

# Sophistication in simplicity – Gary Watson Seminar, Barcham Trees

Storm clouds sweeping across the Fens were the backdrop for a real old-fashioned ‘bash’ at Barcham Trees on 9th June 2010. I don’t use the word ‘bash’ disparagingly, because in size, generosity and hospitality, it was an event rarely enjoyed nowadays in any walk of business life. The conference was in honour of the celebrated American arboriculturalist Dr Gary Watson, Senior Research Scientist and Head of Research at Morton Arboretum in Illinois, on his first visit to the UK for 12 years.

Dr Watson’s primary interest has always been the fullest understanding of how to maintain a healthy balance between the above-ground (crown) and below-ground (root system) parts of trees planted on challenging landscaped sites and soils in urban areas.

A huge 400-strong audience was treated to decades of research experience, simply and effectively reduced to several hours of highly palatable and instructive material. This is a feat only achieved by someone with extra long experience at the leading edge of research.

## ‘Unlimiting’ tree growth – a balancing act

‘Unlimiting’ tree growth was the cleverly contrived title by Dr Watson for the foundation of his delivery, beginning as he ended with firm focus on the essential balance required for strong root growth and a sound status for the entire tree. Seven fundamental factors affect tree growth, said Dr Watson, these being light, carbon dioxide, soil, temperature (atmospheric and root zone), soil nutrients, water (soil and atmosphere) and pH (hydrogen ion concentration). Different tree species will have a specific range of conditions within which they do best, but at the end of the day growth and yield potential is limited by the factor in least supply, he said.

At the root of the equation governing tree establishment, growth and longevity is basic soil structure, said Gary Watson. That is the nature and size of soil particles and therefore the spaces (pores) between them with organic matter as the essential glue holding ‘everything’ together. Tree roots, he said, ‘do not have brains’ but simply respond gradually to conditions as presented. It is all a question of balance. One factor will invariably be limiting but the essential thing is by how much. The secret of success, especially for trees planted in challenging urban soils, is to provide everything required in measured relative amounts so that no single factor is lagging behind.

## Soil type, structure and profile

Dr Watson used a basic comparative



example from his own research to illustrate the point about soil structure, comparing tree root growth in fertile sandy loam with that in a heavy clay soil; the former with a good strong structure and network of sufficiently large pores facilitates good drainage and high levels of oxygen in the pores. Roots were strong and of large mass with many fine roots, compared to the weak root system ‘drowning and suffocating’ in the poorly structured and compaction-prone clay soil of small particles and correspondingly small pores, high on water-logging and low on oxygen. The key positive ingredient was the high level of organic matter (the ‘glue’), said Gary Watson, which meant sandy loam, whether wet or dry, was the same well structured soil. If you don’t have the glue to hold it together then soils, whether sand, silt or clay, end up like ‘pea soup’ when wetted. They hold less water and are less well aerated at the same time, he said.

He proceeded to expose the disparities and deficiencies of urban soils, using photographs of ‘landscaped’ (land-filled) areas showing a patchwork of different soil types from the varied loads of material ‘dumped’ at a single site.

The next experiment described focussed on soil type (urban and agricultural) and soil profile/soil depth interaction. Using elm as the test tree species each soil was divided into three horizons – A top, E

middle and B bottom. Elm tree seedlings were planted in pots containing soil from each individual horizon for both soil types to give six treatments. Irrespective of soil type, tree growth deteriorated from horizon A through to B. Growth in soil from a specific horizon in the agricultural soil was always superior to its equivalent in the urban soil, to the extent that growth in the bottom horizon of the agricultural soil was no worse than for the top horizon of the urban soil. This was all down to soil structure, pore size and availability of water and oxygen, with roots unable to access pores in poorly structured urban soils if they are full of water.

## Soil depth, growth and root ‘turnover’

So when does oxygen concentration in soils actually become limiting to root growth? Dr Watson said reductions of 5% will not significantly reduce root growth but 10 to 20% reductions cause meaningful growth reductions, while 50 to 70% reductions in normal soil oxygen will have a catastrophic effect. But there is also the complicating issue of species, he said, because while pines may react fast and furiously to a fall off in oxygen supply, willow and alder will probably not care. Whether a tree species is regarded as ‘deep’ or ‘shallow’ rooted is all relative, because roots for the most part stay in the surface layers of soil.

Dr Watson said there is also the question and perception of soil compaction. Compaction is invariably related to the intensity of ‘traffic’ on the soil surface, and its interaction with the structure of the soil below – heavy traffic on weak-structured soils resulting in most severe compaction problems. But, the mass of the soil itself and the forces thus created are responsible for considerable compaction, magnifying with increasing depth. This means an increasingly weak soil structure having smaller pore sizes, more water-logging, less aeration and less space for small roots to push through. This is why the deeper a root grows into the soil the slower it grows. In other words root vigour decreases with depth.

He described a stunningly simple physical experiment to prove this is so, by performing an aeration assessment down the profile of urban soils using inserted

steel rods. At a depth where structure was poor, water-logging persisted and conditions were totally anaerobic, the rod came out virtually as shiny as it went in. At the top of the soil profile the rod surface was 100% rusted while at 60 cm depth the level of rusting was just 5%, due to the virtual absence of oxygen for root growth.

He related these physical findings to root growth using maple (*Acer platanoides*), which showed there were significantly fewer fine roots at these depths. The fine root component of the system, says Gary Watson, is highly dynamic and in the dormant season (winter for cool temperate regions) a significant proportion of a tree's fine roots will disappear. At this time of the year there is no need for all these fine roots, said Dr Watson, and in shedding fine roots trees are conserving resources and energy. Root proliferation resumes in spring. Dr Watson calls this phenomenon 'root turnover' and emphasises how it is crucial to maintaining soil fertility, because fine roots contribute 75% of all organic matter returned to the soil. His research showed fine roots to live for just 8 to 10 months in North American hardwood forests.

## Root-space, compaction and mulching

Next on the agenda, and particularly pertinent to planted urban trees, was 'root space quality'. When you plant a tree in the pavement within a 1 metre square soil space it is never going to reach its full potential, even if you do everything for it, says Gary Watson. Space restrictions correspondingly restrict root growth and therefore growth, development and longevity of the entire tree. The best option is to always go for open aspect planting with good soils. One way round this for urban trees, practised in Chicago, is to dilute one part of good soil with four parts of rock in an unrestricted space, to get the same growth effect as putting the 20% of soil in a small confined space in the pavement.

Compaction means less aeration, permeability and difficult conditions for root penetration and development of fine roots; these problems being exacerbated the deeper you go into the soil profile.

Dr Watson likens severe cases of soil compaction and the distinct mini-layers (soil plates) thus formed down the profile, to a pile of dinner plates which can be pulled apart plate by plate. Air can't diffuse down through the soil, and water simply runs off.

Applying mulch to overcome the problem is simply doing what nature does, says Dr Watson, but urged his audience not to overdo it by piling mulch around the tree which North Americans describe as 'volcano mulches'. Managers should go for mulch that has already progressed into decomposing organic matter. We all know it works, but Gary Watson showed indisputable evidence from his own research using woodchip mulch compared with a turf grass control around the base of the trees. Fine root development under mulch at 0-2 inches, 2-4 inches and 4-6 inches soil depth was 15x, 9x and 2x greater, respectively.

Natural leaf litter (mulching) in the forest creates a largely fungal population, whereas under turf the microbial population is more bacterial and this is neither natural nor beneficial, said Gary Watson. Using beech and oak trees he demonstrated a ratio of 5.88 (fungi to bacteria) under woodchip mulch, falling to 1.75 under turf.

## Spoon-fed fungi

He describes *mycorrhizae* (mycorrhizal fungi), which are highly rated for tree growth and development, as purely and simply an extension of the tree's root system. By taking 20% of the tree's carbohydrate, these root-associated symbionts are essentially 'spoon-fed', he says, although in return the plant receives highly valuable nutrients and especially phosphorous. No one can dispute the value of this especially to urban trees in poor soils. If the tree had to grow that many more roots to compensate for their being no *mycorrhizae* in association, then it would take 6-8 times more carbohydrate than is given to the mycorrhizal fungus. Thus *mycorrhizae* extend the tree's root system while simultaneously restricting its inherent growth, the tree not needing to grow more roots if fungi are growing on them in a mutually beneficial (symbiotic) relationship.

His research with white oaks clearly showed how favourable environmental conditions, as well as the fungal spores, must be present and prevail for mycorrhizal relationships to establish. There are as many, if not more, spores in soil around trees growing in turf



'Ash to ashes' – *Fraxinus* trees all but finished after just 10 years in restricted root space and poor soil in a clearly 'uncomfortable' urban planting site.



*Prunus* (flowering cherry) mulched to make up for deficiencies on an urban planting site.

but a dearth of mycorrhizal association, showing conditions are not right or ripe for development. He uses the 'Mycorrhizal Triangle' to illustrate how successful mycorrhizal association depends on two-way relationships between the three points of the triangle, which are susceptible tree roots (sugars in the root tissue and 'helper microbes'), viable mycorrhizal fungal inoculums and a favourable soil environment.

## Concluding thoughts

The real quality of Gary Watson's research work, his thoughts and deliberations is best described as 'sophistication in simplicity'. All the way through you are thinking, "I never thought of it that way", or "Why for the last 40 years did I never think of that?" Some might say he is stating the 'blindingly obvious', but if so that is the real underlying strength of his work. So much modern research in arboriculture is becoming bogged down in unnecessary complexity, passed off as sophisticated research, while the 'purer' science providing the answers is forgotten or passed by. If anyone in the audience needed reassuring that definitive research is the foundation and future of arboriculture then they got it at Barcham Trees from Dr Gary Watson and, like me, went away enlightened.

Dr Terry Mabbett



Back Row: Ian MacDermott, David Lonsdale, Caroline Davies, Neville Fay, Tony Kirkham, Sue James, Russell Ball, Dealga O'Callaghan, Derek Patch, Keith Sacre, Peter Wells, John Heuch, Jim Smith  
Front Row: Jeremy Barrell, Ian Phillips, Colin Bashford, Gary Watson, Mark Johnston, Glynn Percival, Andy Hirons, Nick Eden, Dave Dowson, Andy Summerly