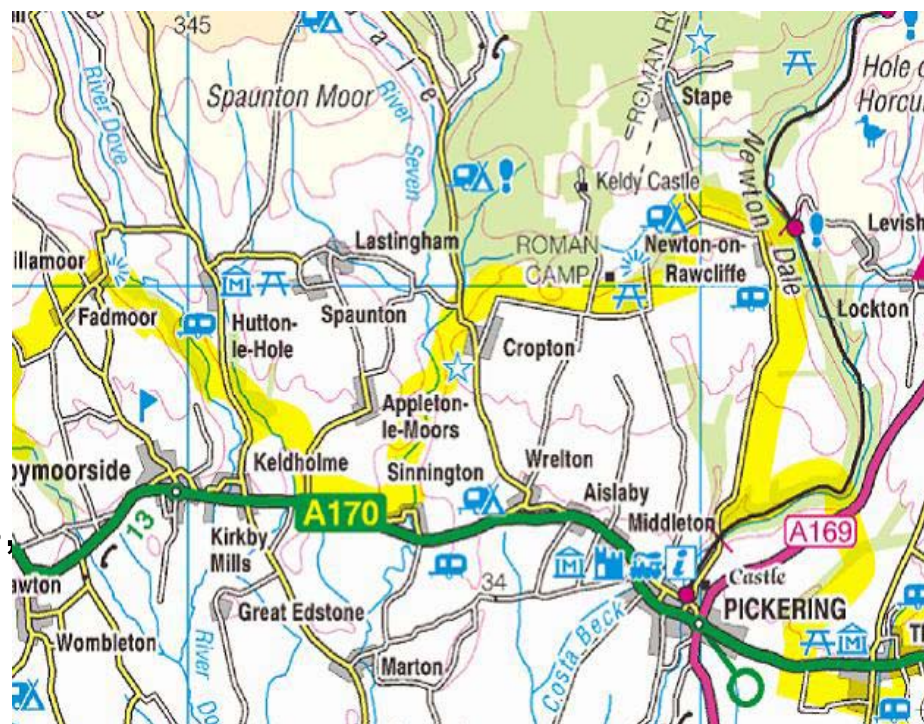


Modelling Studies

- Modelling studies indicate that floodplain woodland could make a significant contribution to mitigating downstream flooding for large flood events.
- Significant barriers exist to securing targeted restoration of floodplain woodland for flood mitigation.
- There remains a need for a sizeable demonstration study to test model predictions and evaluate potential benefits.

Reducing Flood Risk in Pickering, North Yorkshire

- DEFRA funded pilot project to assess how land management can reduce flood risk in the Pickering and Sinnington areas.
- The Pickering project will include planting trees, creating buffer strips along watercourses, and blocking moorland drains with debris dams to delay the flow of flood waters.



The impact of large woody debris dams on flood flows – Great Triley Wood, Wales

- Native floodplain woodland site north of Abergavenny in south Wales
- Great Triley Wood: 8 ha woodland in 1000 ha catchment of River Fenni, tributary of River Usk



LWD dam Construction

- Constructed five to ten LWD dams along reach at intervals of 7 to 10 channel widths.
- Used wind-blown or standing dead trees to construct dams.
- Recorded the effect of the LWD dams on the flow duration curve and peak/flood profile for a range of events

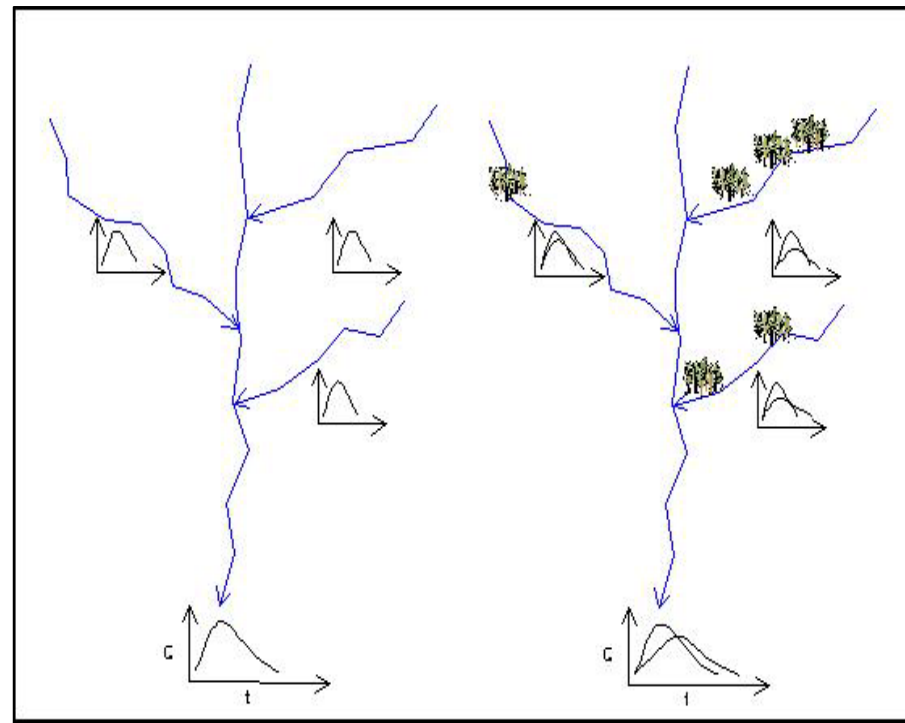


Results and Conclusions

- Significant impact apparent for a relatively small area of floodplain woodland.
- Increased time for flood warning.
- Potential to desynchronise flood peaks.

Woodland and Large Woody Debris Dams

- Cumulative effect of woodland on different tributaries could have a marked impact on downstream flood peak.
- The restoration of floodplain woodland and large woody debris dams could be an effective 'soft' engineering technique for aiding flood control.



Summary

- Woodland offers a number of potential opportunities for flood control.
- Modelling studies suggest that floodplain woodland offers a way of ameliorating extreme flood events at the large catchment scale, although results need to be tested in practice.
- There is a need to quantify the effectiveness of floodplain woodland as a mechanism of flood defence. In particular:
 - the actual flood storage potential of floodplain woodland,
 - the extent to which woodland could retard different-sized flood peaks
 - and how any flood attenuation effect could be maximised through woodland design, including location, shape, size, stocking density, age structure and species choice.

Summary

- Overall, there is significant scope for using woodland to help reduce flood risk, as well as to provide a wide range of other environmental, social and economic benefits.
- However, in order to achieve these, woodland needs to be better integrated with agriculture and other land uses as part of a balanced, whole-catchment approach to sustainable flood management.

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www.forestresearch.gov.uk/fr/INFD-7T9JPW

Thank you