Forest Research

Woodlands & Natural Flood Management

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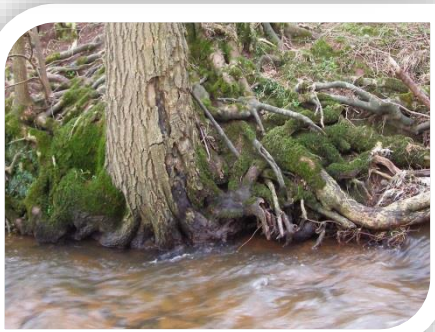
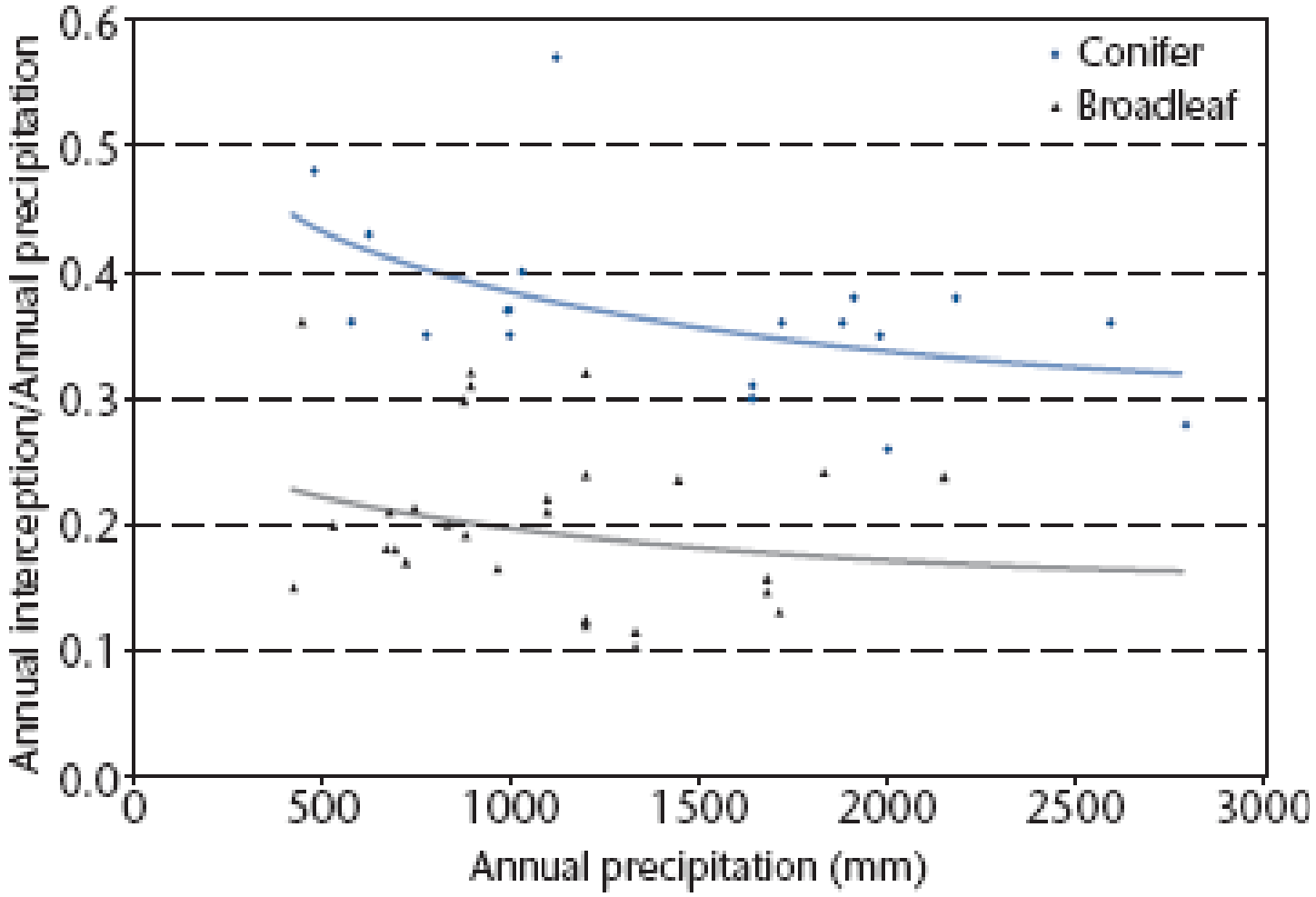
Forests can reduce flood risk by:

- 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.

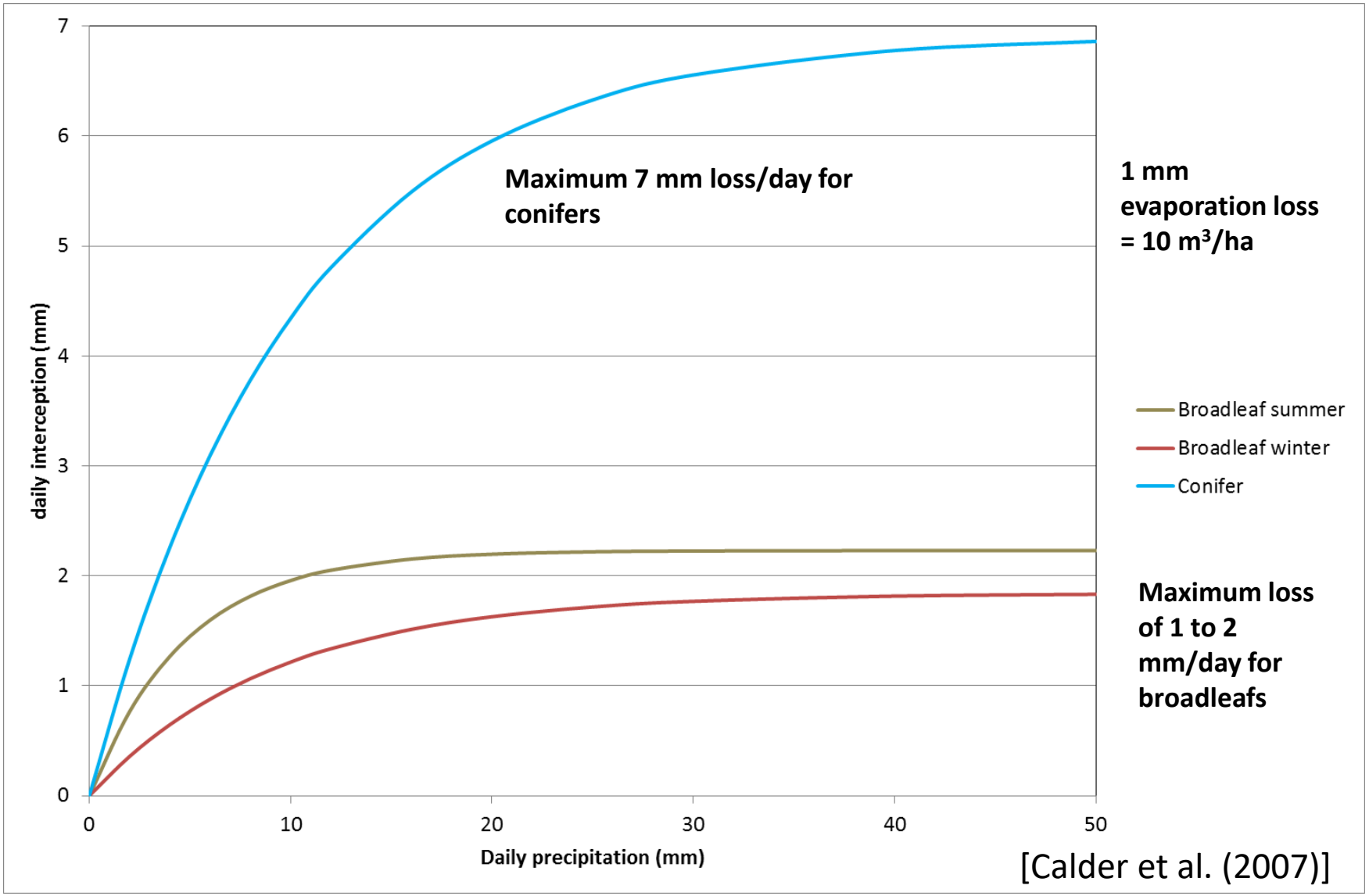


Increasing Evaporation



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

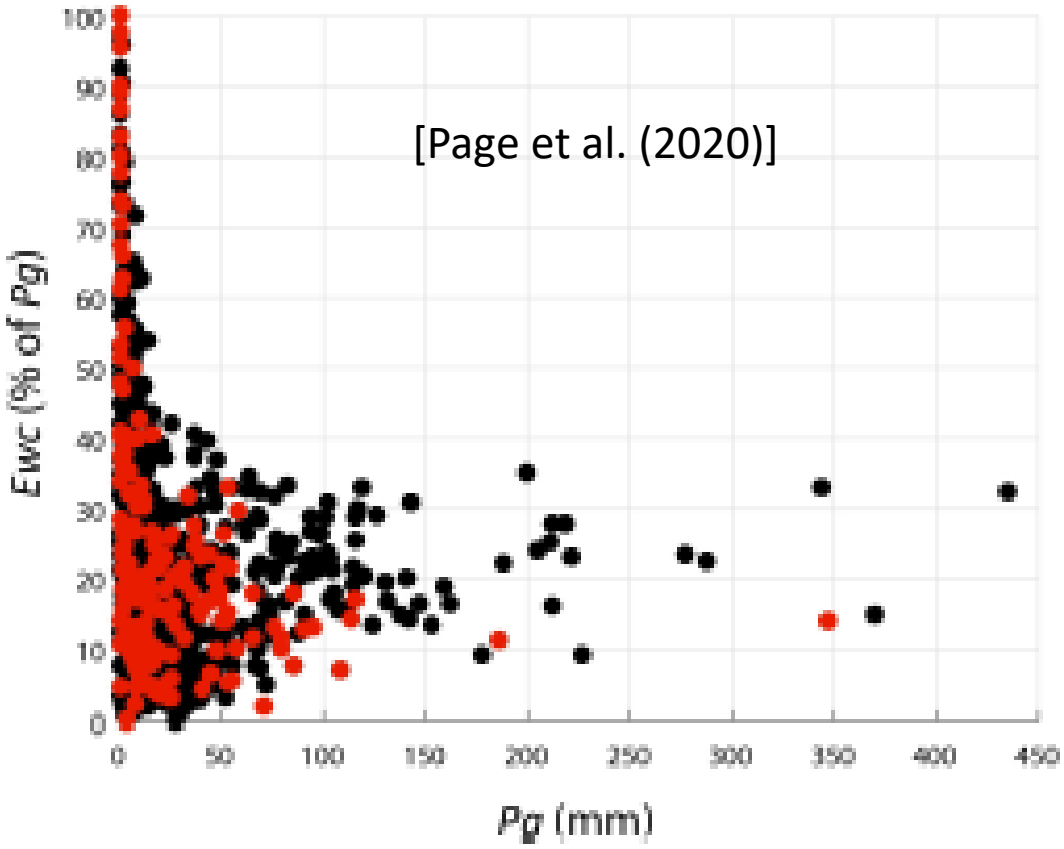
Limit on Daily Interception



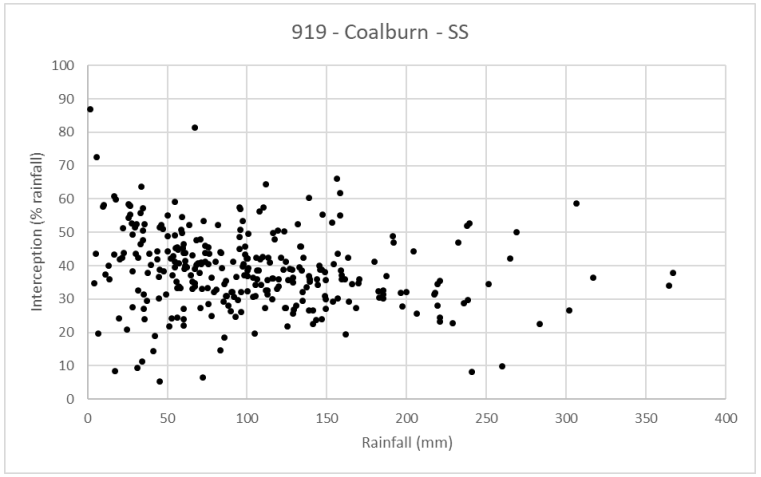
[Calder et al. (2007)]

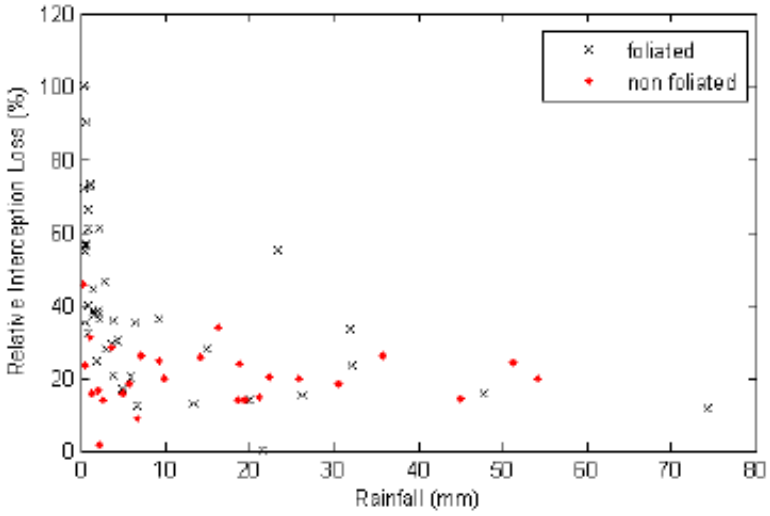
Recent Evidence

Evidence shows marked interception during large rainfall events (10-30% reduction)



[Page et al. (2020)]





[Arcangeli et al. (2006)]

Impact on Soil Water Storage

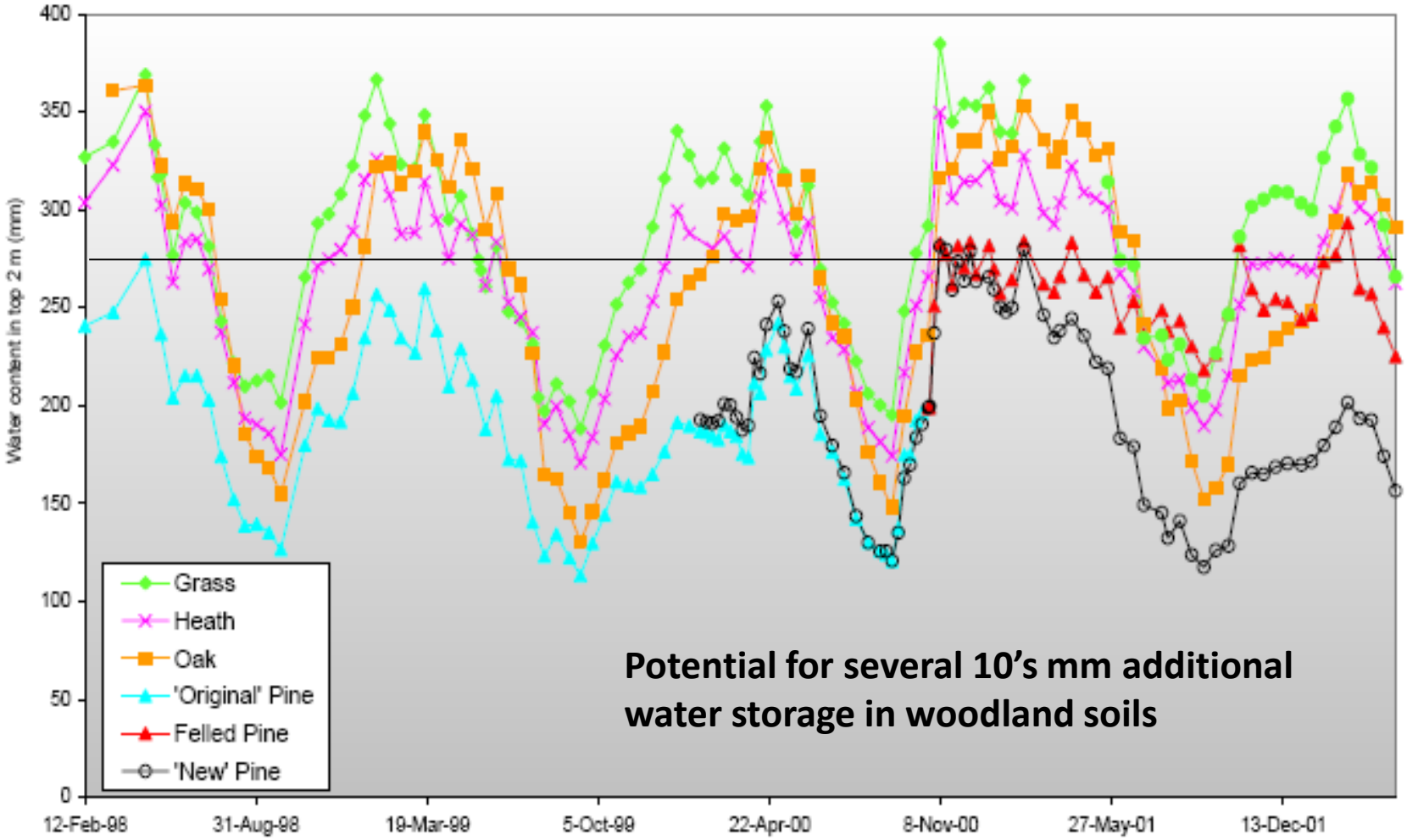
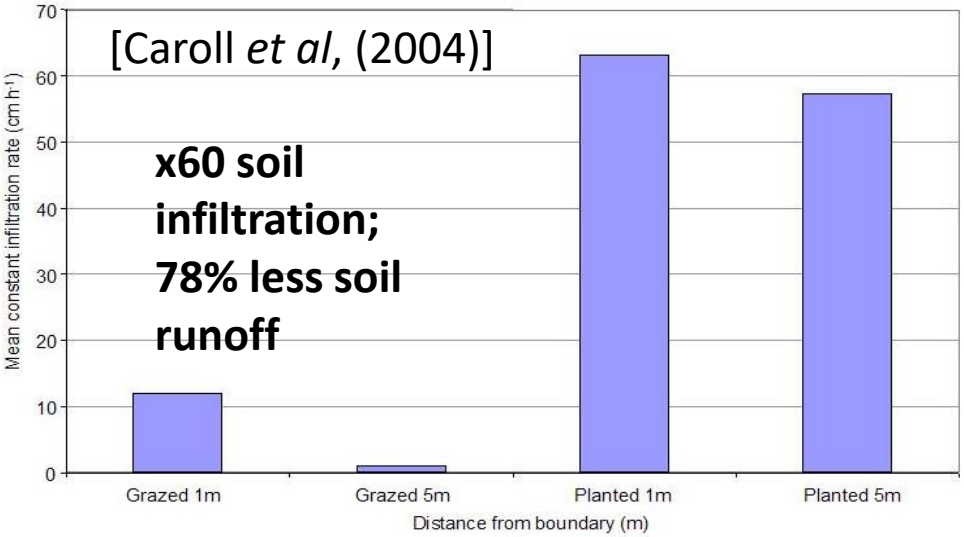


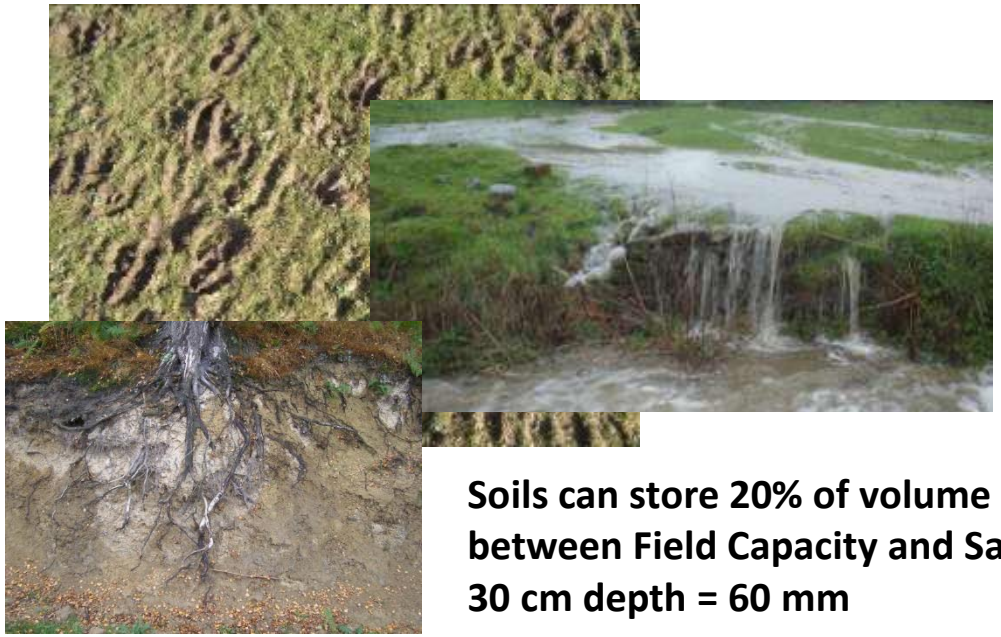
Figure 42. Water content in the uppermost 2 m under each land cover (12th February 1998 to 23rd April 2002) as measured by the neutron probe.

[Calder et al. (2002)]

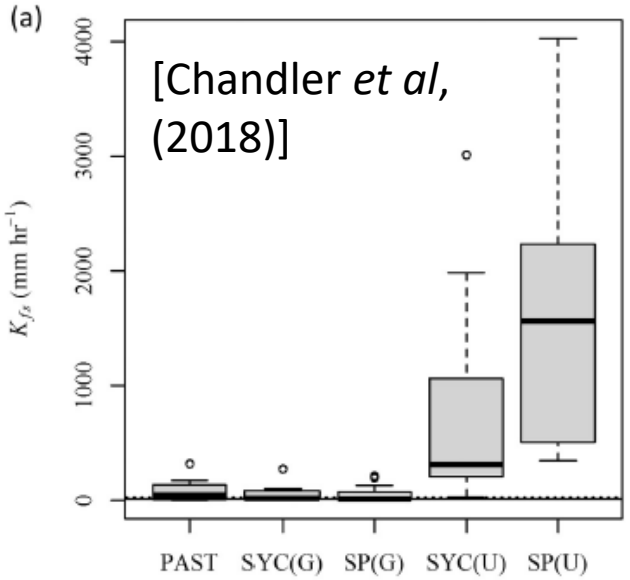
Enhancing Soil Infiltration

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





Soils can store 20% of volume as water between Field Capacity and Saturation; 30 cm depth = 60 mm



Increasing Hydraulic Roughness

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 undergrowth, flow below branches	0.080	0.100	0.120
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

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

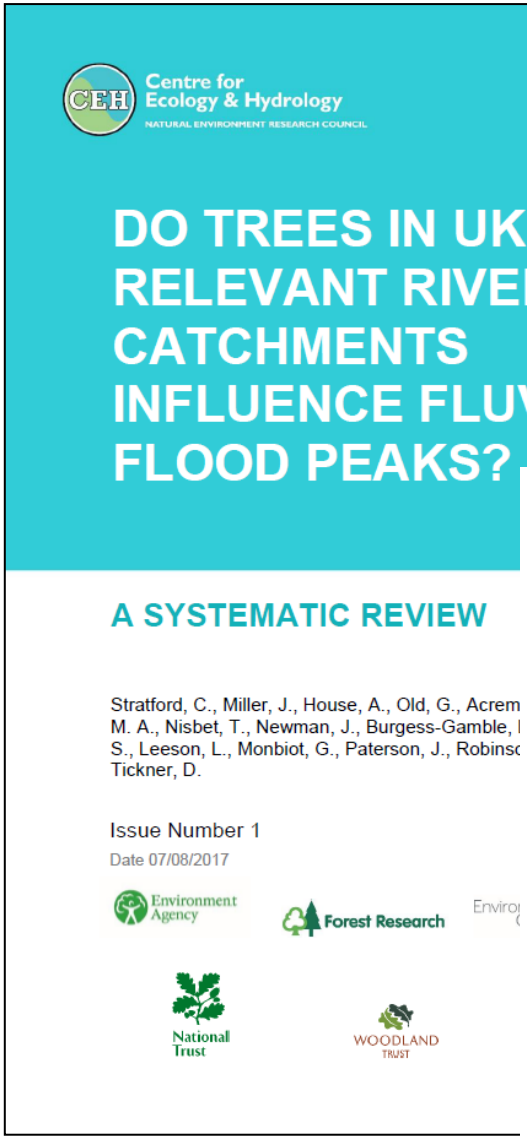
Hydraulic roughness (x5) creates a barrier effect, slowing river flows, pushing water onto/across floodplains and temporarily increasing flood storage (100 m^3 to 100,000+ m^3).

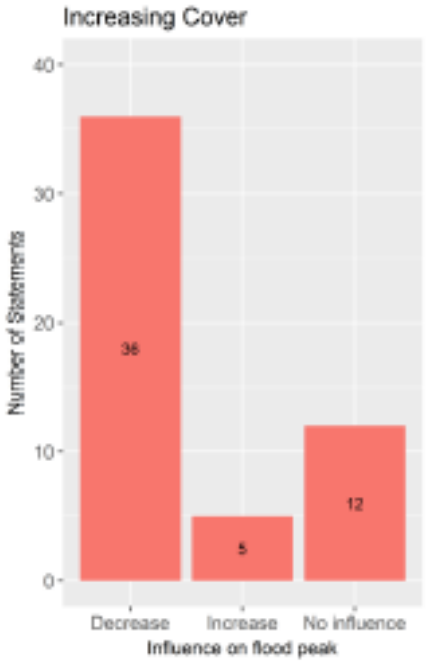
Reducing Sediment Delivery

- 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.

CEH Systematic Review





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 on small floods, only a few observational studies have assessed large floods and the majority of these found no influence on flood peak.

Reasons for mixed results for large floods:

- Challenge of detecting impacts on relatively rare events, e.g. flows exceeding structures
- Lack of experimental studies due to timescale, controlling for background changes, cost etc
- Scale and location issues;
- Role of existing land use and management practices;
- Woodland design factors, e.g. in terms of type, age, shape and structure;
- Woodland management factors, including scale and timing of practices such as felling.

Changes in peak flow due to forest felling:

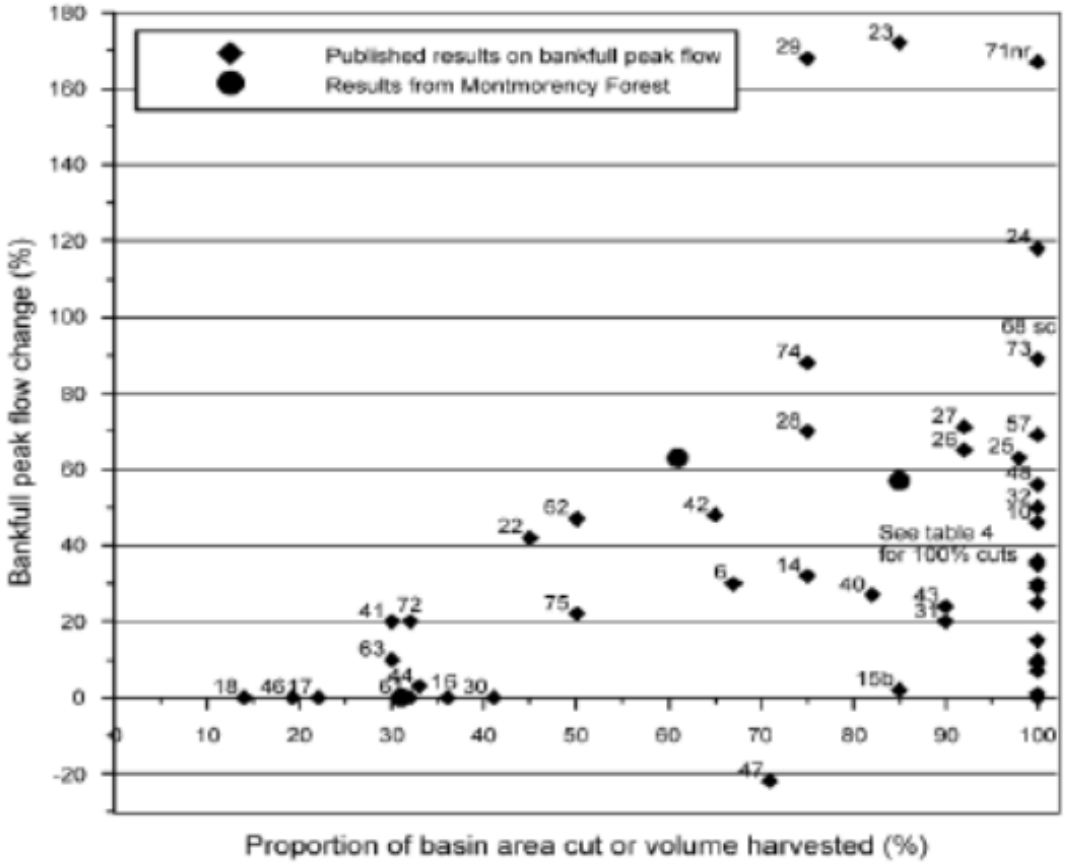
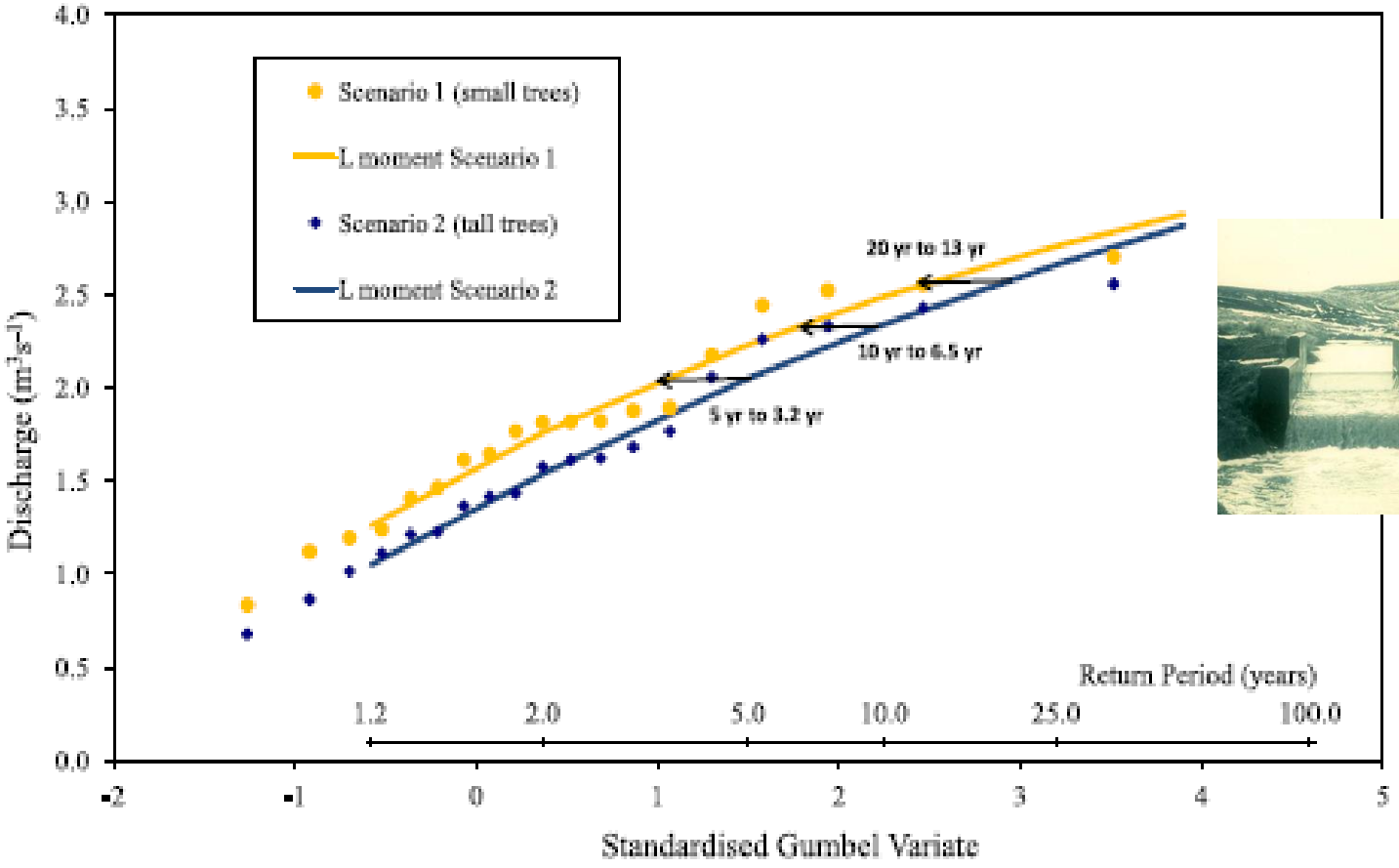


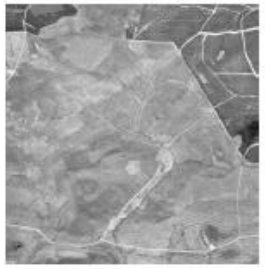
Fig. 20 A review of changes in river peak-flow following forest cutting in boreal and temperate regions by Guillemette et al. (2005 J. Hydrol. 302: 137-153).

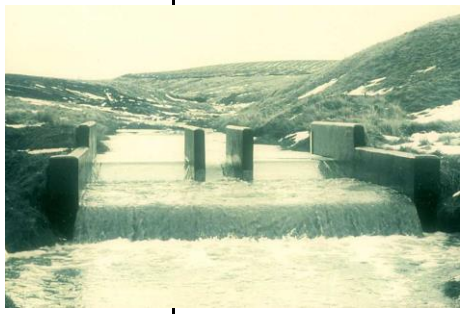
Assessment of impact of conifer afforestation on peak flows at Coalburn, N England



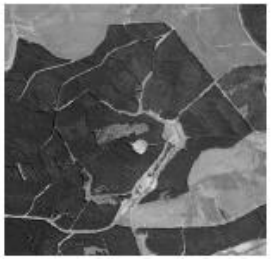
S.J. Birkinshaw et al./Journal of Hydrology 519 (2014) 559–573

1973 - Catchment at planting

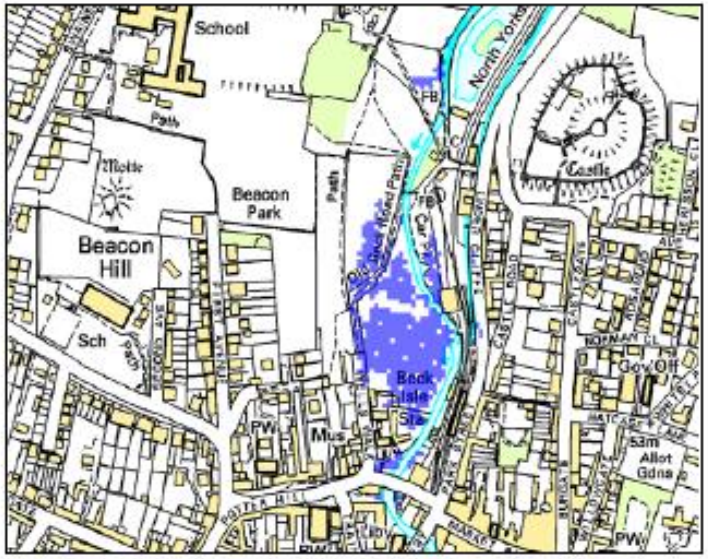


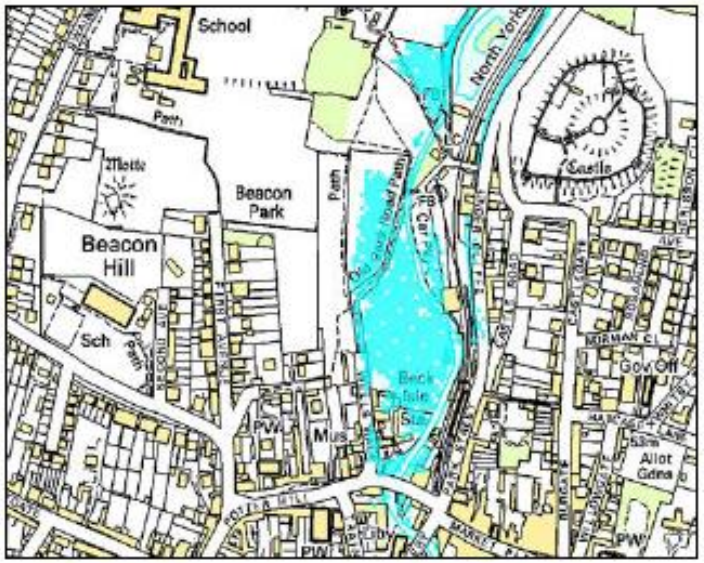


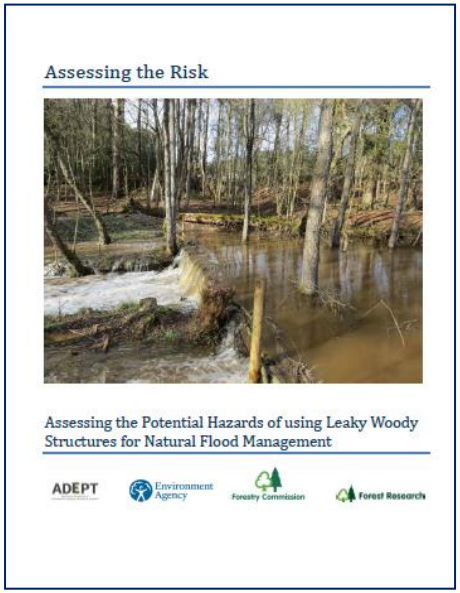
2014 – Post canopy closure



Role of Leaky Woody Structures





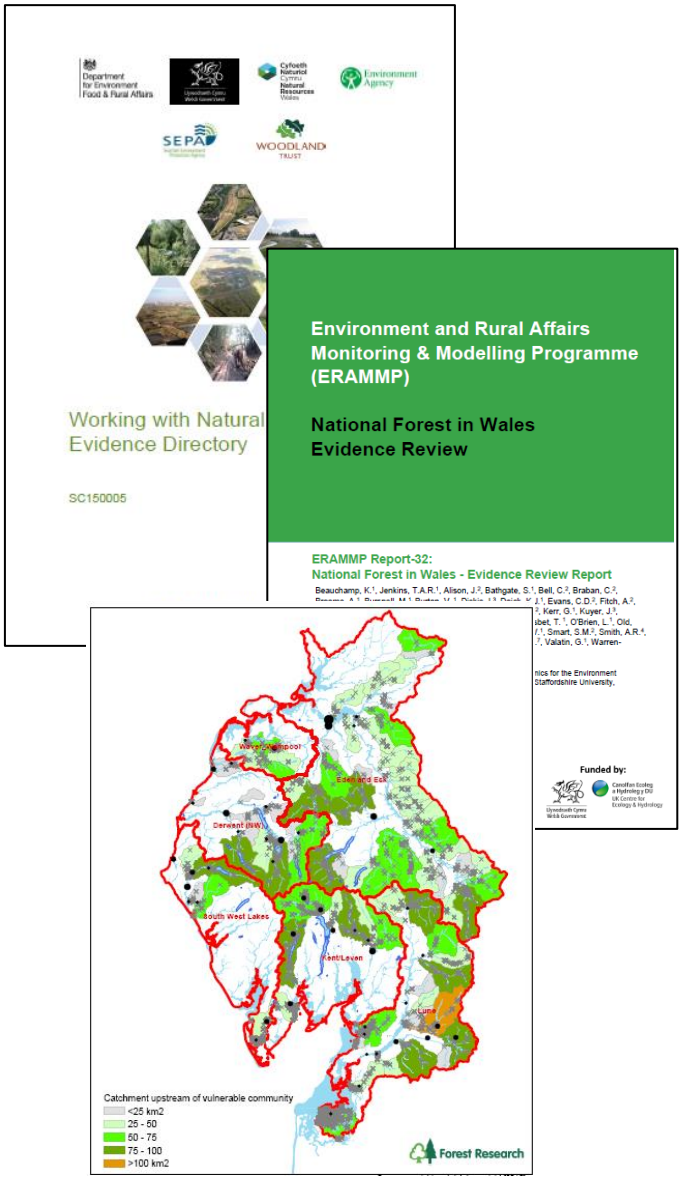


Modelling: Summary

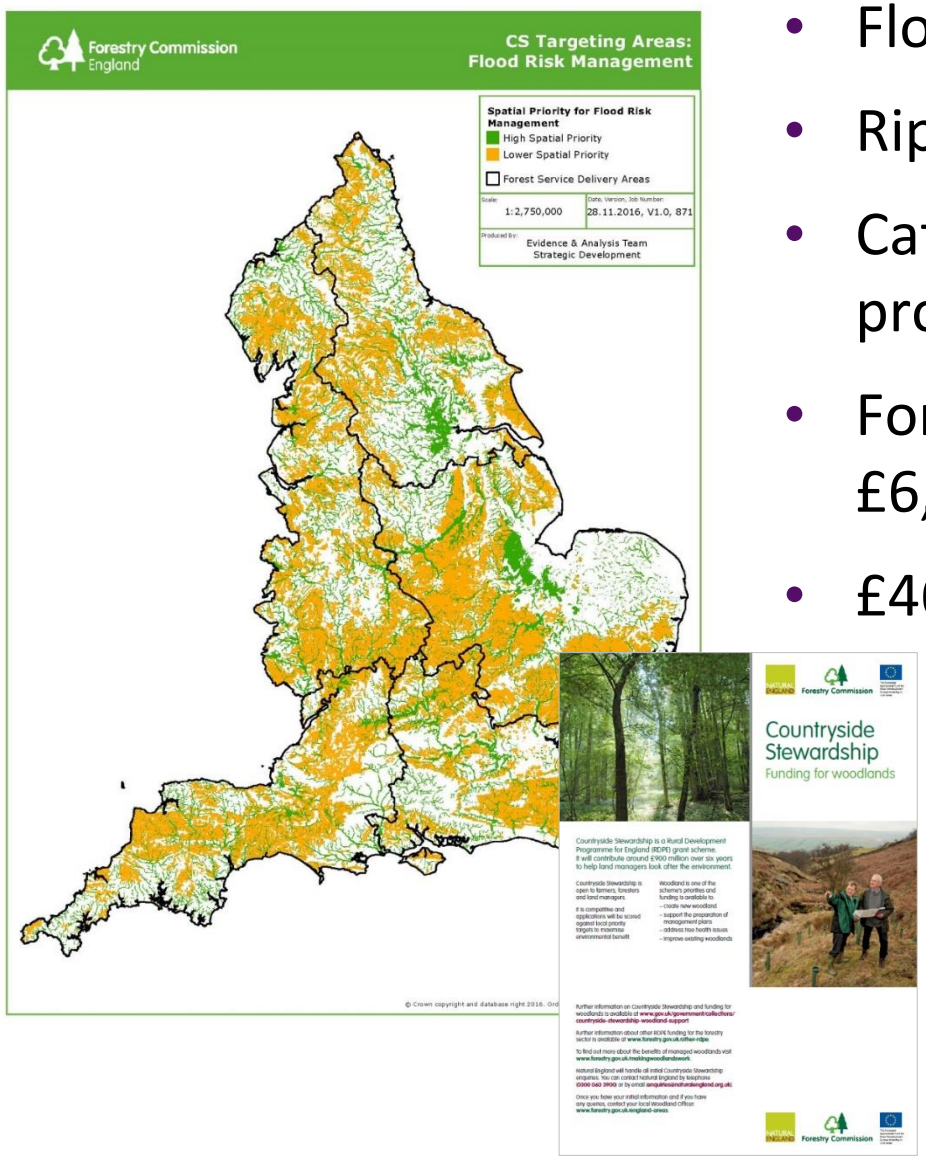
- Hydrology and hydraulic models enable assessments of the impact of woodland on larger peak flows, based on adjusting model parameters to reflect process understanding;
- Woodland creation predicted to reduce catchment flood peaks by **4-8%** (Pickering, 68 km^2), **0-13%** (Hodder, 25 km^2) **-3 to 27%** (River Tone) **2-54%** (Pont Bren, 6 km^2) and **6-19%** (New Forest);
- But there are many issues with models – e.g. lumping or limited process representation, questions over parameter values, and lack validation;
- Need for great care!

FC Approach

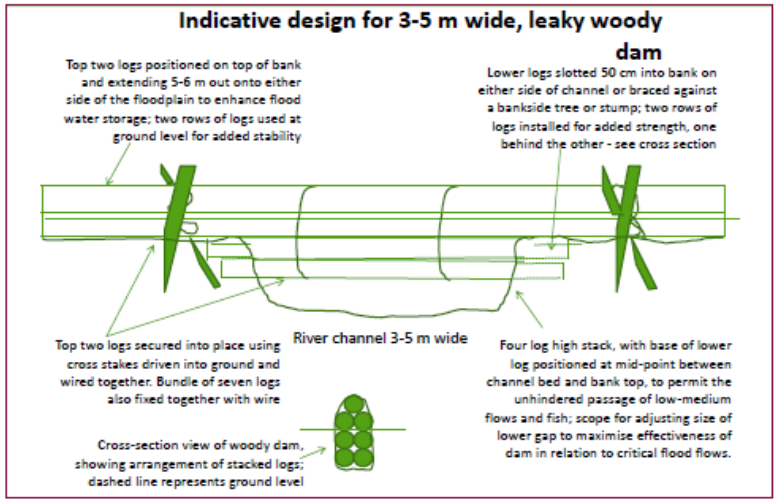
- Evidence is strong enough to inform forest policy and practice;
- Target communities and assets at significant flood risk – draw on opportunity mapping;
- Prioritise catchments (e.g. <100 km^2) where there is most need and scope to make a difference;
- Join up strategies and plans to achieve longer-term goals and greater resilience;
- Provide grants/payments to promote interventions.



Targeting Action and Grant Aid

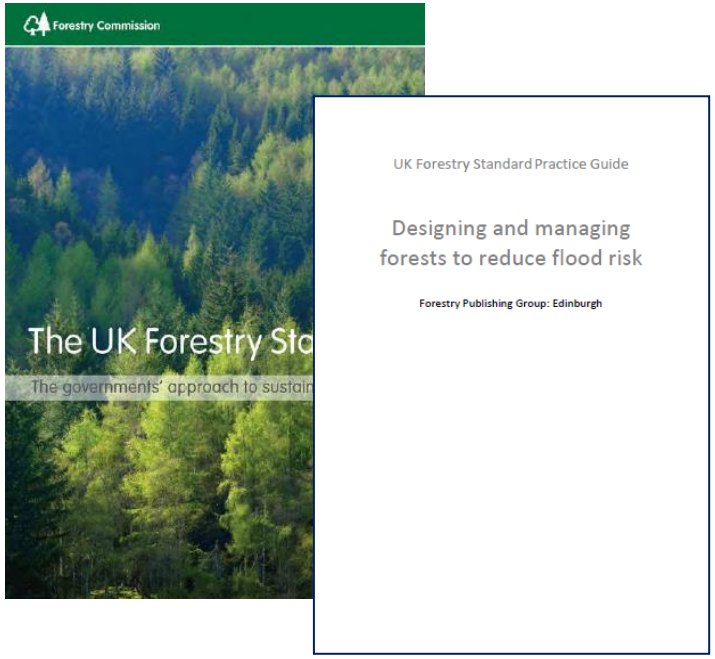


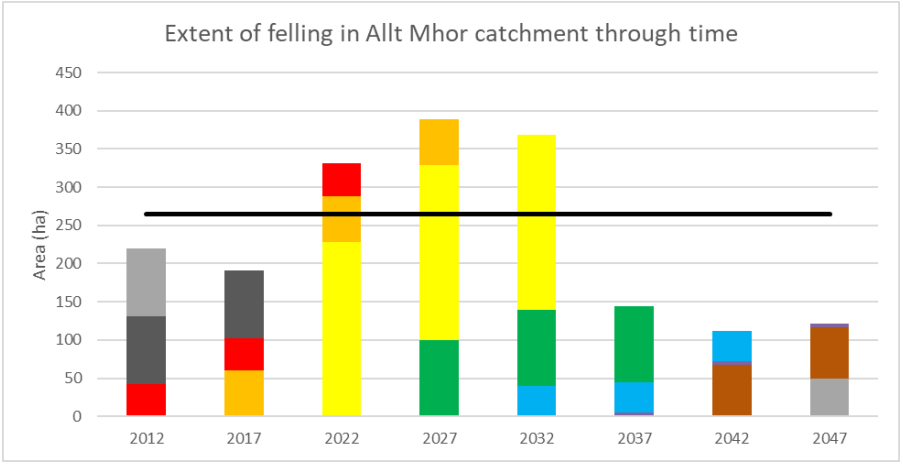
- Floodplain - Flood Zone 2
- Riparian zones – 30 m buffer
- Catchment soils with a high propensity to generate rapid runoff
- Forest planting grant support: £6,800/ha plus £200/ha/yr for 10 yr
- £461/small LWD, £764/large LWD



Forest Management and Design

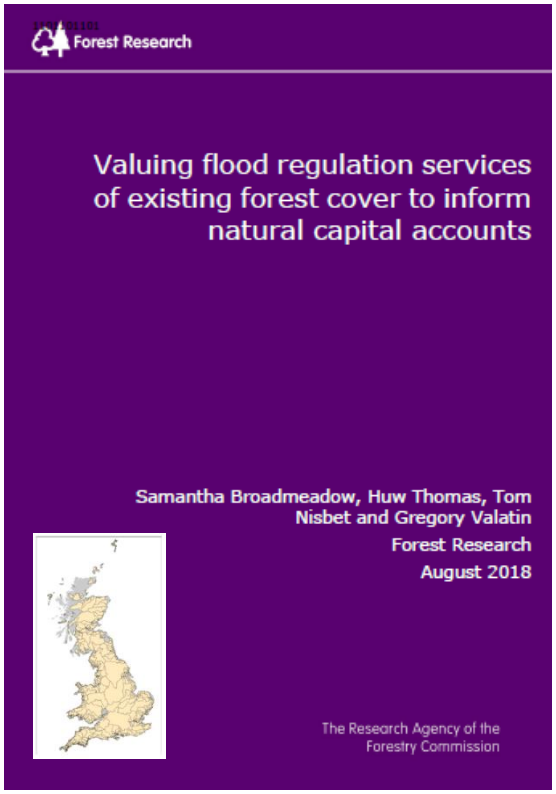
- Avoid large-scale felling, e.g. phase felling so that area of felled, fallow and restock <10 years old is <40% of vulnerable catchments;
- Minimise the fallow period between felling and restocking;
- Consider the impact of planned forest clearance, including for windfarm developments and habitat restoration;
- Follow good practice (e.g. disconnect drains, restore riparian zones and wetlands).





Valuing Flood Regulation Service

Economic studies have generated annualised central estimates for the forest flood regulation service to range between £89-250/ha/yr, although thought to be an underestimate.



Conclusions

- High confidence that woodlands can affect flood runoff based on sound process understanding.
- Strong observation-based evidence that felling can increase and new planting decrease flood peaks in small catchments (<10 km^2). Evidence strongest for small flood peaks (>10% probability).
- Strong logic chain and model-based evidence provides medium confidence that effects can extend to medium catchments (10-100 km^2) and medium flood peaks (>1% probability).
- Logic implies that woodland effects could extend to large catchments (>100 km^2) and large floods (<1% probability) but very limited evidence - low confidence.
- Very difficult to detect changes to flood peaks when the extent of woodland planting or felling is <15-20% of any size of catchment.

Any Questions?