Not in one fell swoop

Drainage in 1972 before trees were planted in the following year on the overturned ridges.

Complex water flows through forested land makes harvesting and planting small areas the best approach, Mark Robinson and Malcolm Newson report.

Top: Forest in 1991 (18 years old). In many parts of the catchment, water levels in the soil were still largely controlled by the drains rather than the trees.

Above: Forest in 1997 (24 years old). The trees over much of the catchment had grown enough to have a major hydrological effect.

Think of upland forests, and you think of an endless vista of uniform conifers: a monotonous, unvarying, man-made landscape. The temptation is to then assume that the physical processes in these forests are equally uniform and predictable, including the way water moves. But is this the true picture? Recent research from the Coalburn catchment in the Scottish Borders has revealed a more complex, diverse and interesting hydrological picture in which nothing is as predictable as it seems.

Coalburn forms part of Kielder, Northern Europe's largest man-made forest. Tree planting began here in the 1920s. As the early forests matured in the 1960s issues began to emerge—effects on water use, flood risk, dry weather flows and latterly water quality and ecology. An intensive hydrological monitoring programme, started in 1967, continues today, making Coalburn Britain's longest running research catchment. When monitoring began, the region was still used for sheep grazing. But the land has since been drained, and a continuous succession of trees planted and allowed to mature for felling. The question is 'what effect has forest management had on this area's hydrology and what lessons can we learn from the monitoring?'

For a start, it opened our eyes to the way that, at different stages of development, the forest affects the hydrology differently. It is too simplistic to map an area as 'forest' and assign it a particular effect or role.

When Coalburn was first drained, the ditches, rather than the small transplanted saplings, had the dominant role. These drain channels at five-metre spacing caused a more rapid run-off after rain (storm-flow response and peak flows were greater). Digging and turning the soil also disrupted the original vegetation and reduced the total evaporation. These changes lasted not just for months. It took up to ten years before they finally disappeared.

There were, however, more permanent changes. Forests evaporate more water than grass and as Coalburn's forest canopy closed over, the total annual streamflow declined by 10-15%. Surprisingly, however, more water flows in the steams during dry weather than before forestry began. The reason for this apparent anomaly is the depth (nearly 1m) of the forest drains, which collect waters seeping through the soil, before discharging it to the streams.

Measurements show that more rainwater evaporates from the forest canopy than the water trees take up from the soil (and transpire through their leaves). Studies of water chemistry show that the streams are acidic during storms, but this varies, with some areas of base-rich geology mitigating the effect.

In addition, research by Newcastle University has revealed that two major soil substrates, peat and boulder clay, give the catchment two sides to its character. Because water permeates both only very slowly (at least at depth), most runs off along near-surface routes (adding to the impact of drainage), and the boulder clay does not buffer the acidity. Therefore fractures in the substrate, such as desiccation cracks in the peat and root cracks in the boulder clay, greatly influence flows and water chemistry. By attaching simple water collectors to each significant soil layer in both main soils, undergraduates confirmed that rainwater running down tree stems collected around the base of their trunks and moved rapidly to nearby furrows and ditches.

The fact that forest effects vary so much over time (as well as with local geology) has important implications for forest design. Recent policy changes mean that smaller forest blocks are planted (or felled) at a time. As a result, undesirable effects such as increased peak flows and sediment movement are restricted to local areas; further downstream the effects are attenuated and diluted by water from other areas of managed forest at a different stage of development. Size really does matter; small is truly beautiful.

Coalburn is a long-term study with participation from the Forestry Commission, Environment Agency and United Utilities plc as well as the Centre for Ecology & Hydrology and Newcastle University.

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