Lancaster University

Lancaster Environment Centre

Quantified effect of individual trees on soil permeability

Direct UK observational evidence

The impact of individual trees on soil permeability (at surface = infiltration capacity; or deeper in topsoil, or in the subsoil) is moderated by several positive and negative factors associated with the growth or management of trees:

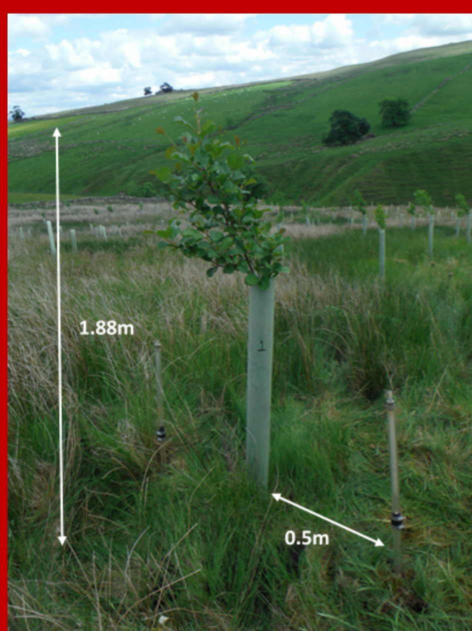
Positive factors

- Development of root macro-porosity due to root growth
- Soil structural improvement due to alkali litter-fall
- Soil structural improvement due to enhancement of soil microbiology and macro-fauna
- Soil structural improvement due land-use management involving exclusion of soil compacting livestock and/or hydrophobic root-mat
- Soil structural improvement due land-use management of stock exclusion that encourages shrub etc growth

Negative factors

- Soil compaction by tree weight (exacerbated by wind movement)
- Soil structural deterioration due to acid root exudates
- Soil structural deterioration due to acid litter-fall
- Soil surface hydrophobicity due to acid litter-fall

The relative importance of each of these factors is dependent on tree species, soil type, local climate and land management activities



The direct observational evidence showing the difference between soil permeability beneath or next to individual trees versus natural or improved grassland is very sparse in a UK context, and indeed globally. Absolute quantification of differences in permeability between soils with and without trees is vital for robust computer simulation of the effects of land-cover on overland flow generation during floods.

Fig 1. Well permeameter in use on Tebay Common, Northwest England at tree 1 in plot C (c/o Tom Mawdsley).

Lancaster University researchers are contributing to the evidence-base of the quantifiable impact of individual trees on soil permeability via several studies using a constant-head borehole permeameter method known as ‘well permeametry’ (Talsma and Halam, 1980), in full awareness of the uncertainties that can arise with any permeability measurement (eg Chappell and Lancaster, 2007), for example:

Case study 1: Mature Sitka spruce (*Picea sitche*nsis) trees

A study in upland Wales involving 34 well permeametry tests showed that the permeability at 0.25-0.45 m depth was a factor of 5.4 less at 0.2 m from individual Sitka spruce trees compared to measurements at a distance of 2 m in the same Ferric Podzol (Pf) soils. The difference was statistically significant (p=0.01) with the cube-root transformed data (Chappell et al., 1996). The study was undertaken in association with the NERC Centre for Ecology and Hydrology

Case study 2: Mature English oak (*Quercus robur*) trees

A study in Northwest England involving 119 well permeametry tests showed that the permeability at 0.10-0.30 m depth in a Dystric Gleysol (Gd) decreased with distance away from individual oak trees within a parkland (Fig 2). The median topsoil permeability was significantly different (p<0.05) at 3, 5, 7 and 11 m from mature oaks to that in soils beyond the canopy (Chappell and Chandler, 2008). The study was undertaken as part of an MSc Sustainable Water Management project at Lancaster.

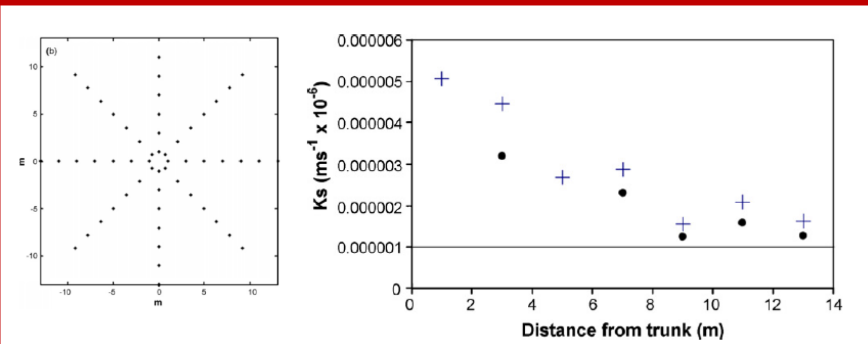


Fig 2. Sampling design around Tree No. 1 (left) and geometric mean topsoil permeability versus distance (m) from tree trunk for Tree No. 1 (+) and pooled for all six trees • (right)

Case study 3: Two-year old common hawthorn (*Crataegus monogyna*) and Alder (*Alnus glutinosa*) trees

A preliminary study on Tebay Fells, also in Northwest England, involved 20 well permeametry tests at 0.10-0.30 m depth (probably a Dystric Gleysol, Gd) at distances of 0.05 and 0.50 m from individual hawthorn and alder saplings (Fig 1). The topsoil close to individual saplings was a factor of 1.75 larger than that away from the same saplings. The geometric mean permeabilities were, however, not statistically different (p<0.10) as a result of the relatively small number of samples and large variance in value close to the saplings. This study was undertaken in association with the Woodland Trust and Lowther Estates, and further data collection is required to confirm the effects of such young saplings on soil permeability

References (including link to obtain)

Chappell, N.A., Stobbs, A., Ternan, J.L., and Williams, A. 1996. Localised impact of Sitka spruce (*Picea sitchensis* (Bong.) Carr.) on soil permeability, *Plant and Soil* 182, 157-169, http://www.es.lancs.ac.uk/people/nickc/sitka.pdf

Chappell, N.A., and Lancaster, J.W. 2007. Comparison of methodological uncertainty within permeability measurements. *Hydrological Processes* 21, 2504-2514 ,http://www.es.lancs.ac.uk/people/nickc/Chappell&Lancaster2007.pdf

Chandler, K.R., and Chappell, N.A. 2008. Influence of individual oak (*Quercus robur*) trees on saturated hydraulic conductivity. *Forest Ecology and Management* 256, 1222-1229, http://www.es.lancs.ac.uk/people/nickc/Chandler&Chappell2008.pdf

Talsma, T., Hallam, P.M., 1980. Hydraulic conductivity measurement of forest soils. *Australian Journal of Soil Research* 30, 139–148

Lancaster University | Lancaster Environment Centre