The Subsidence Forum Innovation Group

Tree Biology

April 2009

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Summary

Trees dominate subsidence statistics as a cause of damage on clay soils

Trees have developed biological strategies for removing bound water from clay soils over millions of years

When precipitation is interrupted plants seek water resources in the clay soils

Tree Biology Special Report

Tree related subsidence dominates claims statistics as the principal cost and vast majority of claims of this type. Tree related subsidence of low rise buildings requires convergence of a range of issues resulting in notification of a claim to insurers:

1. The presence of shrinkable clay soil
2. Presence of vegetation
3. Shortages of available soil water during spring, summer and autumn months
4. A building predisposed to differential failure

In this Subsidence Forum Innovation Group Special Report we look at vegetation as a living drying force of clay soils and the implications that this has for mitigation and management options for claims handlers and managers.

Trees, Clay and Climate

Clay soils are agriculturally some of the most important soils in the world. They are water retentive and they are rich in mineral nutrients necessary for plant growth.

Trees have for millions of years evolved strategies for extracting both water and minerals in solution from clay soils. Deep clay soils offer a reservoir of water resource for plants with water bound to clay particles and free water available which is buffered from rapid percolation to depths at which it would be "out of reach" of plant roots.

Clay soils are therefore able to support a very wide range of tree species which have capabilities to root into the "engineering soil" horizons.

However the very advantages that make clay soils attractive to many trees can also make them difficult environments in which water can be effectively removed. They are very fine grained and soil pore spaces were oxygen for plant respiration can occur take time to appear as soil drying opens up fissures at depth.

The biological dilemma for much of the English lowlands is therefore that trees would prefer the easy resource option of capturing water from rainfall in the first few hundred millimetres of clay soils, however our variable climate can mean that precipitation can fall far below seasonal requirements at different times. When precipitation stops and the resource availability from rainfall fails trees begin to "chase" the gradient of soil moisture from areas of low resource availability (the upper horizons and those beneath the trees canopy) to areas of high resource availability (the area beyond the canopy and with plant competition eventually down into the engineered soil).

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Maintaining a beneficial soil water equilibrium through pruning

Topping and lopping

Heavily topping trees is a poor management response to subsidence cases:

It is unreliable as a method of controlling tree water use except for very short periods of months.

It requires continual subsequent investment by landowners at repeat pruning.

It damages amenity and damages landscapes.

It leads to development of hazards and of potential failure points of regrowing material on topped stems.

It allows decay fungi to invade tree stems and roots making trees unstable.

Trees utilise sunlight captured in leaves and combine this with water captured from the soil with Carbon dioxide to make their own food.

The roots are important because they anchor an organism often weighing many tonnes into the soil and this allows fine non woody roots to make intimate contact with the soil to absorb soil water and deliver this water via the trunk to the leaves.

There is therefore a matrix of large structural woody roots, of secondary branching woody roots and a mass of fine non woody roots often growing in conjunction with beneficial and parasitic fungi in a complex soil environment.

It should be obvious that the rather crude intention to “browse” above ground branches, twigs and leaves through topping and lopping will have impacts on the trees biology and result in responses from the tree to the topping event.

The tree when topped heavily is faced with a biological choice; die, or generate new branches, leaves and twigs as quickly as possible to maintain support via food production in leaves for the large root system.

The benefit of pruning heavily trees that are causing clay shrinkage is immediate—all the water wasting leaves are gone and the supporting scaffold branches that display the leaves is destroyed.

However the pruning as a method of controlling soil water equilibrium is notoriously unreliable and in the next section of this report we illustrate some of the issues that need to be considered.

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Queens Park Revisited

The Queens Park Estate consists of late Victorian two storey terraced houses. The surrounding footpaths are narrow and at the time of or shortly after construction, London Plane trees (*Platanus acerifolia*) were planted at 20m spacings and maintained through their early life as true pollards.

During the 1960s/1970s the pollard strategy was stopped and the trees responded by extending branches and roots. The properties were council owned until the late 1980s and the occurrence of cracking to frontages was not reported. The explosion in property ownership, the housing price boom and changes in the circumstances of the residents of Queens Park led to reported subsidence events coinciding with the severe drought period of 1988 - 1992.

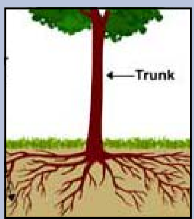
The BRE were commissioned to begin a programme of verticality level monitoring of a large number of properties at the same time as the Council reverted to a topping / pollard strategy to previous pollard heads for all trees and on a two year topping trim cycle.

The results of the monitoring illustrate a sample from the research programme with monitoring points at distances from the trees of between 2 and 10 metres. The verticality measurements are extremely sensitive to movements of only 10ths of 1mm and in this sense, rather than any measurement of crack widths complicated by building dynamics, accurately assess the changes in the plastic profile of the soil surrounding the target structures.

It is clear that following topping in late 1992 the total verticality movements ceased almost completely during 1993. This could almost be considered a successful result indicating that reduction in leaf area can limit water loss. However during subsequent years the trees seem to increase water loss at rapid rates culminating in 1996 with extremely high levels of vertical movement, which would result in structural movements completely unacceptable by modern standards. There then seems to be a period of relatively settled water use culminating in the later results during late summer 1999. Can the above be explained by the proposed model that there is no linear relationship between topping trees and plant water use?

Summary

London Planes planted as street trees were initially controlled as pollards but were then for many years allowed to grow unchecked.



Topping the trees removed leaf surface area but a biologically active root system remained in place.

The root system having access to ample water resources was able to drive rapid regrowth from the topped trees.

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Summary

The trees grew a new canopy very rapidly to allow it to re-pay the debt from the roots by producing sugars to feed the tree

Heavy topping of trees that does not take account of large active root systems is a recipe for recurrence.

Queens Park Revisited

The initial topping event came for the trees after a long period of uninterrupted growth and likely expansion of the rooting environment. The model anticipates that throughout this period trees would have "gradient chased" water resources beneath the Victorian properties. Total root biomass is expected to have been high at the time of topping of the Plane trees.

The immediate reaction of the tree to this change in leaf surface area obviously produced a first season "shock" at the change in status of the root / shoot ratio and water use was effectively curtailed. Following on from this first year one might anticipate a major reallocation of resources to shoot production as the tree sought to manage dynamic equilibrium. Thereafter the trees overcompensate for the damage done to the leaf area and this culminates with the water loss and verticality maximum figures, not in the drought year 1995, but rather to the plants own timetable in 1996.

The principle of cybernetic systems and particularly biological systems overcompensating for such changes to their "natural state equilibrium" has been well known by the scientific community for almost 100 years. Following on from the managed process towards a new equilibrium the trees eventually find an annualised maximum water requirement, which whilst it might grow over time is adequate for the plant's current needs.

It is crucial to note that the impact on the tree's ability to lose water at significant levels lasted for a very short time and that the plants response was dynamic and consistent with an attempt to create an equilibrium of water use as postulated in the Model discussed earlier. The model is shown to be robust in anticipating the responses of plants to attempted linear management by Arboriculturists.

Much of this analysis was subsequently confirmed in the extensive field research on behalf of Government subsequently published via the HortLink Report 212 Final Report Published in May 2004.

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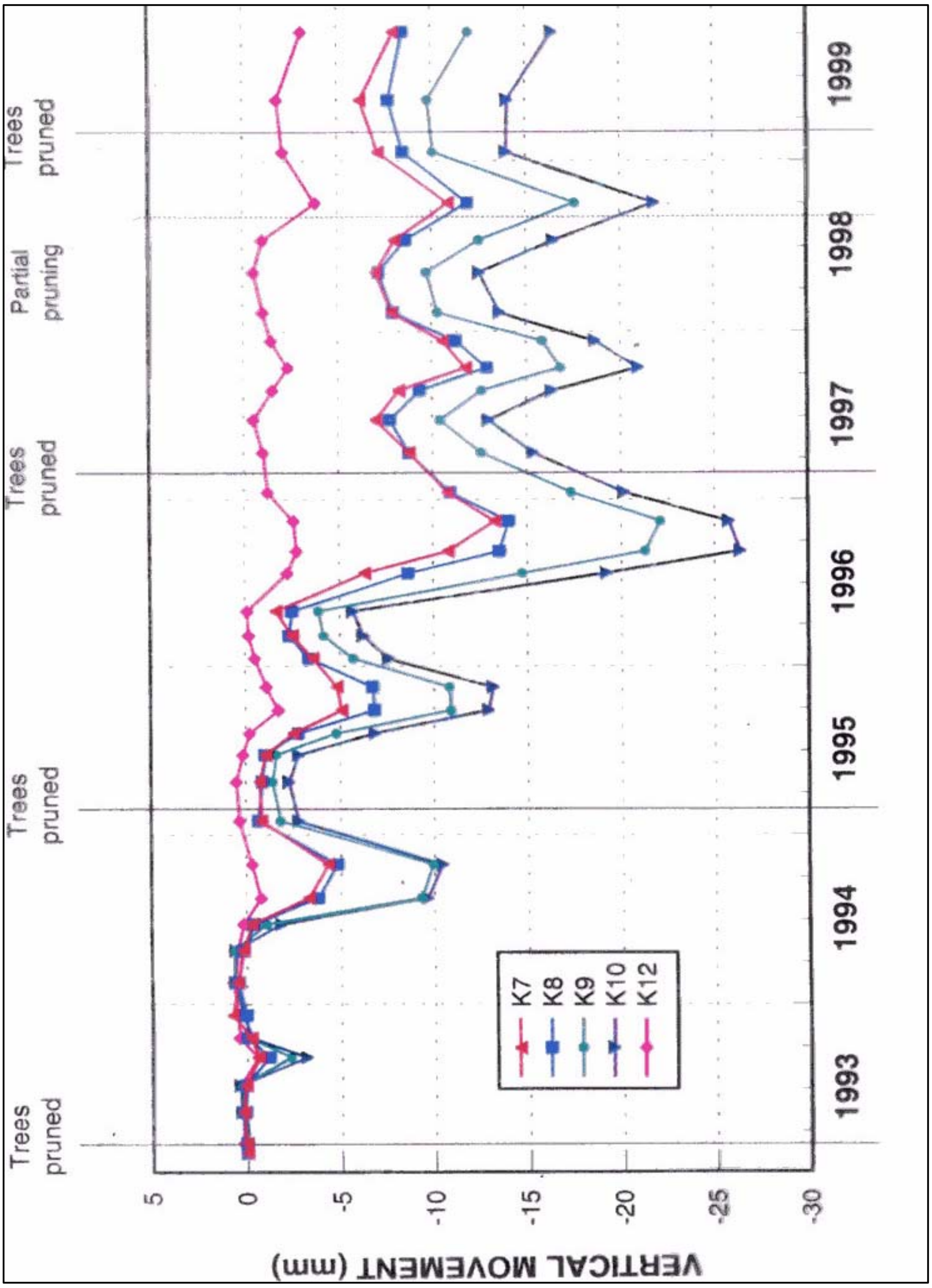

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