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NEW POTS AND PROCEDURES FOR PROPAGATING LANDSCAPE TREES

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1. Introduction.

Thriving urban eucalypts – *Corymbia maculata*

Some of 28 direct sown advanced trees June 2007 at the bus terminal in Adelaide. SA Pictured March 2010

We can be proud of many landscape tree outcomes, but there are some alarming tree failures in our parks and streets that are costing us millions. Up to six parties are responsible for landscape tree outcomes: the designer, propagator, grower, planter, waterer and maintenance crew. Too often the grower alone is held to account for any problems.

We are fortunate to have so many excellent participants, but there are weak links in the chain of responsibility. These weak links are exacerbated by price competition in the absence of adequate quality standards.

I noticed the first dead eucalypt in a nearby park early in 2010, about seven years after it had been planted. I happened to walk past as the contractor was removing it, so asked to have it to take home. “No problem mate! There are plenty more like that”. So I threw it over my shoulder and took it home to dissect. The cross section view of the root ball shows a girdling root that has strangled the tap root.

Three more trees have died recently in the same park. The trees were in their eighth year. Failure occurred in the wind on a wet day – the root ball then exposed was encircled several times by thick roots. Trunk caliper was 150 mm and height 3.0 m

2. **The problem.** Landscape tree seedlings are produced in tubes or cells developed for forestry. Delay in using the seedling can cause fatal root system flaws. Landscapers

often need to cope with delays of weeks or months. Tubes and cells were designed for a shelf life of days. The seedlings shown at the end of the Y2010 trials were all sown on the same day 9 months earlier and are now are all past their use by date

3. **The solution?** First, get the right tools and procedures. Then skilled workers; trained tree planting tradesmen would make a big difference. "Advanced Tree Teamwork" is essential. Finally, measure outcomes and publish the results.

4. **Tree costs.** City of Hume cost data show that the cost to buy, plant, mulch and stake the typical tree is about $200 (AUD). The cost to water it to self sufficiency West of Melbourne is about $200. Total costs are about $400 [1]…….if there are no failures[2]. The Hume data suggest that the cost of a typical tree failure after one year is $288 (Tree Cost $110+Plant and stake $51+ First year mulch, water (24 visits) and spray weeds $127). $288 is more than 35 times the cost of an elite propagated seedling. Why skimp on the seedling and risk wasting another $288 needed to plant a second time? Using anything less than a perfect seedling is false economy.

About 2 million advanced trees are planted annually in Australia. The annual cost of planting and bringing these trees to self sufficiency may be of the order of $800 million. So what proportion of advanced landscape trees we plant fail to survive and prosper? We should measure and know the Australian figure but we don't. Consensus opinion among five tree growers with vast experience was that:

- **More than 20% of advanced trees fail after planting and even more are seriously compromised.**

The annual cost probably exceeds $100 million ($280 x 400,000) What other industry could tolerate 20% defective product? Cars? Appliances?

[1] Derived from data supplied by Daniel Rayment and Ronan Hamill of Hume City Council

[2] David Willyams IPPS Freemantle 2010 "In restoration projects the cost-per-surviving–plant 2 years after planting is more relevant than the nursery plant price"

5. **Managing container grown trees through their root system.**

After 8 years of trials, we have learned to manage trees by pruning their roots in all three dimensions 24/7 – starting a few days from germination.

Our research is unfunded and basic.

It seems that basic horticultural practices are being overlooked.

Year >	11	10	09	08	07	06	05	04	03
Acacia melanoxylon					X			X	
Angophora costata	X		X	X	X				
Allocasuarina verticillata					X				
Banksia integrifolia			X	X					
Casuarina cunninghamiana									
Corymbia maculata	X	X	X	X	X	X	X	X	
Corymbia citriodora		X			X				
E. leucoxylon megalocarpa		X	X						
Eucalyptus manifera			X		X				
Eucalyptus viminalis									
Eucalyptus pauciflora					X				
Eucalyptus polyanthemos	X		X	X	X				
Eucalyptus sideroxylon	X								
Jacaranda mimosifolia		X							
Melaleuca var.					X				

Seeking some solutions

Tree trials at Berwick Victoria Y2003 to Y2011

<These tree species were grown direct from seed

On top of a windy hill and exposed to all winds

I believe that Industry R&D funds could be used to fine-tune a set of products and practices that will lead to consistent propagation, growth and establishment of superior ornamental trees.

Direct sowing is essential for good root architecture.

In our small trial nursery, we hand fill pots, direct sow seed with a depth-controlled dibble (nut and bolt with flange), cover the seed with the same mix and water it in.

We hand water until the radicle reaches the root-pruning base of the pot - then start flood and drain watering. We select the best seedling when it is about 50 mm tall.

Procedures in large nurseries should include mechanised pot folding, machine filling and machine seeding. It is already possible to stack palletized pots in blocks under existing overhead spray systems.

6. **3DARP.** We are using relatively new technology in these trials. Its generic name is three dimensional air root-pruning (3DARP) – This may be defined as: “The use of containers with vertical walls and elevated flat bases with at least 20 mm air gap above recycling water flow, with both wall and bases fitted with at least 400 open ended root guidance cusps per square metre”.

I have spent about 20 years seeking to control a tree’s growth in a container through its root system. This picture is the culmination of that work. For the first time, downward pointing roots can be made to grow on down and colonise the planting site below the root ball. We just have to have 24/7 automatic air root-pruning for direct seeding eucalypts in larger pots.

7. **Caliper - Wise buyers purchase trees and tree seedlings for caliper and not height.** We found that we can keep seedling height down and caliper up by: *Limiting fertilizer incorporated in the media to less than 4 kg per cubic metre of 9-12 month release. *Letting in light as the seedling matures. *Rotating inside seedlings to outside. *Sheltering the pot against evaporative cooling and root scorching. *Keeping the root ball warmer than the trunk and of course *air root-pruning 24/7 with 3DARP. We attempt a caliper at least 1% of height but it is species specific.

Our trials have led to a better understanding of root behaviour in air root-pruning systems. This picture shows the effect of pot size on seedling caliper in the first **28 days** from seed. These Corymbia citriodora were direct sown with the same seed, sowing date, water and nutrients but different pots. The diameter of radicles were:

0.5 mm for cell trays (RHS),

1.0 mm for forestry tubes ,

1.0 mm for 1.5 litre pots and

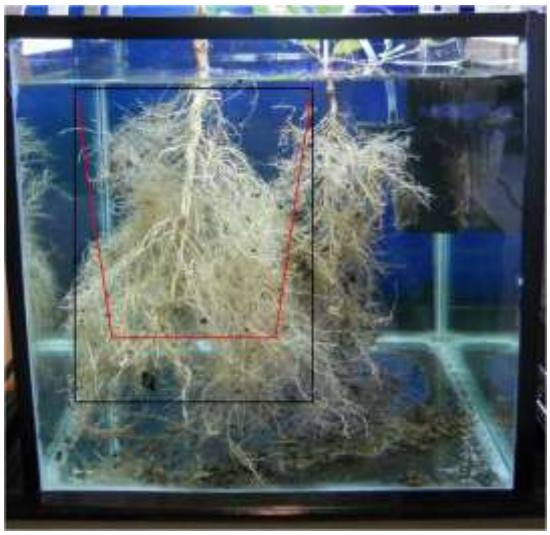
1.2 mm for the 1.5 litre and deeper 3DARP pots (LHS) So pot size does matter to seedlings.

Note that air root–pruning has started already on the 3DARP seedling

Over 200 seedlings were “key-hole dissected” with a compressed air jet during the trials. In every case an un-branched radicle had air root-pruned at the base. These two typical root systems at day 133 from seed show how the radicle is surrounded by an array of laterals uniformly arranged in 3D space.

8. Part of **understanding root behavior in 3DARP pots** is to study root systems suspended in water.The specific gravity of the fresh seedling roots is fractionally higher than water (1.0). The washed out root ball hangs naturally in an aquarium tank .

Notable findings being used in the design of new 3DARP pots are: *The radicle runs quickly to the base of the pot and air root-prunes each and every time - i**f the humidity in the basal air gap is low enough. ***Lateral root growth is stimulated and root-pruned at the wall – i**f the humidity in the air between pots is high enough. ***Three or more roots emerge from each root that is air root-pruned, then nine, then 27 and so on. *The rate of root tip development becomes exponential. *In our Melbourne summer trials of fast growing eucalypts, colonization often occurred quite suddenly at about 110 days from seeding. (8 litre) and 90 days (1.5 litre) *The volume of wood in the trunk increases fourfold if the volume of mix in the 3DARP pot increases fourfold. *Germination in this windy site increased from 80% to near 100% when we increased dibble depth from 5 mm to 10 mm. The length of the seed radicle when first pruned is probably determining the future shape of the tree, but much more research is needed to verify and detail this finding.



The seedling's natural shape fights with and suffers from the normal 7 degree inverted pyramid taper in smooth wall pots.

Consider two pots of the same diameter.

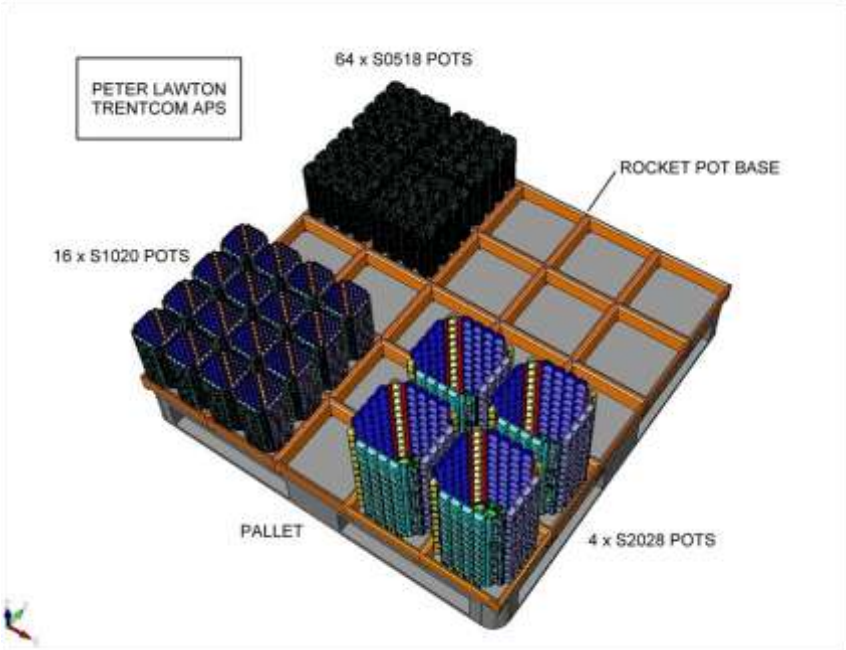
*A 200 mm 3DARP pot normally has an effective depth of 240 mm and 7.5 litres of useable volume (shown in black). *A 200 mm smooth wall pot normally has a depth of 190 mm and 4.5 litres of useable capacity (shown in red). *Parallel wall pots give about 50% more root space – just where it is needed. *The shelf life of a seedling germinated in a 200 mm diameter 3DARP is at least 4 times the shelf life of one in a 200 mm smooth wall pot.

9. **The trial equipment** we used has led to the design of new procedures and racks.

Notable findings from the trials include:

*We still need to cull 20% of the crop - despite multiple seeds per pot. *Watering by weight works well. We weigh a sample at field capacity and monitor it daily. When the pot loses 30% of its original weight we flood, dwell for an hour and drain. In 8 litre pots, 1.2 litres of air is expelled and replaced with water. *Watering is every 3 days in windy hot weather but normally less frequent.*Filtration and sanitation with a 24 watt UV Bio-filter works well - running 50% of the time. *Salinity is measured and adjusted by dilution if it exceeds 1.3 ms (rare). *Culling 20% of a rack after 10 weeks allows re-spacing to let in more light to increase caliper and minimize height. *Lifting 8 litre pots repetitively is stressful. If the 8/10 litre pot slides (or better – glides) across the rack floor it is very easy to grade, cull and re-space stock. *Correct working height and full access around the rack are essential for good OH&S. *Carrying pots individually from nursery to truck and truck to planting site is expensive and dangerous. It can be mechanized. * New pots and racks have emerged as modules of a shipping container. *Racks are fitted with a “mezzanine floor” that maintains an air gap of 50 mm beneath the pots for air root pruning and hygiene. This floor is a key component of the 3DARP system

10. **New pots.** Here is a 3D computer graphic of our new pot proposal. Three new pots are shown on a **new pallet**. At the top of the picture **-** 400 of these 0.4 litre pots will fit on the new pallet. The depth of the root ball is set at 160 mm for big trees. Bottom left - 100 of these 1.5 litre pots will fit on the same new pallet. The depth of the root ball will be 180 mm. Bottom right - 25 of these new 10 litre pots will fit on the same new pallet. The depth of the root ball will be about 250 mm. Detailed designs for our new 3DARP pots and patents are pending. We want to tackle this project now. The new 10 litre pot offers a way to solve landscape tree root quality problems quickly**.** It will be a one piece design selling for about $2.75. It will be designed for more than 10 reuses – stacked flat for easy return. There will be a folding machine to form the pot from the flat moulding.



Features and funds required:	New 0.4 litre	Revised 1.5 litre	New 10 litre
Mechanized pot folding, filling and seeding possible?	Essential	Yes	Yes
Biodegradable option possible?	Essential	Yes	Maybe
Our estimate of fast grow seedling shelf life (without root ball modification)	Weeks	Months	Many months
Matching shelf life in smooth wall pot of the same volume	Days	Weeks	Months
Pot construction	One piece	One piece	One piece
Budget selling price	TBA	AUD 1.10	AUD 2.75
Design life – number of reuses	TBA	10+	10+
Approximate number of reuses required to break even with smooth wall pot		5	3
Budget cost to complete pot design, tool up and test	$ 250,000	$ 100,000	$ 200,000

We need funds to complete the designs and make precision models, Then we need customer orders based on the working models.

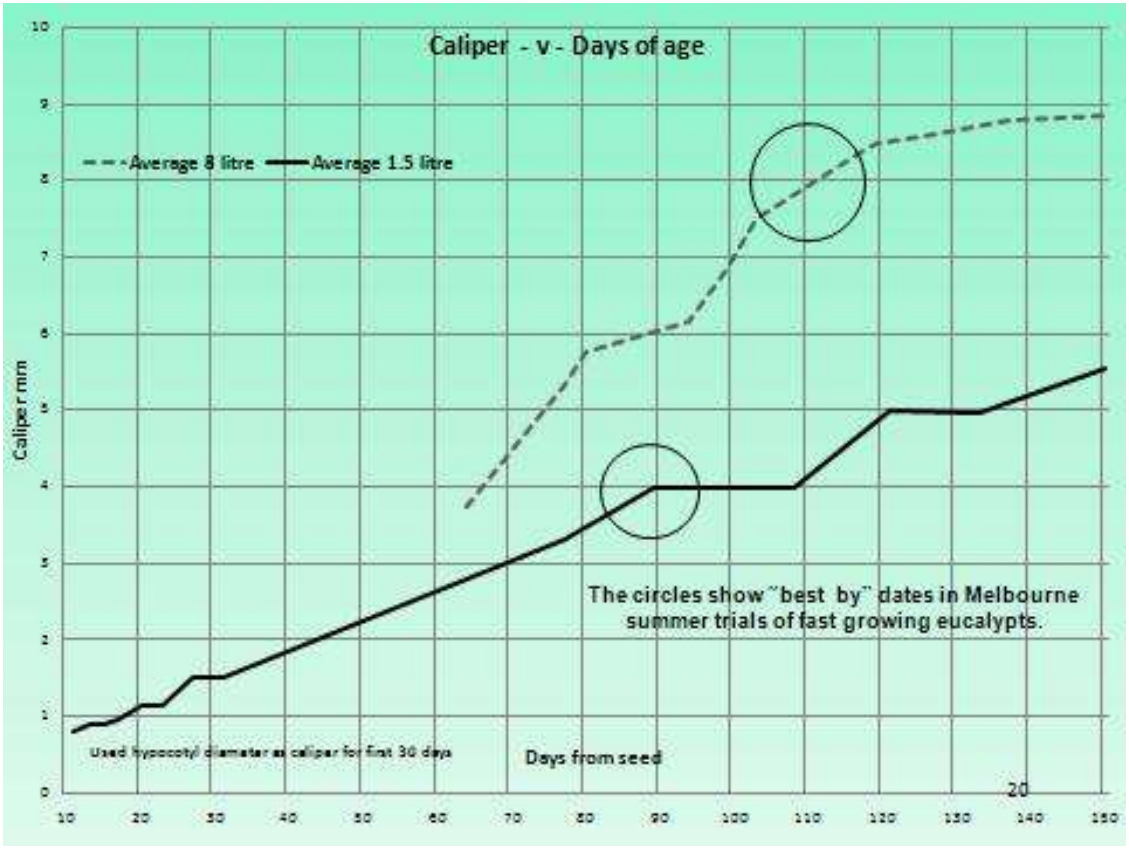
11. **New procedures.**

We recommend sowing direct to the 3DARP pot size you will sell. For landscape applications we recommend sowing direct to 8 litre 3DARP pots because it gives: *Shelf life of many months. *One step not two. *4 months to sale not six. *25 pots per pallet not 16 taper pots. *Root growth without circling. *Grow outdoors in Spring/Summer. *Selecting the best seedling without pricking out.

Y2011 trail - Angophora costata seedlings. Both at day 125 from seed in same mix and using the same methods. LHS 1.5 litre pot has 5.2 mm calliper and is 550 mm tall. RHS 8 litre pot has calliper 8.6 mm and is 880 tall

12. **Root ball colonization and shelf life.** We washed out seedling root balls at frequent intervals to understand root development in the first 5 weeks from seed, Root dimensions can now be scaled from photographs and used to track seedling growth rates. The results are shown in a graph. Plotting the radicle diameter (Y axis)

against days from seed (X axis) shows the shape of the “root ball colonisation curve”. Growth of fast growing seedling caliper in 3DARP pots appears to plateau



after 90 or 110 days. Our “best by” date is the day on which most of the media in the pot is colonized (circled).

The shelf life of trees in 3DARP pots is much longer than smooth walled pots but trials have proved that trees grow on significantly better when planted out close to their “best by” date.

13. **Measuring outcomes**. We have found an RFID chip encased in a plastic moulding that can be buried in the root ball of tree. Millions of similar (half duplex) tags are used in the Australian cattle industry annually. We are exploring the possibility of having the planter collate and record the exclusive 13 digit chip number, along with details like the species and provenance, the growers name, the growers recommended “best by” and “use by” dates along with the GPS coordinates of the planting site. The chip can be read though 150 mm of clay and mulch with a reader as shown. It is looking good.

14. Summary

1. Propagating landscape tree seedlings in forestry tubes and cells is causing serious problems when landscape tree plantings are delayed.
2. 20% or more defects in any industry is unacceptable and the cost in our industry probably exceeds $100 million per year.
3. Sowing seeds directly into the 8 litre 3DARP containers has given excellent caliper and shelf life - consistently over 8 years of trials.
4. The simpler process produces root systems with less labour, less water, faster stock turn and reduced nursery space.
5. We need three new 3DARP pots, 10 litre, 1.5 litre (V2) and 0.4 litre, to allow propagators to sow direct to the pot that their customer wants to use or sell.
6. We need Australian Industry and Australian Government support to create these pots.
7. The pots might become part of a technology based quality standard for trees.
8. A new tree growth measurement plan is available using simple electronic tags that are readable for years after planting.
9. Let’s measure and recognise landscape tree excellence.
10. Hope springs eternal ☺

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