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Revealing plot scale heterogeneity in soil moisture dynamics under contrasting vegetation assemblages using 3D electrical resistivity tomography (ERT) surveys

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Soil moisture is a fundamental component of the water cycle that influences many hydrological processes, such as flooding, solute transport, biogeochemical processes, and land–atmosphere interactions. The relationship between vegetation and soil moisture is complex and reciprocal. Soil moisture may affect vegetation distribution due to its function as the primary source of water, in turn the structure of vegetation canopies regulate water partitioning into interception, throughfall and steam flow. Such spatial differences in inputs, together with complex patterns of water uptake from distributed root networks can create marked heterogeneity in soil moisture dynamics at small scales. Traditional methods of monitoring soil moisture have revolved around limited point measurements, but improved geophysical techniques have facilitated a trend towards more spatially distributed measurements to help understand this heterogeneity.

Here, we present a study using 3D ERT surveys in a 3.2km upland catchment in the Scottish Highlands where increasing afforestation (for climate change adaptation, biofuels and conservation) has the potential to increase interception losses and reduce soil moisture storage. The study combined 3D surveys, traditional point measurements and laboratory analysis of soil cores to assess the plot scale soil moisture dynamics in podzolic soils under forest stands of 15m high Scots pine (Pinus sylvestris) and adjacent non-forest plots dominated by heather (Calluna vulgaris) shrubs (<0.5m high). These dominant species are typical of forest and non-forest vegetation communities the Scottish Highlands.

Results showed differences in the soil moisture dynamics under the different vegetation types, with heterogeneous patterns in the forested site mainly correlated with canopy cover and mirroring interception losses. Temporal variability in the forested site was greater, probably due to the interception, and increased evapotranspiration losses relative to the heather site. The smaller moisture changes in the heather site are probably due to lower interception (~30% compared with 45%) and the microclimate of the moss-dominated ground layer which has high humidity and low evapotranspiration, which serves to maintain water content in the soils below. These results are important as the point to potential water stresses with planned increased afforestation which may be compounded by climate change projections of decreasing precipitation during the growing season.