Tree planting and reducing flooding: will it work?

Dr Miles Marshall *reports on the Pontbren study in Wales, and the need for much more research into the catchment as a whole.*

Following the storms that hit large areas of the UK during winter 2015, and the floods that resulted from them, there has been much discussion in the media, parliament and wider society of ways in which we can reduce the impacts of flooding. One method that has been suggested and was seriously considered by Government at the beginning of 2016 was "to plant trees in the uplands to help slow the flow of rain water".

Many commentators have cited as evidence for tree planting the results of a study we carried out at Pontbren in mid-Wales between 2005 and 2012. Pontbren is an area approximately ten miles west of Welshpool, taking its name from the stream which drains this small headwater catchment of the river Severn. It is a rolling upland landscape dominated by grassland production, mainly for sheep with some suckler beef and dairy enterprises.

In the study we planted broadleaved trees on previously grazed pasture and measured the subsequent effects on soil hydraulic properties and runoff processes. Plots were fenced off, sheep were excluded and we planted a random mix of *Alnus glutinosa* (alder), *Fraxinus spp.*(ash), *Betula spp.*(birch), *Prunus spinosa* (blackthorn), *Crataegus monogyna* (hawthorn), *Prunus spp.* (cherry and plum), *Corylus spp.* (hazel), and *Sorbus aucuparia* (rowan). What we found was that soil infiltration rates were 67 times faster and surface runoff volumes were reduced by 78 per cent under trees compared with grassland [1].

Findings

Prior to our work, several studies had shown that high stocking densities can cause soil surface compaction leading to increased surface runoff. Our study at Pontbren clearly indicated that excluding sheep and planting trees resulted in reduced near-surface soil compaction, increased infiltration rates and reduced surface runoff volumes. However, what we did not measure was whether there was any change in the ability of the soil to store water and whether the water was able to penetrate deeper into the soil profile as a result of the presence of tree roots. These are important parameters that we need to know if want to try and estimate what size of storm this type of land use intervention may be effective against.

Our study and other work [2] undertaken at Pontbren shows that the age of the trees is important and it has been predicted that further improvement in soil hydraulic properties could be achieved under mature trees. We also know that different tree species have different root architecture which will have an impact on the way that water is able to penetrate into the ground. Further work is needed to understand the full impact of trees as they reach maturity and whether the ability of soil below trees to store water could be further improved through tree species selection.

Across the UK, the landscape is highly variable with many soil types, often with very different characteristics. Many studies have shown a high degree of variability in hydrological function, even for a given soil type, depending on how intensely that soil is managed. What we found at Pontbren was that despite choosing four replicate sites with broadly similar soil characteristics, measured infiltration rates and runoff volumes were highly variable. Therefore, we cannot say with any certainty what impacts planting trees would have on different types of soil. This indicates

a strong need to measure the relevant physical properties across a range of soil types to quantify the relative impact.

The results reported in our paper were from a field study undertaken at relatively small scale (each of the plots being 12 metres by 12 metres in area). The UK's landscape has a very complex structure and one cannot simply upscale the results measured in plot-scale studies like ours to the catchment scale in order to predict the impacts that planting trees might have on flooding. In order to do that, we need to employ hydrological models which take account of land use and land use change in their predictions.

Developing the evidence base

To gain a better understanding of whether tree planting would have a positive impact in reducing flooding we need to develop the evidence base. Our work is one of very few studies which provide any empirical information. Recently published work from Scotland [3] comparing differently aged *Pinus sylvestris* (Scots pine) stands with grazed grassland, indicates the potential benefits of tree cover in flood mitigation. In future, we need to measure what effects planting trees has on the hydraulic properties of soil, such as its water storage capacity, under a range of soil types and conditions, as well as looking at different tree species and ages. Some of this is currently under way as part of the Welsh National Research Network for Low Carbon Energy and Environment's Multi-land project [4]. Once collected, we can use this information to improve flood model predictions to get a better understanding of where interventions such as tree planting may be effective, what area they may be effective over and what size of storm they might be effective against.

Above, left to right: Tree Shelterbelt with rainfall collectors; Tree Shelterbelt; Tree Shelterbelt with standards. Photos: Tim Pagella.

A cautionary tale

Caution must be given to the expectation that tree planting is the panacea to all flooding. When soils are already saturated, as was often the case during winter 2015, the positive contribution that trees may have in terms of providing additional water storage space in the soil below will be greatly diminished. However, that is not to deny that the added surface roughness provided by the trees and the associated understorey could also aid in slowing down the waters, particularly on the floodplain [5]. We just need more research to work out the magnitude of these effects.

Finally, and as other articles in this issue show, we need to think of the catchment as a whole when thinking of ways to reduce flooding. Planting trees is only one option amongst a suite of natural flood management measures (for example, woody debris dams, peatland and wetland restoration, field bunds and storage ponds) that we should consider along with conventional engineering solutions.

References

1. Marshall, M.R., Ballard, C.E., Frogbrook, Z.L., Solloway, I., McIntyre, N., Reynolds, B., and Wheater, H.S. (2014). The impact of rural land management changes on soil hydraulic properties and runoff processes: results from experimental plots. *Hydrological Processes*, 28, 2617-2629.
2. Carroll, Z.L., Bird, S.B., Emmett, B.A., Reynolds, B., and Sinclair, F.L. (2004). Can tree shelterbelts on agricultural land reduce flood risk? *Soil Use and Management*, 20, 357-359.
3. Archer, N.A.L., Otten, W., Schmidt, S., Bengough, A.G., Shah, N., and Bonnell, M. (2015). Rainfall infiltration and soil hydrological characteristics below ancient forest, planted forest and grassland in a temperate northern climate. *Ecohydrology*, 9 (4), 585–600.
4. National Research Network for Low Carbon Energy and Environment. www.nrn-lcee.ac.uk
5. Thomas, H., Nisbet, T.R. (2004). *An assessment of the hydraulic impact of floodplain woodland.* Forest Research, Alice Holt Lodge, Farnham, Surrey.

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