Some interesting reads on catchment management.

http://www.therrc.co.uk/pdf/References/Lane_et_al__2003_.pdf Leeds paper on upland catchment management and flood / water quality management. Focus on grips.

http://onlinelibrary.wiley.com/doi/10.1002/hyp.9285/abstract;jsessionid=9F4892FFAE452C5C489674AF4CB83D61.f04t04 Another Lane one. This following on from the above study. Again, focuses on grips but concepts and approach are interesting. Needs access, but think the EA has a user login for these journals.

http://rsta.royalsocietypublishing.org/content/369/1942/1784 Interesting read more generally on evidence based approach, reliance on observations and evidence generation

http://www.environment-agency.gov.uk/research/library/position/94565.aspx Our (EA) position on land management. Supporting papers and statement text is useful I think.

http://www.forestry.gov.uk/fr/INFD-7ZUCQY Pickering slowing the flow. You'll certainly have seen this I think, but the papers provided in the reports and references are really useful.

http://knowledge-controversies.ouce.ox.ac.uk/Ryedale2/documents/usefuldocuments/Lane.pdf
Slowing the flow in the UK. Pennines Uplands: waiting for Godot? S N Lane. Durham Uni.

http://www.ciria.org/service/Home/AM/ContentManagerNet/ContentDisplay.aspx?Section=Home&NoTemplate=1&ContentID=25895 – Land use management effects on flood flows and sediments – guidance on prediction.

Tom Ball. Management approaches to floodplain restoration and stakeholder engagement in the UK: a survey. Echo hydrology and Hydrobiology, vol 8, issues 2-4, 2008, pp.273-280.

http://www.ncl.ac.uk/press.office/press.release/item/natural-engineering-offers-solution-against-future-flooding

A framework for managing runoff and pollution in the rural landscape using a Catchment Systems Engineering approach

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Opportunity Mapping for Woodland to Reduce Flooding in the Yorkshire and the Humber Region
Samantha Broadmeadow and Tom Nisbet
Forest Research Monograph: 1

http://www.forestry.gov.uk/pdf/York_and_Humber_flooding_final_report_2009.pdf/$FILE/York_and_Humber_flooding_final_report_2009.pdf

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The Influence of Floodplain Restoration on Flow and Sediment Dynamics in an Urban River

1. S. Ahilan[1],
2. M. Guan[1],
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DOI: 10.1111/jfr3.12251

Journal of Flood Risk Management

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Yorkshire Water leads major improvement for Pennine moorland

03 February 2014

http://www.moorsforthefuture.org.uk/news/yorkshire-water-leads-major-improvement-pennine-moorland

A significant project to conserve wildlife, improve drinking water and reduce flooding downstream is being carried out by Yorkshire Water on nationally important moorland overlooking Hebden Bridge in Yorkshire.

Yorkshire Water has commissioned more than five kilometres of fencing and dry stone walling for its Heptonstall and Widdop moors to help control grazing animals – mainly sheep.

Helicopters have spread lime and fertiliser across 75 hectares of the fenced-off moorland where 12,000 plug plants will be planted this spring to re-vegetate the bare, peaty soil.

400 bags of heather brash have been spread over bare peat to prevent further erosion while young plants establish. The work will improve wildlife habitats and help soak up heavy downpours, reducing flood-risk lower down the valley.

The project is being managed by the Moors for the Future Partnership for Yorkshire Water which is funding the majority of the work. We are working closely with Natural England, six commoners who have the right to graze livestock on the land, Calderdale Council, rural regeneration company Pennine Prospects, a local grouse shoot and contractors.

The wildlife habitats on this land have the highest protection level in the UK, but historic smoke pollution from former mills, over-grazing and wildfires have degraded the soil, leading to large stretches of bare moorland where little could grow.

The new fencing and walling will protect freshly vegetated areas from animal grazing, enabling the heather, cotton grasses, bilberry and sphagnum mosses to return and flourish.

This will create a more diverse and abundant site for wildlife, better catchment and natural cleansing of our drinking water and reduced flooding downstream as rainwater sinks in rather than running over once-bare peat.

New vegetation will hold together the peat and reduce erosion, enabling it to retain carbon in the soil and lessen the impact of climate change.

The scheme is part-subsidised by Natural England agri-environment payments to land managers, with the aim of improving the moors to ‘favourable’ condition – Natural England’s target for Sites of Special Scientific Interest such as this.

Lane, S.N., Reid, S.C., Tayefi, V., Yu, D. et Hardy, R.J. (2008). Reconceptualising coarse sediment delivery problems in rivers as catchment-scale and diffuse. GEOMORPHOLOGY, 98(3-4): 227-249. Doi:10.1016/j.geomorph.2006.12.028

Document type: Article

Author(s): **Lane, S.**N., Reid, S.C., Tayefi, V., Yu, D. and Hardy, R.J.

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Note: General Assembly of the European-Union-of-Geosciences, Vienna, AUSTRIA, APR 24-29, 2005

Abstract: This paper assesses river channel management activities in the context of the interaction between coarse sediment delivery, climate change,¦river channel response and flood risk. It uses two main sources of¦evidence: (1) an intensive instrumentation of an upland river catchment¦using both traditional hydrometric and novel sediment sensing methods;¦and (2) a sediment delivery model that combines a treatment of sediment¦generation from mass failure with a treatment of the connectivity of¦this failed material to the drainage network. The field instrumentation¦suggests that the precipitation events that deliver sediment from¦hillslopes to the drainage network are different to those that transfer¦sediment within the network itself Extreme events, that could occur at¦any time in the year (i.e. they are not dependent on wet antecedent¦conditions), were crucial for sediment delivery. However, sustained¦high river flows were responsible for the majority of transfer within¦the river itself. Application of three downscaling methods to climate¦model predictions for the 2050s and 2080s suggested a significant¦increase in the number and potential volume of delivery events by the¦2050s, regardless of the climate downscaling scenario used. First¦approximations suggested that this would translate into annual bed¦level aggradation rates of between 0.10 and 0.20 in per year in the¦downstream main channel reaches. Second, the importance of this¦delivery for flood risk studies was confirmed by simulating the effects¦of 16 months of measured in-channel simulation with river flows scaled¦for climate change to the 2050s and 2080s. Short-term sedimentation¦could result in similar magnitude increases in inundated area for I in¦0.5 and I in 2 year floods to those predicted for the 2050s in relation¦to increases in flow magnitude. Finally, we were able to develop an¦alternative approach to river management in relation to coarse sediment¦delivery, based upon reducing the rates of coarse sediment delivery¦through highly localised woodland planting, under the assumption that¦reducing delivery rates should reduce the rate of channel migration and¦hence the magnitude of the bank erosion problem. Thus, the paper¦demonstrates the need to conceptualise local river management problems¦in upland river environments as point scale manifestations of a diffuse¦sediment delivery process, with a much more explicit focus on the¦catchment scale, if our river systems are to become more insulated from¦the impacts of future climate changes. (C) 2007 Elsevier B.V. All¦rights reserved.

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Q. J. R. Meteorol. Soc.
139: 350 – 357, January 2013 B

Towards understanding links between rural land management and the catchment flood hydrograph

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http://nora.nerc.ac.uk/502685/1/N502685PP.pdf
Acreman, M.; Holden, J. 2013. How wetlands affect floods. Wetlands, 33 (5). 773-786.
10.1007/s13157-013-0473-2

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Our specific conclusions are that five characteristics of wetlands largely determine their influence on floods.
1. Landscape location and configuration. In a broad sense, upland wetlands tend to be flood generating areas. Rainfall normally increases with altitude and upland wetlands are frequently saturated and have little water storage potential. Downstream wetlands, particularly floodplains, have a greater potential to reduce floods. Some wetlands are in endorheic hollows in the landscape. Whilst they may capture and hold local rainfall and runoff, they are not in direct connection with rivers and so have little influence on river floods.
2. Topography. The morphology of the wetland controls its ability to hold water on the surface and reduce floods. Depressions and ridges support water retention.

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3. Soil characteristics. Grain size, organic matter content, and hydraulic conductivity control the ability of soils to absorb water and the speed of movement of water through the soil. Coarse-grained soils allow water to move more quickly. The existence of macroporous preferential pathways allows water to move more rapidly through the soil.
4. Soil moisture status. Antecedent conditions control the soil moisture status (including the ponding of surface water) at the start of a flood-producing event and thus further control the absorption capacity of the soil during the flood. High rainfall in upland areas means that headwater wetlands are frequently saturated. Downstream river-fed wetlands are often relatively dry before a flood and so provide water storage during the flood. These are time-varying conditions that depend on past meteorological circumstances. Flood attenuation also depends on the morphology of the wetland and the ability of the wetland to lose water though both soil drainage and evapotranspiration.
5. Management. Drainage of upland wetlands can increase flood runoff from wetlands. Removal of vegetation reduces friction and increases overland runoff speed in upland wetlands and reduces floodplain attenuation of flood waves. Maintaining low water levels during potential flood periods may enhance soil water storage capacity and reduce floods (though this may conflict with other wetland priorities such as maintenance of biodiversity).

A distributed TOPMODEL for modelling impacts of land-cover change on river flow in upland peatland catchments

Gao, J, Holden, J and Kirkby, M *A distributed TOPMODEL for modelling impacts of land-cover change on river flow in upland peatland catchments.* Hydrological Processes. ISSN 0885-6087 (In Press)

http://freshwaterhabitats.org.uk/wp-content/uploads/2016/01/FloodingMythsAndReality09-01-2016v1.1.pdf

Floods and land management: myths and reality
Freshwater Habitats Trust, January 2016, Jeremy Biggs, Director

Do we have really effective flood models? Computer modelling can be a very effective way of modelling catchments to assess the effects of land-management changes for flows, sediment control and pollution reduction. Most of us would think that, in this day and age, our existing flood models would be more than sufficient for this. In fact the hydraulic models used by engineers to design flood schemes have not previously needed to consider land management so don't include it effectively. This is an important practical problem and something we are addressing in our Water Friendly Farming work with Environment Agency funding and the expertise of Prof Colin Brown's modelling team at the University of York: beginning to directly link the land management models and the flood defence models used by the Agency flood engineers so that we can much better explore the options for using the land to store water.

Application of a 2D Hydrodynamic Model for Assessing Flood Risk from Extreme Storm Events Sohan Ghimire The James Hutton Institute, Aberdeen AB15 8QH, Scotland, UK; E-Mail: sohan.ghimire@hutton.ac.uk;

A statistical tool called "WINFAP-FEH" (Version 3) has been used to undertake flood frequency analysis based upon the Flood Estimation Handbook (FEH) method which is recognized as the best practice method for estimating peak flood discharge especially from ungauged catchment. The method essentially involves estimation of the index flood which is the median annual maximum flood (QMED), defining a polling group for the catchment of interest involving hydrologically "similar" catchments, development of a flood growth curve using the pooling group data and derivation of flood frequency curve as the product of QMED and the flood growth curve for a give return period.

The QMED represents a typical magnitude of flood which has a return period of two years and is estimated using the following equation based on the use of a set of catchment descriptors essentially for rural catchments [13]: QMED = 8.3062 AREA 0.8510 0.1536 (1000/SAAR) FARL 3.4451 0.046 BFIHOST 2 (1) where AREA is the catchment area (km2), SAAR is the standard average annual rainfall(mm) based on measurements from 1961–1990, FARL is an index of flood attenuation due to reservoirs and lakes and BFIHOST is the base flow index derived from HOST soil data. All of these parameters are readily available and are obtained from the Flood Estimation Handbook (FEH) CD ROM.

As estimating QMED using two years' flow data generally provides a better estimate than the catchment descriptors method [14], QMED has also been estimated using the flow gauge data and compared with the QMED estimated using Equation (1). Qt = QMED × ZT (2) where, is peak flow in m3/s, QMED is median annual maximum flood, m3/s and is flood growth curve. A flood growth curve is constructed by fitting a probability distribution to the observed annual maxima (AM) data series. The Generalised Logistic (GL) distribution has been recommended for fitting values of extremes for the UK flood data series [15] and therefore has been used in this study.

The approach adopted in this study includes modelling of the channel as a 1D network nested within the 2D domain representing the floodplain.

Studies in America (Hewlett and Helvey 1970), and South Africa (Hewlett and Bosch 1984) were amongst some of the first to question the importance of the link between forest conversion and flooding. Studies in the Himalayas indicate that the increase in infi ltration capacity of forested lands over non-forested lands is insuffi cient to infl uence major downstream fl ooding events (Gilmour et al. 1987; Hamilton 1987). Instead, the main factors infl uencing major fl ooding given a large rainfall event, are: (i) the geomorphology of the area; and (ii) preceding rainfall (Bruijnzeel 1990, 2004; Calder 2000; Hamilton with King 1983; Kattelmann 1987).

Even at the local level, the regulating effect depends mostly on soil depth, structure and degree of previous saturation. Thin soils produce 'fl ashy' fl ows (quick responses). Massive programmes of forestation that have often been proclaimed as 'the answer' to preventing fl oods simply will not do the job, although there may be many other benefi ts from reforestation (Hamilton and Pearce 1987).

Bruijnzeel, L.A. 1990 Hydrology of Moist Tropical Forests and Effects of Conversion: A State of Knowledge Review. Humid Tropics Programme, UNESCO International Hydrological Programme, UNESCO, Paris. Bruijnzeel, L.A. 2004. Hydrological functions of tropical forests: not seeing the soil for the trees? Agriculture Ecosystems and Environment 104(1): 185-228.
Calder, I.R. 2000. Land use impacts on water resources. Background paper 1. In: FAO Electronic Workshop on Land-Water Linkages in Rural Watersheds, 18 September-27 October 2000. http://www. fao.org/ag/agl/watershed/. Calder, I.R. 2004. Forests and water — closing the gap between public and science perceptions. Water Science and Technology 49(7): 39-53.
Hamilton, L.S. with King, P.N. 1983. Tropical Forested Watersheds: Hydrologic and Soils Response to Major Uses or Conversions. Westview Press, Boulder CO, USA.
Kattelmann, R. 1987. Uncertainty in assessing Himalayan water resources. Mountain Research and Development 7(3): 279-86.

Hamilton, L.S. 1987 What are the impacts of deforestation in the Himalayas on the Ganges-Brahmaputra lowlands and delta? Relations between assumptions and facts. Mountain Research and Development 7: 256-63.

and a few more papers focusing on participative catchment management; on the development of Tweed Forum; and on land owner compensation mechanisms and attitudes to NFM:

- *Governance structures for effective Integrated Catchment Management - lessons and experiences from the Tweed HELP Basin, UK*. – explains Forum's Origins and modus operandi
- A more general paper, just accepted for publication on *Working across scales in integrated catchment management: lessons learned for adaptive water governance from regional experiences*. Looks across a range of examples, with Section 4 focused on Tweed Forum.
- LAND OWNER COMPENSATION AND APPROACHES FOR FLOOD PROTECTION WORK. Report to Scottish Government on *Mobilising the Contribution of Rural Land Management to Flood Risk Management in Scotland (2012)*
- *Land Management for Increased Flood Protection (2015)* – the full report from which the information on farmers' attitudes to NFM measures comes