Trees and Waterlogging

Trees have evolved to occupy a wide range of environmental niches and while a minority of species have adapted to succeed in sporadically or permanently flooded areas most are not well equipped to deal with waterlogged soils.

Different species and individual trees have developed a range of flood tolerance levels but it is difficult to predict how long a tree can tolerate waterlogged soils. In part, the duration and timing of the waterlogging event, the complexity of the soil as well as individual tree characteristics all affect the outcome for the tree.

Waterlogged or saturated soils are those where the voids between the soil particles are entirely filled with water and occur when water enters soil faster than it can drain away under gravity. The duration of a waterlogging event is influenced by the rate of water input and the rate of outflow or drainage. Topography will influence lateral flow; however soil structure and texture is critical in influencing vertical drainage.

Soil is made up of solid material, accounting for around 40-60% of the soil by volume, and the spaces between or pores. Soil texture determines pore size, while soil structure influences the interconnectivity of the pores. The ease with which water passes from pore to pore is referred to as hydraulic conductivity. Small pore size and poor connectivity, such as occurs in clay soils, will drain slower than sandy soils which although having lower porosity than clay soils have larger pores that are efficient in the movement of water and air.

The immediate effect of waterlogging is to significantly reduce the movement of oxygen from the atmosphere to the soil and the root surface where it is used for respiration. A lack of oxygen is the principle cause of injury to roots and other parts of the tree. Oxygen depletion in waterlogged soils occurs rapidly. The maximum amount of dissolved oxygen in still water is a little over 3% of that in a similar volume of air. Available oxygen

is quickly used by respiring roots and aerobic microorganisms creating an oxygen depleted or anaerobic environment.

Oxygen deprived or anaerobic soils lead to the production of, and accumulation of, gases such as carbon dioxide, ethylene, methane, hydrogen, nitrogen, sulfur and cyanogenic compounds, some of which are toxic to trees influencing plant growth and function. The soil ecology is altered as anaerobic soil organisms replace aerobic organisms. Soil pH becomes increasingly acidic influencing nutrient availability. Anaerobic organisms, primarily bacteria alter soil chemistry and cause denitrification and reductions in manganese, iron and sulfur.

Waterlogging can be fatal to trees. Mature, well-established trees are generally more tolerant of waterlogging than senescent trees or seedlings of the same species. Healthy trees are generally able to withstand periods of waterlogging better than trees that were already under stress. Waterlogging during periods of growth tends to be more harmful than during period of plant dormancy.

Signs of waterlogging include the yellowing or paleness and mottling of older leaves. Growth is stunted and internodal extension may cease. Wilting of young shoots and leaves may occur and brittle green leaves present. Premature senescence and abscission of leaves (older leaves first) can occur. Fibrous root death occurs and the death of small ephemeral woody roots may follow. The dead roots become blackened and the bark may peel away. Prolonged waterlogging can result in root decay rendering trees susceptible to windthrow. Notably the anaerobic decay of organic material including dead roots in waterlogged soil creates a characteristic sour sulphurous smell.

Waterlogging alters the biochemical functioning of trees, impairing defence mechanisms and increasing the potential for trees to succumb to attack from opportunistic pests and diseases. Soil-borne fungal diseases that tolerate low soil oxygen levels include *Phytophthora* spp. and *Pythium* spp.

Following periods of extended waterlogging, tree management should aim to enhance tree vigour whilst avoiding further stress. The addition of a light dose of nitrogen, potassium and phosphorous can assist, though the addition of micronutrients should generally be avoided. Pruning that removes live foliage or foliage-bearing branches should be avoided to conserve the trees energy supplies and photosynthetic potential and capacity. Mulching may encourage the return of aerobic micro and macro soil organisms improving nutrient cycling.

Knowing your site conditions and if the area may be prone to periodic inundation or extended waterlogged, will allow appropriate plant selection to suit the location. Some ornamental Australian native tree species tolerant of temporary inundation include some of the Bottlebrush (*Callistemon viminalis*, *C.* 'Harkness' and *C.* 'Kings Park Special'), Argyle Apple (*Eucalyptus cinerea*), Plunkett Mallee (*Eucalyptus curtisii*), Spotted Gum (*Corymbia maculata*), and Water Gum (*Tristaniopsis laurina*). Some exotic trees include the River Birch (*Betula nigra*), Black Tupelo (*Nyssa sylvatica*), Dawn Redwood (*Metasequoia glyptostroboides*) and Callery Pear varieties (*Pyrus calleryana* var.).