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Practices for the Production, Planting, Establishment & Maintenance of Trees

using

S1020 Rocket®Pot Direct Seed Sown – Produced Trees

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Background

Various authorities want to identify a more cost effective approach to planting of trees and shrubs that will rapidly, and with the minimum of losses, colonise planting sites.

To achieve this it is proposed to:

- Use plants that are produced following a procedure that will minimise if not eliminate imperfect root systems.
- Prepare a planting site using a procedure that enhances the rate of plant establishment.
- Provide procedures to assist the plants to outcompete weed competition promoted by soil disturbance of the planting site.

Document Mission Statement

To establish procedures for the cost effective production, planting and establishment of plants with fault free roots systems that will achieve their life potential.

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1 Production Procedure:

1.1 Container:

To ensure that the root system of the trees produced have no imperfections that would be detrimental to their long term health and structural survival, it is proposed to use the RocketPot[1] S1020 1.5lt Air Root Pruning, reusable, flat packable, container for the production of direct sown trees,

The S1020 comes as a flat injection moulded panel that is folded and self-locks to form a container. The sides and bottom of the container are cuspated with a total open area of 20%. The S1020 is made from high impact HDPE with high UV stability and will have a useful working life of 10 cycles or more.

1.2 Potting Mix:

The potting mix is produced from a range of materials; organic, inorganic or a combination of these. The mix must produce a desirable matrix of particles that can support the root system of the plant structurally and hold moisture and nutrients available for the plant to absorb.

The Potting mix should be substantially stable and not decompose or shrink excessively during the production cycle.

The basic mixture should have a known available nutrient status that is supplemented as required to meet the demands of the plant for the desired time period.
The pH of the mix should be adjusted to meet the preferred pH of the species being grown. The higher the organic matter in the mix the lower the acceptable pH can be to match the plants preferred nutrient profile.
A typical Potting mix is listed in Appendix I. However, trees grown under a contract can be tailored to closely match the pore size and soil type of the planting site.
The mix is compacted after filling, leaving 25mm of clear space above its top surface.

1.3 Pre Sowing:

The filled pots should be fully hydrated - preferably by placing in a flood and drain bed with water reaching 75% up the side of the S1020 pot for between 12 & 24 hours.

1.4 Sowing Method:

Seeds are sown directly into the S1020 Rocketpots. This can be done by hand or using needles under vacuum to pick and place the seed. Multiple seeds are sown, anticipating the variable viability of seeds. The depth of sowing and the inclusion or exclusion of light is adjusted to meet the germination requirements of the species being sown. Many species require pre-treatment of seeds prior to sowing.

1.5 Post Sowing Hydration:

The pots are placed within a flood and drain bed system. Initially, water is applied as mist to the top surface of the S1020.

In most species roots will penetrate 180mm to the bottom of the S1020 pot by the time the first two true leaves have developed, and the plant is 10 - 20mm high.

In addition to misting, a flood application of water may be required before germination. This will depend on some or all of the following; time of year, temperature, humidity and evapotranspiration and germination time. Where germination takes less than 14 days flood applications should not be required. Where germination is longer, flood and drain applications may be required. Care should be taken not to over water the plants.

1.6 Flood and Drain Method and Frequency:

Plants grow best when their root systems are taken from saturation down to near wilting point and then fully rehydrated. Thus, pore spaces are filled with water when flooded and oxygenation is maximised when the mix approaches the plant’s wilting point.

High organic potting mixes become hydrophobic as they dry down to these levels. The open nature of the mix can see water bypass pockets of dry soil. This can be prevented by flooding the S1020 pots to 90% of potting mix depth for at least an hour, thereby preventing dry pockets. Maintaining the flood for up to 24 hours to ensures that the organics fully rehydrate.

Flooding frequency is controlled by plant size, wind and weather. Weighing the pot and plant as it dries and comparing it with the weight at field capacity provides the best guide to watering frequency. Hand lifting a sample plant here and there soon demonstrates when the next flood sequence should commence.

1.7 Plant Selection:

Multiple seeds are sown with the aim of getting at least three plants to germinate in each pot. When these seedlings are between 20 - 30mm high the least desirable plants should be nipped off with scissors. Unwanted plants should not be pulled out, as this will damage the lateral roots of the remaining selected plant.

As the trees grow, now individually in S1020 pots, it is possible to utilise a Shigometer to determine the Vigour of each plant. Seed grown plants each have different genetic characteristics which is manifested in the width of the Cambial Layer.

A set of needle probes, connected to the Shigometer, is introduced through the bark of the seedling and readings are taken. Low resistance means a thick Cambial Layer – High

Vigour, and High resistance means thin Cambial Layer – Low Vigour. By selecting a representative cross sectional sample of all the trees a range of readings can be collected. These numbers are then totalled and divided by the number of samples, at least 20, to provide a mean. The mean is the average and thus all plants with a resistance below the Mean are classified as High Vigour plants and all plants with resistance reading above the mean are classifies as Low Vigour Plants.

Planting High vigour plants in poor sites is more likely to see the trees survive, whereas Low Vigour trees in poor sites will probably fail. Medium vigour will grow in Average sites. In this way a more even stand can be established. This can be particularly important in avenue tree selection where a substantially even growth rate across the length of the avenue is desirable.

1.8 Pest and Disease Control:

Germinated plants are very sensitive to pests and vermin. Some plants like Hymenosporum flavum attract snails, while Eucalyptus leucoxylon attract moths. These pests seem to appear from nowhere, particularly at night. In the Autumn foliar pathogens also appear. These are a particular problem if the potting mix is retained at high moisture levels. An integrated pest management system is essential, coupled with good nursery hygiene.

1.9 Nutrients in the Potting Mix and Supplementation:

The fertiliser regime is tuned to ensure the best calliper to height ratio. The aim is to avoid lush high nitrogen dependent plants. Nutrient levels within the potting mix should be reduced one month before planting in the landscape. This will cause plant growth to stall. The foliage takes on a yellow tinge. Nutrition should not be so low that the plants become unable to protect themselves from pathogens.

The type and quantity of fertiliser provided from seeding to planting out varies. It depends on production location and temperatures at different times of the year.

1.10 Training and Staking:

Plants should not be staked unless absolutely essential. Some trees germinate and spread over the surface of the pot. This is a competition response to gain space. Once this spreading has established a space footprint, either the trunk will lift up straight or the plant will send up a dominant shoot that will form a trunk. Many Mallee species form multiple trunks from a lignotuber. If staking is required for some reason, the stake should be flexible to encourage trunk calliper.

1.11 Size Specification:

Plant size at the time of planting out will depend on species and the natural conformation of the plant. For many Eucalypts, calliper measured at 10% of the height should be between 1.5 - 2% of the tree height. E.G. a 400mm tall Corymbia maculata should have a calliper of between 6 – 8mm.

Most planting will be undertaken when the trees are between 300 - 500mm. Such plants are wind stable with callipers of 6mm or more. In exposed sites, smaller plant heights, larger calliper and/or dense planting will help establishment without stakes. Where dense planting is used, thinning can achieve the required final planting density.

1.12 Establishment Rate:

S1020 planted at different times of the year, in different soil types and varying levels of available moisture will perform differently.
Growth to 4 times planting height within a 3 month period was achieved in typical February trial plantings of Eucalypts. The S1020 plants were hungry when potted on to 26lt or 50lt Air Root Pruning pots. Species were Corymbia maculata and citriodora, Eucalyptus camaldulensis and Angophora costata.

The 400mm S1020 hungry plants grew to an average of 1.6m within a 3 month period.

If the planting specification below is followed, this rate of establishment and height increment should be achieved or exceeded within most planting sites.

2.0 Field Planting of Nursery Produced Plants

2.1 Soil incompatibility:

Plants produced in Nurseries use potting mixes that are highly or totally organic. Most planting site soils are mineral as they have been disturbed or degraded. This can lead to establishment problems because of the incompatibility of the planting site and the nursery mix.

To understand the problem we first need an idea of scale. There is a big difference in the size of the soil particles and potting mix particles.

Typical natural soil particle sizes in mm

Very coarse sand	2.00 – 1.00
Coarse sand	1.00 – 0.50
Medium Sand	0.5 – 0.25
Fine Sand	025 – 0.10
Very Fine Sands	0.10 – 0.05
Silt	0.05 – 0.002
Clay	Below – 0.02

Typical potting mix particles in mm

Pine bark	20.00 – 2.00
Pine bark Fines	025 – 0.10
Very coarse sand	2.00 – 1.00

Natural soils are made up of horizons or layers. The top layer is an organic layer called the O horizon because soil scientists originally scraped it away to get to the soil. The top layer of which they labelled the A horizon or topsoil. Then the B horizon or subsoil generally devoid of organics is classed as mineral soils. The C horizon is the parent or underlying generally undisturbed material.

Typically soil is thought of as having four principal parts: Mineral matter, Organic matter, Water and Air. In a loam soil the typical constituents of each of these is 45% Mineral, 5% Organic, 25% Water and 25% Air.

But we don’t always plant into loam soil. Soils range from deep sands to heavy clays. There are two different problems with planting Nursery produced plants into natural soils. These are exactly opposite to each other and are dictated by the site soil type. In sandy soils the water goes around the planted root ball and in Clay soils the root ball becomes flooded. Interestingly the foliage symptoms are almost identical, as both induce root failure and wilting of the crown.

2.2 Sandy Soils:

Deep sandy soils have high levels of oxygen, low water holding capacity and normally low organics and very high mineral content. Organics are low due to the high levels of oxygen that sees any incorporated organics decompose rapidly.

When planting Nursery stock into such sandy soils the organic matter in the mix tends to dry out. Dry organic mixes become increasingly hydrophobic. Thus, the water tends to run around the root ball and not into it, further increasing the moisture stress problem. Wetting agent can help but some are seen as environmentally undesirable. Blending the site soil is preferable as described in “Blended Soils” below.

2.3 Clay Soils:

Clay soils have: fine particles, low oxygen, high water holding and low organics. Digging a planting hole in such soils creates a “Well” in the slow draining clay soil. This will fill with water and the inundated section of the plants root ball will become anaerobic. Some plants can tolerate anaerobic soil, but there are very few species that do. The anaerobic conditions cause a number of phototoxic materials to be generated; one of these is Arsenic, a highly toxic herbicide that kills the roots of the plant. This can be seen as a blue purple stain is cross sections of dead roots.

2.4 General Rules for Soils:

As you increase depth the gas exchange capacity of the soil changes. While the topsoil and organic layer are highly oxygenated, lower levels become increasingly slower to exchange both Oxygen and Carbon dioxide. Plants and most other life forms that inhabit soil require oxygen for respiration. They exhale carbon dioxide. Thus, low gas exchange will limit cell division of plant roots. Also low oxygen exchange will limit the health and extent of Mycorrhizal roots and other beneficial soil inhabiting fungi.

Many Australian soils are very shallow with “A” horizon depths of between 50 - 150mm. Thus planting Nursery produced plants, with deep root ball from 150 - 500mm with up to 100% organic matter in their potting mix will lead to trouble in shallow soils, particularly if inadequate drainage occurs at the planting site.

2.5 Blended Soils:

Typical organic potting mixes will have most particles from 2 - 15mm and air filled porosity, of 20% or above. Thus, you have a highly organic, highly oxygenated matrix full of roots right to the bottom of the container. With smooth rigid walled pots you will find a profusion of roots circling the bottom of the pot. These roots are constantly bathed in moisture, often twice a day. They are effectively hydroponic roots.

Air root pruning pots have 10 - 20% of their walls and base open to the atmosphere. The openings at the base drop the perched water table in the pot and minimize hydroponic root development. The openings allow increased gas exchange. The air filled porosity of the potting mix can substantially be reduced to between 8 - 12%. This is a closer match to many planting site soils.

When Nursery produced plants are planted in incompatible soil there is no transition from one soil type to the other. The interface between the two soil types create physical and environmental barriers for the roots to cross. The transition zone, with large particles adjacent to small, is highly suitable for fungal and bacterial pathogens. These bacterial pathogens occur naturally in all soils, and colonize this anomaly (zone). A film or layer of pathogens build up in the zone and attack the new white root tips as they try to cross the void from the coarse potting mix to the fine site soil.

Creating a transition zone where potting mix or similar organics are incorporated into the site soil can eliminate this problem. Ideally the mix should be 75% organic / 25% site soil adjacent to the plant, then 50 / 50 midway. It should be 25 / 75 near the hole wall becoming 100% in the planting site. Each planting site will need to be drained to prevent waterlogging in heavy clay soils.

This blending process is not always possible in this exact way, but it can be achieved substantially by modifying planting methods. Backhoe buckets or spades both tend to extract a clod, rather than a crumbled tilth. Trenchers, crumbler bars or augers can be used to break up planting site soils into a fine tilth. Placing, a measured amount of organics prior to excavating the planting site soil can achieve the desired blending. Correct amounts of the backfill material added before excavation will achieve a satisfactory transition layer from Potting mix to site soil.

2.6 Water and Watering In:

Waterlogging and dehydration are the two big risks of planting Nursery produced plants in incompatible planting site soils.

In clay soils that are not free draining, the planting site and/or root ball can become a well and fill with water. This water becomes deoxygenated and anaerobic bacteria thrive producing toxic by-products that kill the plant.

In a very open planting site soil such as coarse sand, the water can run around the plant root ball rather than into it. As the root ball dries, it becomes hydrophobic leading to further drying of the root ball and increased hydrophobia.

Both of these situations will lead to retarded plant establishment or death. Plants should be fully watered in the pot prior to planting. If possible, wet up using a water bath in which the plants can stand. The depth of water should be above the top of the potting mix. To ensure that all the organics are fully saturated, the detention time in the water bath should be in excess of half an hour. Overnight is ideal. Lifting the plant directly from the water bath into the planting site will allow the root balls drainage water, (the excess water above field capacity) to seep into the planting site soil.

Watering in after planting should ensure sufficient water to sustain the plant for one to two weeks, depending on climatic conditions at the planting time. Future supplementary waterings should ensure that the original root ball and the excavated site receive sufficient water to fully hydrate the planting site.

2.7 Calculating Water Requirement for a Planting Site:

This can easily be determined in the following way:

- Fill a bucket with exactly 10 litres of water
- Fill an S1020 with planting site transition mix and compact to a similar degree.
- Place the S1020 in the bucket and allow the water to saturate the soil in the S1020 fully. This may take a few hours.
- Remove the saturated S1020 and measure the water left in the bucket.
- The difference between the original 10 litres and the remaining volume is the water taken up by the S1020.
- The S1020 has a volume of 1.5 litres. Determine the approximate litre capacity of the planting site hole. Multiply that volume by the litres absorbed by the S1020. eg S1020 took up 0.5 lts of water. Planting hole was say 50 litres. 50 x 0.5 = 25 litres of water should be added to fully water the planting site and allow for drainage into the surrounding soil.

Depending on the watering frequency, the top half of the soil profile will dry before the bottom due to its exposure to sun and wind. Thus care must be taken that the bottom of the profile does not remain saturated. This will require some excavation of the planting site to determine just how drying of the planting site profile is occurring. Providing full irrigations and then half irrigations is often the best method of managing the moisture profile of the planting site. Thus, using our calculations above, the drying profile might be optimised with 25 litres applied first and 12.5 litres next, then alternating with each subsequent irrigation.

2.8 Hungry Plants Establish Best:

Nursery production often uses lots of fertilisers in the form of fertigation or slow release fertilisers. High rates of fertiliser produce fast growing plants with high biological demand. The cell growth of such plants are large and lush, the plant appears succulent with long intermodal length between each iteration of leaves.

When such plants are planted into a site of lower fertility they have to change their growth pattern. They slow their metabolism and shed parts, older leaves or twigs, to balance their resources with their demand. The plants stop growing in an effort to get into balance with their new environment.

High growth rate plants not only demand lots of nutrients but they also need lots of water to hydrate their large lush weak cells. So not only do they suffer from the drop of nutrient status but also they become moisture stressed. In exposed sites they will also transpire more water increasing the need for supplementary irrigation. Lush plant cellular structure is comparatively weak and more likely to fail structurally. They will definitely require artificial support such as staking.

Conversely, hungry plants have slow rates of growth, dense strong cell structure, and low water demand. Hungry plants have had a lower level of available nutrients, and had nutrients withheld.

It is easy to identify a hungry plant - it has a yellow tinge to the foliage. If you hold the twigs or trunk they will be stiff and resistant to bending. The trunk will have shorter inter nodal lengths and stiffer and marginally smaller leaves. Its calliper will be a better ratio to its height.

Because the planting site soil will be richer in nutrients than the root ball, new roots will grow rapidly from the root ball into the planting site. Such plants rapidly establish and resume growth because of the increased nutrient availability. They will rapidly grow to reach equilibrium with the growth rate potential of the new environment.

2.9 Holding Plants & Potbound Plants:

Plants grown in rigid walled pots develop root systems that circle around the pot. They also circle around the bottom of the pot in the perched water table. The time between roots reaching the outside of the rigid walled pots and becoming pot bound is very short – often just a few days. In the forestry industry, forest tubes are planted precisely when ready on a day pre-determined when sowing.

Faulty roots - circling or girdling roots - will not limit the growth rate of the plants after planting. However, they will commit the plant to be structurally faulty. Trees with faulty root systems can take up to two decades to die when the tree fails at ground line. For climax vegetation trees, 10 human years is equal to one tree year. So a tree failing from faulty roots at 20 years is only really a 2 year old tree failing. This is quick in tree terms but a long time in human terms.

The advantage of an Air Root Pruning Pot such as S1020 Rocketpot is that you can hold plants without developing root faults. The air root pruning achieved by the S1020 cusped openings sees the root ball filled with roots but none circle the inside wall of the pot. Plants can be held longer and kept in a hungry condition ready for planting without detriment to the trees long-term structure.

Hungry S1020 plants 300 – 400mm tall at planting often achieve a height of 2 – 2.5m in 6 - 10 weeks given adequate soil moisture and a reasonable level of site fertility. Actual results depend on species and time of year

2.10 Planting Secrets:

The secrets of planting success:

1. Ensure a transition from potting mix to planting site,
2. Plant hungry plants,
3. Add some fertiliser if the planting site is very poor,
4. Water in and ensure adequate moisture / drainage for establishment,
5. Avoid staking by using large calliper plants,
6. Plant densely if the site is very exposed.
7. Never forget that all planted trees are “PETS” and will require ongoing maintenance. Also many trees are planted sparsely or as individuals, this is not natural for trees, they would naturally grow within a close and diverse community.

3.0 Post Planting Treatment and Maintenance

3.1 Moisture:

All plants require moisture to sustain life. Moisture is absorbed into plants through the roots and the foliage. It is essential that adequate moisture is available at the time of planting to maintain the moisture within the root ball and within the planting site soil if supplementary moisture is not available after planting.

If planting without supplementary water, undertake this after the Autumn break, preferably while there is still some remaining soil warmth. This will encourage rapid colonization of the site and an extensive root system that will sustain the plant through the dry periods of the years.

If supplementary water is available it should be delivered in such a way as to soak deep into the soil profile (see Calculating Water Requirement for a Planting Site.). Few heavy applications are essential. Frequent shallow irrigation is counter-productive to healthy plant establishment. Frequent shallow irrigation encourages topical root growth that stimulates top growth. When finally the irrigation is stopped or missed, the developed root system is shallow, the profile dries out and the plant becomes moisture stressed or dies.

Different soils hold different quantities of moisture. It is imperative that appropriate amounts of water are applied to each soil type to achieve the depth or penetration required. Just how much water is required is best determined by digging and tracking the extent of moisture penetration. This should be undertaken 24 - 48 hours after the application of irrigation in most soil types. Heavy clays will take longer while open sands will show quicker.

Small drainage tubes inserted into the ground provide little benefit due to their small volume. Once the soils water holding capacity has been calculated and the volume of water to be added determined, the most suitable and cost effective method of application can be ascertained. This can range from suitably sized slow release reservoir installed in the ground to sacrificial drip systems.

3.2 Weed Control:

Competition is perhaps the biggest problem facing trees. Grass is a very successful competitor due to the chemicals they exude from their roots that limit tree and other dicot plants roots. Mature specimens of trees exude chemicals from their foliage and bark under their canopy that prevent or slow the germination of their own seeds.

There are many methods of weed control; material spats, wood chips, chemicals. All have advantages and disadvantages. Whichever is chosen, it should not:

- prevent the ingress of moisture into the soil, not too thick so the area becomes waterproof. Also it should not be heaped around the truck, particularly green waste which will heat up, and can kill the cambium.
- drag nutrients from the planting site to aid decomposition.

If green waste mulch is used, add some complete fertiliser, with high levels of nitrogen topically to the planting site prior to placing the mulch.

3.3 Structural or Formative Pruning:

Many tree species have a range of genetic characteristic. Some trees will have the propensity to form multi-leaders with included bark. This is not always apparent at planting time but soon becomes apparent after establishment. Such trees should be culled in the thinning stage that should take place within the first 12 months of planting. Alternatively multi-leaders can be pruned out. In most cases, however, trees that generate multi-leaders will continue to do so. These trees will fail in the future and may be hazards depending on their proximity to people or roadways. Over planting at the start or removal and replanting will be the most cost effective management program in the long term.

3.4 Natural or PET:

Most plantings are not natural as the site has been disturbed and fragmented by various infrastructure, roads, drains, trenches etc. Trees are often planted without the natural diverse community of plants and other fauna that is required to sustain them. In this case they will require maintenance support over time, the same as any PET.

3.5 Tree Selection:

The correct and appropriate positioning of trees within the landscape is essential if trees are to achieve long-term health and life expectancy. Trees of appropriate scale and structure to match the site environment is also critical to the long-term success of the planting. Trees have a life cycle, short, medium or long, it is crucial to get this mix right.

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1: – S1020 Rocket®Pot is the trade mark of Trentcom APS Pty Ltd.

Appendix I

Example S1020 potting mix

The mix should have an AFP between 8 – 12%.
The mix comprises the following constituents:

Aged and composted bark	70%

Particle Distribution of:

- <1mm 10%
- >1 & <2 20%
- >2 & <3.15 20%
- >3.15 & <4 20%
- >4 & <6.3 20%
- >6.3 & <9 10%

Sedge Peat	30%

Macro Elements added to meet species requirements.

N.P.K.

Trace elements Fetrilon Combi 2 applied at a rate of 0.014 Kgs /M^3:

Zn	4.0%
Fe	4.0%
Mn	3.0%
Cu	0.5%
B	1.5%
Mo	0.05%
MgO	2.2%
Mg	1.3%
S	1.3%

Ca. – Calcium Adjusted using some or all of the following:
Gypsum
Dolomite Lime
Fine Hydrated Lime.

pH adjusted to species requirement:

pH range 4.5 to 6.5

APPENDIX II

Definition and Discussion of Term Used in this Procedures Manual:

Tree Definition – A highly compartmented, perennial, woody, shedding plant that is usually tall single stemmed and long lived.

Shrub Definition – A highly compartmented, perennial, woody, shedding plant that is usually multi-stemmed, generally shorted than a tree and mostly long lived.

Planting site – The location where a plant is planted.

Establishment – The time at which a plant is no longer watered artificially.

Weed – Any plant that is growing out of place and competes with the selected plant for space and resources.

Imperfect Root System – Nursery Practices that lead to the formation of unnatural root distribution – such as the following;

- Pricking out; Seeds sown in trays are germinated and the seedlings are taken out of the seedling trays individually and planted into individual containers.
- J roots – Caused by the pricking out plants from seed trays into tubes or other pots where the root is not one long straight line down into the potting mix.
- Girdling roots that reach the wall of the container and grow circumferentially around the inner wall of the pot. This may occur at any height within the pot, but commonly occurs at the base.
- Plug Sown; Seeds are picked up by hollow needles by means of a small vacuum. The number of needles corresponds to the number of plugs within the tray. Plugs are normally about 10mm deep conical in shape 1omm at the top and a rounded dome at the base with a radius of some 5 mm.

Air Root Pruning – The method of plant production where the walls and base of the container have between 10 - 20% open air space. Holes of at least 5mm in rank and offset file. These openings may be shaped to direct the roots to the opening. The potting mix behind the opening becomes locally dry causing the root tip to die. This causes the root to form laterals back down the root. The many branches of the root system provide many well-placed and oriented root primordial that will enhance root colonisation of the planting site.

Primordia – Specialised meristematic tissue points, in the case of roots, from which new roots will grow or from where the root will extend into the planting site to achieve establishment.

Meristematic Tissue – This is the generating tissue that divides to form new cells; the principal meristematic tissue is called the cambium. This forms the Xylem and Phloem conducting tissues.

- The Xylem is the sapwood and then wood of the tree, it conducts water and nutrients, this movement is generally up.
- The Phloem conducts the carbohydrates produced, mostly in the leaves, mostly down the tree. Within the Phloem is a Bark meristem that produces the trees bark, some barks are persistent and others are shed.
- Cambial zone or layer this is a layer of as yet undifferentiated cells. The thickness of this layer is genetic and determines the Vigour of the plant.

Vigour and Vitality.

- Vigour – The genetic ability of a plant to resist strain. To increase Vigour we have to select for genetically superior plants.
- Vitality – What you do with your potential within the available environment. To increase Vitality you increase desirable cultural practices.

pH – A logarithmic scale of 0 – 14 with 7 as neutral depicting the range from Acidity to Alkalinity. Lemon juice has a pH of 4 and neat hydrated lime is about 13.

pH and Nutrient availability – The pH of the soil determines the availability of a range of Macro and Micro nutrients within the soil. Understanding the preferred pH range of a plant is essential to maximising its Vitality. The wrong pH will not always cause the death of the plant but will reduce its prosperity and can expose it to pest and disease to which it would otherwise not be susceptible. pH can cause colour change in foliage or flowers. Red cabbage is red to purple in acid soils and blue grey in Alkaline soils. Hydrangeas are Pink in Alkaline soils and Blue in Acid soils.

Shigometer – This is an electrical pulse generator instrument used to determine the relative resistance of different tissues and their current state. In plant selection it is used to determine the electrical resistance of the cambial layer. The thicker the layer the lower the resistance and visa versa.

Using a Shigometer to determine the Vigour of a range of plants enables them to be grouped into various categories such as; High, Medium and Low. If we had three planting sites that were considered as Good, Average and Poor we could select the plants for each site. The High Vigour plants would be allocated to the Poor site. The low vigour to the Good site and the Medium to the Average site. In this way all plants should have a good chance of prospering while the reverse would be likely to see the Low Vigour trees fail in the poor site and the High vigour out perform the Medium Vigour plants.

PETS and NATURAL

- Planted trees within the built environment are “PETS” and will require care and attention. This maintenance work is required to ensure the safety of the community and its assets. After planting follow up maintenance will be required on a regular basis, both within in the crown of the tree and its surrounds.
- Natural tree population are broad stretches of diverse communities of integrated interdependent and mutually beneficial organisms that form a webwork of interconnections. These large undivided communities have the biological mass to be self-sustaining. Structurally and genetically week members of the community simply do not succeed and fail to provide new space for the next colonisation sequence.

Indigenous Species – Indigenous is normally applied to a plant community identified by people at a particular place. However, what is overlooked is that Indigenous also has a time reference point. As the climate has changed over millions of years plant communities have moved following their preferred climate. As landforms changed and rocks became soils, plant communities colonised these mineral soils and changed them to organic soils. Land use change has divided these plant communities with various forms of infrastructure; soils have become re-mineralised due to the loss of vegetative cover and the organic layer. Climate change has moved the preferred climatic condition further up the hill and the time has changed.

The sites are so different in so many ways that what was "Indigenous" to an area is no longer valid as a plant selection at a particular location. There may be pockets of "Natural" conditions that still prevail and provide the same environment as originally supported the Indigenous plants, but these are increasingly rare.

What should be strived for is identifying plants that will now form "New Indigenous" plants for these new environments. Selecting plants that will prosper is a better outcome than simply planting a species, because they used to be there.

Roots –White and Brown – The root system is an organ of a tree that is responsible for the maintenance of structural support, the capture, through absorption, of water and essential nutrients from the soil, the return food to the associated microorganisms, and as an energy storage area.

- White roots are active growing roots and are non-woody and form fungal associations if conditions are suitable. Short lived hair roots do form but do not live long in nature. Non-woody fine feeding roots live for one to a few years. Then they die which initiates the formation of a corky layer of periderm at the root base. This corky tissue resists the spread of microorganisms into the woody roots. Low energy levels, adverse soil conditions, disturbance such as compaction can disrupt the formation of this protective periderm giving pathogens the advantage to colonise the root systems.
- Brown roots are non feeding structural conductive roots. A Tree's structural and feeding roots are generally shallow. Most feeding roots are within the top 300mm with some roots down to a meter depending on soil type. However, dropper or sinker root for in some species, Jarrah in Western Australia send them down to 10m or more. Other trees like Poplar send roots out laterally up to 5 times the height of the tree.

Roots as with above ground sections of the tree shed redundant and old tissue. When roots are cut they generate a callous tissue from which ne roots develop. These roots will colonise the adjacent area and the cut roots will decompose providing nutrients for the plant.

Root pruning to provide new space is a maintenance method for the conservation of old trees that would otherwise run out of space and decline and die. Many trees die as a result of pathogen entry into roots systems that have gained access due to disturbance and no follow up remediation works.

Many new tree diseased – Yellows or other declines, are the result of significant changes to the trees environment. A healthy unwounded tree that has perhaps 200 years of starch storage will take decades to die long after its roots system has been permanently damaged, see a tree life below.

Mycorrhizal Roots: – Sometimes called fungal roots. This is an association between the host plants non-woody, absorbing roots, that is symbiotic, non-pathogenic, or weakly pathogenic. The fungus – root association comes in two forms; ectotropic the fungus on the surface of the root and endotropic the fungus within the root. Some fungi are both in and on the roots - these are endectotropic.

Fungal roots are essential for the long-term health and growth potential of any tree. Often trees will start apparent normal growth but after a few years start to decline. This is often a manifestation of the lack of Mycorrhizal root association. Disturbed, compacted, contaminated and/or depleted soils will often loose their Mycorrhizal flora. Taking some leaf mould and organic matter from sites with healthy trees and undisturbed soils can reintroduce the Mycorrhiza to the area.

When I studied plant propagation under Mr Jack Plumridge, before the advent of the UC system of plant propagation, Jack always used leaf mould in his propagating and potting mixes. He knew that plants grew better when he did this, he did not know the reason, but he new it was essential for healthy plant production.

There is reasonable belief that healthy mycorrhizal association is also probiotic. All pests and diseases require space, feeding roots without the fungal roots association provide space for pathogens to attack. Where a vigorous and healthy mycorrhizal population exists space is already occupied, thus limiting available resources to pathogens.

The mechanisms whereby mycorrhizal roots function and benefit the tree are not fully understood. However, it is generally thought that the fineness of their hyphae can form a closer association with the soil colloid to absorb nutrients. The absorbed nutrients are passed into the plant and carbohydrate is passed from the plant to the fungus. Thus the tree feeds the fungus with energy and the fungus feeds the tree with the nutrient building blocks to produce the carbohydrates they both need.

Understanding how carbohydrates manufactured by the leaves load (store) down through the starch storage area of the plants is essential in understanding why mycorrhizal association is lost in declining trees. In summary all storage areas have to be full before the next area lower down the tree can be filled. Though sick and dying trees will compartmentalise the tissues they can’t maintain, storage area can still exceed carbohydrate production. When this occurs over an extended period of time the root system runs out of energy – carbohydrate. The fungi also lack starch, their energy source, and so they die. This then denies the tree nutrients, which further diminishes carbohydrate production. The end result is death of the tree.

Tree Life Cycle – All trees go through tree stages of life, Growth, Plateau and decline. Dr Alan Mitchell showed that the time for trees is generally a quarter of life expectancy for growth, Half for Plateau, and a quarter for decline.

We also know that large long-lived trees are the climax of a vegetation cycle that could have taken many thousands of years. We know that many of the worlds oldest trees are up to 10 or 14,000 years old but these are rarities. Many Australian native Eucalypts are 1000 years old, if we take such species and compare them to a human with a life expectancy of lets say 100 years, so 1 tree year is equal to 10 human years. Or 1 human year is equal to 1 month of a long lived tree.

Why is this important? If you understand time frames you can understand what the implications will be on the tree of any works. If you work within the trees time frame you can achieve dramatic environmental changes and the tree will have time to adapt to the new environment.

Climax vegetation requires organic soils, disturbance often returns soils to mineral solid due to the loss of the organic layer. Unless the organic soil profile is retuned and maintained the climax vegetation species will die. Changes in soil from organic to mineral are often demonstrated by the rapid colonisation by pioneer species such as Pittosporum undulatum – Sweet Pittosporum, and a wide range of weeds.

Soil Moisture

- Saturation Point – Watered soils first become saturated, no air in the pore space, to a depth until the addition of water stops. During saturation all gases are driven out of the pore spaces.

- Drainage Water or Gravitational Water – Water drains down under the influence of gravity. When this drainage stopes the amount of moisture held against gravity is called Field Capacity.

- Field Capacity – The amount water held against gravity.

- Water Holding Capacity – The amount of water that is available to the plant between Field Capacity and Wilting Point.

- Water Logging – Soils have varying levels of air within their pore spaces depending on the particles sizes within the profile. All living organisms respire, breath, in most cases they require the air to provide the vital element, oxygen. The oxygenated soil state is classified as Aerobic.

  When soil receives water it must become fully saturated, all spaces filled, driving out all the gasses present in the pore spaces. Then the soil profile drains down and air is drawn in to refill the pores with fresh oxygenated air. If the soil water does not drain down the organisms that rely on the oxygen die, including the tree roots. These dead organisms and other organics within the profile provide a food source for organisms that do not require oxygen – anaerobic organisms. Phytotoxic compounds are also developed by the anaerobic process.

- Suction Pressure – The removal of water from the soil is a function of suction pressure exerted by the roots on the moisture held on the surface of the soil particles. The required suction pressure to remove this water changes from very low at field capacity until it is so high that no more water can be pulled off by the roots at wilting point.

- Wilting Point – Plants transpire, loose, water from various organs, particularly the leaves. When more water is leaving the plant than is entering the plant the cells become flaccid or limp causing the foliage and shoots to hang limply. The application of water will rapidly see the rehydration of the vascular system and turgor, stiffness, will return to the plant.

- Permanent Wilting Point – This stage is reached when the water deficit within the plant leads to damage or death of the cells. The addition of water will not restore turgor to these damaged tissues and they will die.

Phytotoxic – Any substance that causes damage or death of plant tissue is classed as being phytotoxic.

Plant Food – Sugars are plant food not fertiliser. The production of various sugars or carbohydrates during the photosynthesis process provides the plant with its food. Plants produce and use carbohydrates, young vigorous plants produce more food that they use, and this supports growth. Old debilitated, stressed or diseased plants or plant sections produce less food than they use, such plants or plant sections are committed to death.

Fertiliser – Nutrients – Nutrients form the basic building blocks which the plant tissue uses for cell construction and the photosynthetic process. Various plants require various types and amounts of nutrients. This allows plants to grow in close communities while not all trying to rely on the same nutrients. Nutrients within and outside the plant are constantly recycled. Most tissue within a tree is deionised, the nutrients ions are removed, these are then repositioned redistributed within the plant. Plants also shed parts these are recycled through being eaten by other life forms or decomposition.

- Macro nutrients – N, P, K, Ca, Mg, S.
- Micro nutrients – Mn, Fe, B, Zn, Cu, Mo, Cl.

Shedding organism – Woody plants shed parts such a flowers, fruits, old leaves, twigs and branches.

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