



Sydney Environmental & Soil Laboratory

Specialists in Soil Chemistry, Agronomy
and Contamination Assessments

Understanding Soil Preservations

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The root systems of trees of any reasonable size have established themselves at a depth in the soil that affords the tree root an optimal supply of-

1. oxygen and gaseous exchange
2. moisture availability
3. nutrient supply
4. ease of extension.
5. anchorage to a firm base.

A consideration of these five factors is essential in planning changes of any sort to the tree root environment. Any development has the potential to change the mix of these factors such that the new environment may not be conducive to the old depth at which the root system was established. The tree must either change its root depth distribution or die. Sometimes death in a tree presented with changes with which it cannot cope is imperceptibly slow and is usually labelled "reduced longevity".

The root system of a tree is dynamic (Watson 1990) and changes its depth of maximal activity according to season, moisture, and oxygen availability. Nevertheless, since oxygen depletion and gaseous exchange problems are the most limiting factor in determining root activity and growth rates, roots are typically distributed at shallow depths. Something like 90% of the root mass of a tree is in the surface 200mm as a consequence of oxygen supply rate and carbon dioxide removal rate. At lower depths the root simply suffocates in its own carbon dioxide. Thus the tree establishes what Watson (1998) calls

The surface 200mm of a soil is, unfortunately, the most sensitive to disturbance during development. Common causes of disturbance are-

- compaction by any kind of traffic including pedestrians.
- scalping of topsoil either deliberately or by erosion
- burial by fill brought in to raise levels
- disposal of chemical wastes such as cement wash down water
- significant reduction in the available soil volume by alienation of soil.

The four factors determining root depth should be examined to understand the impact of these disturbances and how to avoid, correct, or plan for changes in soil properties.

1. oxygen and gaseous exchange

Gases diffuse through pores and voids in the soil. Compaction by traffic reduces the amount of pore space and thus the gaseous exchange rates leading to a reduction in the depth at which roots can effectively function. The tree must try to re-establish new roots at a shallower depth. Ill conceived of excessive depths of actively rotting mulch can kill trees by cutting off oxygen supply to the root system.

2. moisture availability

Water displaces air in soil reducing the amount of pore space and effective diffusion of gases. Thus in water logged soils roots must grow very shallow to obtain enough oxygen. In compacted soil the smaller pore space is more easily filled with water, further reducing pore space and rooting depth. On the beneficial side water is needed for plant growth and a compacted soil not only reduces infiltration (lowering the effective rainfall at the site) but it dries out more quickly.

A truncated rootzone brought about by alienation of part of the rootzone (eg by roads, paths, buildings) obviously leads to a lower exploitable root volume and thus less available water.

3. nutrient supply

Disturbance to the natural cycling of organic matter on the forest floor disrupts the trees access to the nutrients it needs. A truncated rootzone obviously leads to a lower exploitable root volume and thus less available nutrients. The addition of pollutants such as cement washdown water, glues and other building products, and even ill conceived fertiliser or mulch programs can further limit the trees ability to access the nutrients it needs. For example a very woody mulch can cause nitrogen depletion in the soil.

Scalping and erosion can remove the precious topsoil layer containing most of the nutrients and have a severely debilitating effect on a mature tree's health, and the growth rates of newly planted trees.

4. ease of extension.

While the tree is trying to develop a new root system in the post development landscape, the natural depth at which it soil like to establish its roots can be opposed by compacted soil, barriers, concrete, paving etc. Compacted soil is strong and resists root penetration thus roots trying to grow nearer to the surface in a compacted soil can be prevented from doing so by the strength of the compacted soil surface.

5. anchorage

A tree that has established a shallower root system as a result of compaction and drainage problems will have suffered root death at depth and thus be less well anchored. It was obvious to me during the aftermath of the severe wind storms in 1991 in Sydney's North Shore that those trees most prone to being felled were those in drainage lines where poor drainage combined with increased urban run off of water lead to a wet soil with a shallow root system. Symptoms of epicormic growth and poor canopy health is the outward symptom of this decline of the roots.

Maintaining a Balance

There are several golden rules in our book of tree soil care on development sites explained as follows.

1. **Leave as much soil around the tree as possible.** Roots of the tree will be most active around one canopy height away from the tree trunk but will venture up to around two and a half times the trunk height in Eucalypts.
2. **Protect the soil from compaction** including pedestrian traffic. Topsoil in the silty loam, clay loam, fine sandy clay loam, clay loam and clay are most prone to compaction. A second compaction with a foot or wheel on wet soil can take years for nature to restore. Strong and impenetrable fencing is the only way, builders do not understand tree health and have their own job to do.
3. **Protect the soil surface with 50mm of mulch** if there is no leaf litter. Not only does this reduce erosion risk but it makes the tree look like someone cares about it, a powerful psychological tool during the development phase.
4. Particularly where root systems are truncated **analyse the soil** and improve the chemical conditions with fertilisers and ameliorants if necessary. Remember that the reduced root system means that we should make nutrients more readily available so that the plant does not have to work so hard to get the nutrients it needs.
5. **Avoid level changes at all cost.** Removing topsoil to lower a soil level will effectively eliminate the root system on that side of the tree and it must grow a completely new one. Burying topsoil to raise soil levels is nearly always fatal if a substantial part of the root system is buried. Probably burial of 20-30% of the root system can be overcome by many trees but in my opinion Eucalypts do not cope with this well. Soil cannot be changed around the trunk as aril cambium tissue cannot convert to root cambial tissue and will die. There are techniques to increase the prognosis for the tree in a buried situation but it is much better avoided. In many situations you are probably better off removing the tree and planting a new one at the new level.
6. **Avoid changes in surface hydrology.** Channelling water toward an established tree, impeding the free runoff of excess water even with small barriers can be fatal or result in poor condition while the tree adjusts. I have seen a very large Morton Bay fig killed in an impermeable soil type by a well meant but ill conceived barrier of soil placed only 300mm high on the downhill side of the tree. The tree died of wetness (oxygen depletion). Likewise avoid permanent excavation close to a tree that will result in drying or reduction of soil moisture availability.

Coping with the changes imposed by building development, such as level changes, root system reduction is a complex task which requires specialist advice but a few points to observe might be as follows-

- Truncated root systems. This is the most common result of development and nearly always occurs at the area of maximal surface root activity. The tree is now reliant on a greatly reduced root system. It will establish a new root system but may require some help in the form of-
 - adjustment of canopy size (to reduce evaporative leaf area)
 - watering to provide a more continuous water supply
 - mulching and feeding of the surface

Trees can recover from savage damage to their root system without decline if a little thought is given to helping it through the adjustment phase.

- **Scalping and erosion.** Roots grow very poorly in exposed subsoil and new topsoil layer complete with mulch and fertiliser will greatly help new root establishment.
- **Buried Root systems.** This is a very difficult issue for an established tree to cope with. Any more than about 50mm of soil level change is likely to endanger the tree. In my opinion the tree will not cope with changes in level to its entire root system or even most of the root system and should be removed. If less than 50% of its root system is to be buried then it may be worth trying the installation of oxygenation pipes on the ground with continuous coarse gravel layers between, before placing the fill. This will probably not save the root system but will slow its death and give the tree a chance to get a new one established.
- **Wetness.** Continuous wetness in a soil can only be rectified by interception drains to remove the source of water, or by systematic drainage to remove excess water around the tree.
- **Compaction.** This is the slow killer of all urban trees, canopy decline, insect attack, and limb death are all symptoms. It can be prevented and slowly improved by reducing traffic levels with such techniques as shrub planting, mulching, or fencing. In extreme cases of decline work on the soil is vital and can be highly successful. This basically involves removing the surface soil to 200mm using careful techniques to avoid root removal (eg hydraulic excavation) and replacing the soil with a “compaction proof” gap graded material (sand) perhaps with some organic matter, a small amount of soil (less than 10%) and some manures or fertiliser. We have seen this cause radical improvement in trees pronounced hopeless.

These are the observations of an urban soil scientist working with arborists and parks managers for many years. We have witnessed an improvement in the understanding of urban soil/tree issues over the years and a resultant improvement in our urban forest. The application of these simple principles will help the arborist avoid the silliest mistakes in caring of trees where change in their environment is inevitable.

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