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Development of soil hydraulic soil properties below ancient forest, planted forest and grassland

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A number of serious flood events in recent years have focused attention on flood prevention and mitigation and modelling work suggests that climate change will lead to an increase in the intensity and frequency of flood events in many areas. To understand how soil hydraulic characteristics develops in relation to facilitating the infiltration and storage of storm rainfall, a hypothetical pedogensis sequence was first developed and then tested by investigating a grassland site and four Scots pine (Pinus sylvestris) forests of different ages in the Scottish Highlands. These sites are: grassland, six and 45 year-old Scots pine plantations, remnant 300 year old individual Scots pines and a 4000 year old Caledonian Forest. The soil characteristics measured were: field saturated hydraulic conductivity (Kfs) using a constant head well permeameter, root numbers and proportion were estimated from soil pits and soil cores were taken for three different soil depths (0.06 – 0.10, 0.16 – 0.20 and 0.26 to 0.40m) for laboratory measurements to estimate organic matter, soil water release curves, macro-pores, and X – ray tomography measured pore connectivity and soil pore structure.

It was observed that cutting down of the plantation increased organic matter because of the increase of dead biomass and decreased pore connectivity, which resulted in reduced hydraulic conductivity during the early years of re-afforestation. Where older trees were left, after cutting and removing younger trees; the range of OM, hydraulic conductivity, pore connectivity, and macropores remained similar to and older Scots pine plantation (45 years old). The undisturbed Ancient Caledonian remnant forest (approximately 4000 years old) was observed to have remarkably heterogeneous soil characteristics, providing extreme values of Kfs (12 to 4992 mm hr-1), OM, and macropores. Such ranges of soil characteristics were considered to be the optimum to reduce local flooding, because the soil matrix could transport high intensity storm rainfall and re-direct storm rainfall to deeper layers and the presence of micropores and larger quantity of OM provides a greater area to store. This combination of soil characteristics would slow down the flow of rainfall to ground water reservoirs and rivers and reduce flood peaks.