

Improving Seedling Survival and Revegetation Outcomes

or

A users guide to silver bullets

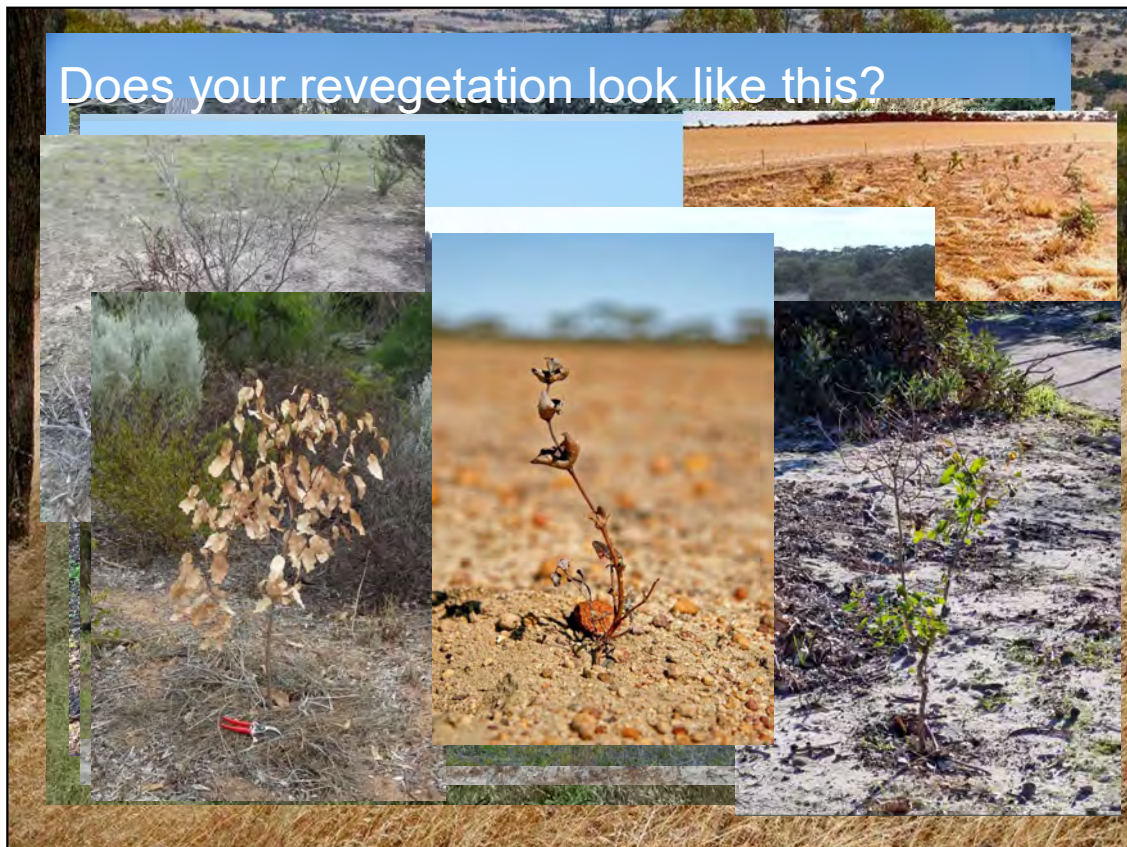
Peter White
Revegetation practitioner and
volunteer

What a riveting title!

Whilst I've been involved in revegetation works in the wheatbelt for over 35 years, I've also been involved in several urban restoration projects in the Perth metropolitan area. The title of this seminar has a focus on improving seedling survival, but I think there are some bigger picture issues that go hand in hand with seedling survival, hence the reference to improving revegetation outcomes. Im here in many guises, but in particular as a community member and a volunteer.

This is a brief overview of the topic of revegetation and it draws on work that has been done in many areas of the wheatbelt as well as Perth metropolitan and south coastal areas,

Thanks to revegetation staff, colleagues, nursery operators that have provided me with assistance, information and knowledge as well as more recent colleagues in various friends groups as well as the WALN.



Weedy revegetation is never a good look

Apparently, there are seedlings there

A happy collection of tree guards

5 year old revegetation commencing die off

Stunted seedling, not happy

The nearly dead, the dead and the should be dead



- This presentation includes a mixture of information from the literature, comments from experienced revegetation staff and empirical data.
- This presentation doesn't cover all revegetation / restoration techniques and there is always more to learn.
- I have worked for many years advising on revegetation and nursery problems, and believe the present survival and growth rates unacceptable. I also consider that many accepted observations of seedling performance are not correct
- My assertion is that attention is needed to basic principles not miracle cure – no silver bullets required
- I want to talk about the principles of revegetation, you have not have access to the same equipment but the basics still apply. Think of this as Reveg 101, not Rolls Royce.

Discussion points

- Planning and preparation
- Revegetation design
- Seed and seedlings
- Site preparation
- Weeds and rabbits
- Monitoring and evaluation
- Summary

1. Commercial operations look for 95%+ survival – though not always achieved. Nature conservation survival success commonly cited at less than 50%, often 10 – 15%. Poor survival is often attributed to factors such as drought but it can usually be attributed to poor planning / management
2. Not much effort is invested into post mortems – commonly cited causes such as drought readily accepted. “It’s a disease” is a common “leaping to confusions”. Some “causes” such as rabbits should never be accepted. Also inspections are often done too late – hence if weeds are a problem, nothing can be done.
3. Discussion of many projects includes comments such as “if we have a good year” or “in an average year” or “all things being equal” or my favourite “you would think that ...” A revegetation project needs to be supported by more than just hope and wishfull thinking. Attention is needed to the entire process to make it work – not to just segments of it– this approach works on the basis that if plants can survive through the worst conditions, they will thrive in the good conditions (but it won’t happen the other way around).
No amounts of soil additives, enhancers, tree guards can take the place of sound work.

Planning for success

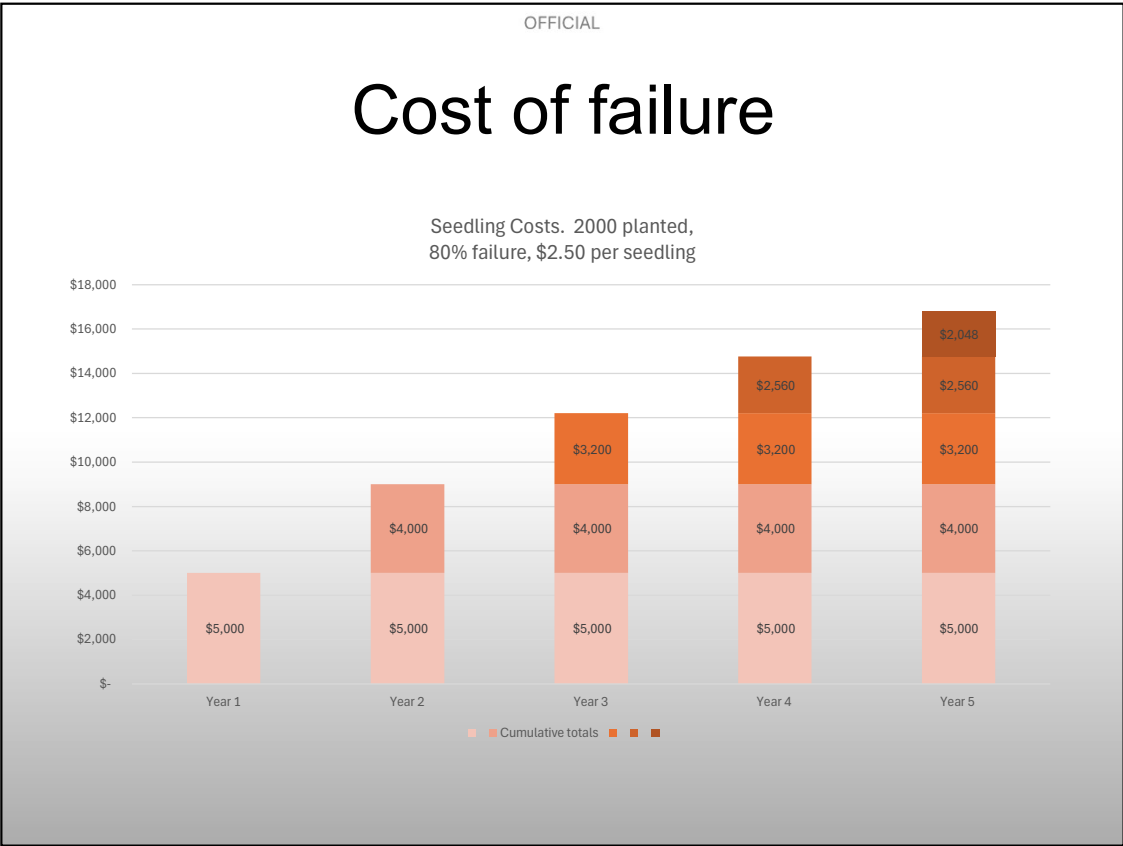
- Who plans for failure?
- Planning for legacy
- Planning for the project
- Planning for the day



- Sounds like an oxymoron doesn't it. No one plans to fail,..... but we frequently fail to plan.
- Planning for failure – we do. We plan for infill. However, when I hear groups talking about their survival rates which are often less than 30%, I think people are not planning for success, they are planning for infill i.e. the expectation of failure. I think its also important to recast a few notions – one being that of seedling survival, when we talk about numbers like that we should talk about 70% failure rate. You can and will live down to expectations.
- Example of nursery supplying seedlings for a last minute project, late and using the left over seedlings the nursery had. Just a one off or is this a familiar theme? We don't start our projects early enough, or most often, we lack the physical resources to do all of the work involved in a timely manner. Problems with funding availability always a difficulty – better to say no.
- Planning for positive outcomes. Planning for legacy. What do I mean by that? Just imagine what the site will look like in 30 years time. Or in 30 years time someone says “why did they do it like that, didn't they know better?”
- Planning for the project – the big picture stuff, species, quantities,

layout, weeds, pests, logistics, etc, etc, but especially resources. Do you have the time, money and people to do all of the required work?

- Planning for the day. Is the soil moisture adequate, have the weeds been controlled, do you have enough supervisors to make sure everything goes where it should and goes green side up?
- Note, there is an emphasis on planting as being a great day for the community / kids, which it can be, but it shouldn't be the determinant of work timing.
- Meet "the watering can of hope"



An example of a 2000 seedling planting, with 20% survival, 80% failure, at \$2.50 per seedling

2000	80%	\$2.50	
Year 1	2000	5000	
Year 2	1600	4000	9000
Year 3	1280	3200	12200
Year 4	1024	2560	14760
Year 5	819.2	2048	16808

	\$5,000.00	
total planted	6723	\$11,808.00 infill seedling cost
		\$16,808.00 total expenditure of seedlings
		\$8.40 seedling equivalent cost

Insert your own costs and failure rates and see how your project looks

Planning for 2024	Sept 23	Oct 23	Nov 23	Dec 23	Jan 24	Feb 24	Mar 24	Apr 24	May 24	Jun 24	Jul 24	Aug 24	Sept 24	
Site selection and inspection	Inspect sites while winter growth is still a good indicator of site conditions			Planning and preparation: Revegetation timeline										
Finalise 2024 seedling orders		Finalise orders												
Seed collection	Collect and clean seed	Clean and prepare seed, deliver to nursery		131										
Rabbit control				Bait trails, warren fumigation										
Planning			Mark out sites, plan fencing program, plan ripping											
Ripping & Mounding						Site preparation works, complete ripping and mound if necessary								
Weed control	Spray weeds to limit seed set				Control summer weeds if necessary					Pre planting control of winter weeds according to prescription		Post planting control if requ'd		
Hand planting										Sandy or gravelly upper slope areas first (June), mid slope. 131 then heavy soil, lower slope areas				
Machine planting										Sandy or gravelly upper slope areas first (June), mid slope. 131 then heavy soil, lower slope areas				
Fencing	132 Note that the seed collection indicated for this period is for a nursery program in 18 months time										133 Commence fencing		134 Finish fencing after planting	
	133 Planting times may vary according to rainfall, planting times will also be slightly later than the herbicide application										134 Planting times may vary according to rainfall, planting times will also be slightly later than the herbicide application			
	134 Planting times may vary according to rainfall, planting times will also be slightly later than the herbicide application													

The first horrendogram of the presentation

- Look at where the timeline starts.
- To get the best results, there must be time for plant identification and seed collection.
- In some cases there may not be enough time to collect important species (such as *Acacia* spp) – your project may need to be delayed or a different technique employed.
- The nursery needs to be able sow seed at the correct time – otherwise seedling quality will be compromised. Late sowings come with a risk.
- Seedling quality is paramount for good establishment survival and growth.
- The work continues well after the planting has finished – need to be out the week following planting, not going on holidays.
- A good example of this can be seen in “Ruthrof 2011 Restoration timetables CoE Bulletin No. 17”

Revegetation design

- Species choice
- Layout
- Structure
- Biodiversity considerations
- Amenity consideration

Note that the focus is on legacy – what's left after the work is done. Its not about how many trees were planted in a day, its if those trees are still alive and develop as it was planned for. Design will help improve survival as the placement of seedlings in the correct location with provide a greater chance of success.

- The goals of planting can be manyfold, but the aim in this instance was to try to get as many benefits as possible from the planting ranging from ensuring optimal growth, providing for structural diversity, maximising biodiversity outcomes as well as enhancing the aesthetic appeal and future use of the site. Many of these goals overlap.
- Species were arrayed across the planting area according to their site preferences i.e. soil depth, moisture availability. Matching species to site, gives species the greatest chance to prosper and meet the planting goals for the project.
- The growth potential of plants was maximised by putting larger growing plants into open areas and smaller species closer to / under the crowns of established plants.
- Smaller shrubs were planted closer to / under the canopy of standing trees. This was to maintain the feeling of open space in parts of the planting and to allow some views across the site. In particular this was done under the Acacias on the western side.



- The *Eucalyptus decipiens* and some other taller shrubs were planted closer to the tracks. This was to improve the shade benefits of the planting to CH users.
- Some *Melaleuca huegelii* were used as screening plants around the old well – with a gap left on the northern side to facilitate future access to the well. This was partially for aesthetic effect but also as one of the group plantings.
- Some species such as *Melaleuca systema*, *Hakea prostrata*, and *Banksia sessilis* were planted in groups. This helped develop structural diversity, both horizontally and vertically across the planting areas. The notion of structural diversity is to provide an array of habitat types for wildlife. It also meant the massed flowering would benefit pollinators, improve seed production values as well as visual appeal.

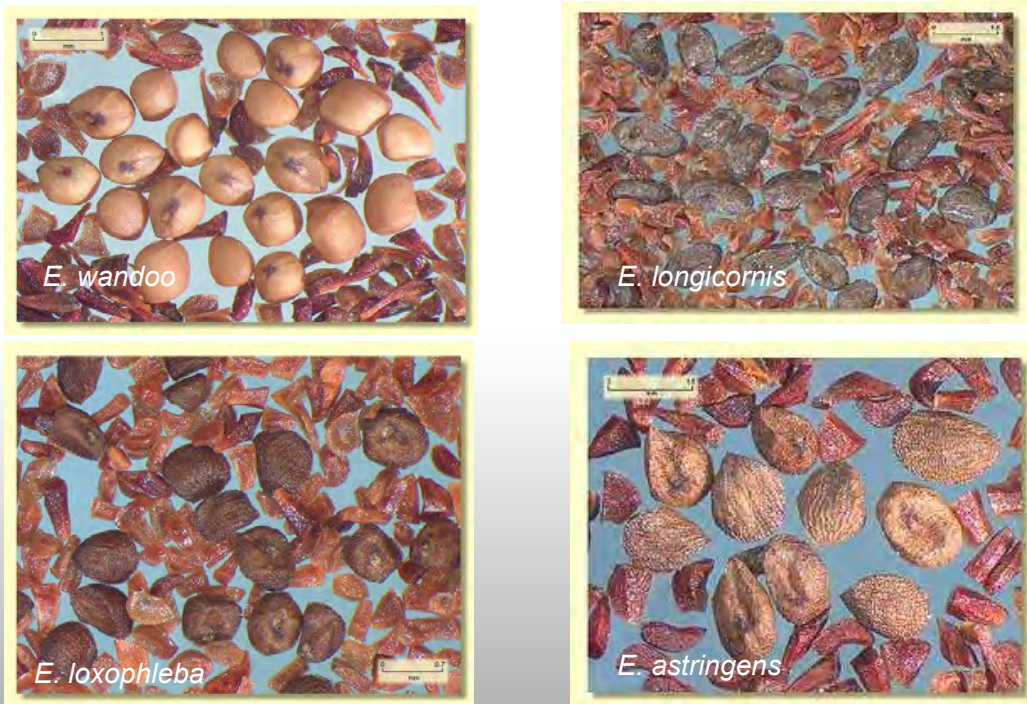
Design matters: species selection and species location



Wrong species choice usually because too many of the wrong species were ordered, or the information about the species tolerances / preferences was incorrect. There are some time when older literature contains erroneous information, in this case it was the assertion of this species salt tolerance

Species positioning during planting, two examples of newly planted seedlings close to or under the canopy of standing trees. Very difficult for seedlings to survive, other species are possible but possibly need to understand that just because the area has no plants doesn't mean it can support seedlings

Seed – the key to success



Seed is where it all starts – this can be an aspect of work that many don't get to see even though it's well understood in any sort of agricultural cropping enterprise. The quality of the seed is a long term survival issue, so it needs to be of the best genetic stock, collected according to sound practice, not just from a single isolated plant in someone's backyard.

This is part of the legacy!

A lot of effort goes into securing the best suite of species collected from a wide range of parent plants

Seed can be very hard to find, needs extracting, cleaning, labelling and storing. It is a very valuable commodity, but often it is not valued. People often believe that cheap seed is a bargain.

Seed is scarce and needs to be conserved, therefore survival is important and as is effective use in the nursery

Species are often site specific, therefore it is important to select the site well before the seed collection and nursery program commences.

Seedling quality

- Why is it important? - Why do we care?
- How can it be achieved?
- Key issues - seedling cells and trays
- Other seedling standards

- Implications of poor quality nursery stock

- Good quality seedlings give better survival and growth.
- They are also much easier to handle, from transporting them on a trailer to getting them out of the pot to getting them in the ground.
- It maximises the value of volunteer time, both in the act of planting but also the survival justifies their efforts – they got out of bed on a wet Sunday and actually achieved something

Need to focus on outcomes – not outputs. You must be able to visit sites in 4 or 5 years time and see the revegetation progressing as planned – this is much more value than having obtained seedlings at half price.

There is no difference between nature conservation and commercial seedlings – all seedlings are commercial as someone has paid for them!!

Nursery seedling quality



Make sure you have good quality seed and it is delivered on time. The nurseries are busy places and need all the time they can get to do things in a timely manner

Poorer quality, purple seedlings, thin stems, free moss, much more difficult to handle – time consuming and transfers cost from nursery to customer.

Trays full of weeds

Nursery seedling quality



Good robust seedlings

Seedlings of the correct height, stem diameter, topped if necessary

Big is not better

A balance of shoots and roots is needed

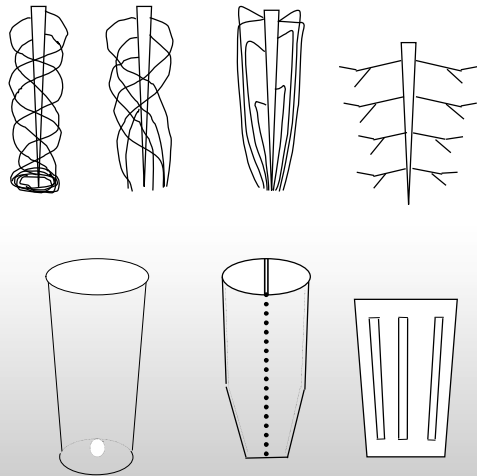
The dongolocking project also provided a good insight into seedling quality and how much it matters. When asked about seedling survival in the district farmers usually said “ohhh about 60%”, what were the problems – “rabbits”, “weeds”. So, we were in charge of the project so we killed the rabbits and sprayed the weeds. Survival improved but there was still not to the desired level. The answers lay below ground – once the seedlings were dug up and examined, that was when the problem became clear.

This is will be the emphasis of the next few slides

Seedling standards

- Request for specific container types ie pots with demonstrated root training capacity.
 - Seed sowing practice and standards
 - Thinning, grading and topping requirements
 - Seedling height range and stem diameter
 - Seedling age.
 - Properly developed root systems.
 - All trays full stocked
 - All seedlings healthy, disease free and hardened off.
 - No substitute species unless agreed to by customer.
 - Agreed nursery inspection process
-
- Request for specific container types ie pots demonstrating root training capacity.
 - Seed sowing practice and standards – timing of sowing, one seedling per cell, centrally positioned, direct sown or transplanted to an agreed standard
 - Thinning, grading and topping requirements – thinning to one seedling per cell, preferably graded mid year into different size classes to allow smaller seedlings to grow properly, topped if necessary 6 weeks before despatch
 - Seedling height range and stem diameter – seedlings grown to an acceptable minimum / maximum height range and stem diameter
 - Seedling age – fresh miniplugs and this seasons seedling
 - Properly developed root systems – roots adequately distributed though root bolus, no coils or kinks
 - All trays full stocked – all seedlings supplied to be of a plantable standard, no gaps or seconds
 - All seedlings healthy, disease free and hardened off – seedlings in good health, colour and vigour
 - No substitute species unless agreed to by customer – the customer needs to know if advance if there will be a shortfall in numbers
 - Agreed nursery inspection process – this assists both the nursery and the customer with the planting project

Effects of containers on root structure



Unpainted plastic insert



Root training cell: no side slots



Root training cell: slotted sides

The effects of containers on root structures

Coiling

Caging

Side air pruning

Use of root retardant paints

Note the danger of the name “root trainer”

Cell trays verses forestry tubes – sometimes its not so much the container as it is how the seedling has been grown ie it is still possible to get an overgrown seedling in a cell tray.

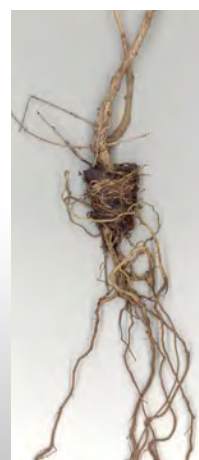
Seedling root development



E. loxophleba subsp.
lissophloia showing
unthinned seedlings
(and root structure
from off-centre
seeding)



E. salmonophloia
showing "J" root
structure from poor
transplanting
technique



Over
developed
Mini plug

- Unthinned seedlings – “you would think that the strongest would survive”. Perhaps you would, but the experience is that “all things never being equal”, except that all seedlings perish equally
- Work with mattock digging up dead seedlings
- Off centre seedlings: “you would think that” In the dry seasons which have experienced recently, this sort of seeding is not of acceptable quality.
- The J curve did not disappear when Paul Keating left office!
- The miniplug was supposed to resolve these issues but also can be a considerable contributor to the problem



More examples

Masterful J root

Unthinned seedling grown in miniplug times two

Unthinned seedlings in miniplug eroded

Implications of poor root structure

- Sudden seedling death, usually in the early years after establishment
- Reduced growth rates and eventual failure after several years
- Compromised growth rates on trees which survive
- Plants more susceptible to windthrow

Many of the above problems are attributed to:

- Insufficient ripping
- “weak” plants” – somehow genetically inferior. Note that by the time a seedling is produced it has been through several sorting process such as seed cleaning to nursery thinning that removed the poorer performing seedlings.
- Or are just accepted as a normal part of growing plants

However this is not the case. I believe many of these plants are dead already, they just don't know it.

Limitations to success



Plants become very susceptible to windthrow

Very common problem with this species – often attributed to poor ripping. However, as this species commonly growth in this soil types, and has had nearly 8 years to overcome any hardpan problems, this is not likely to be the case.

Planted 1997, first problems with windthrow noted in 2001, widespread plant deaths 2009. Painted tray seedlings.

Importance of site – seed production area for catchment group.

Site planted in 2008, seedling quality explains many of the gaps and this one is an example of how long a seedling can persist....and here it is!

Blackwall Reach advanced seedling which lasted about 18 months....here it is!

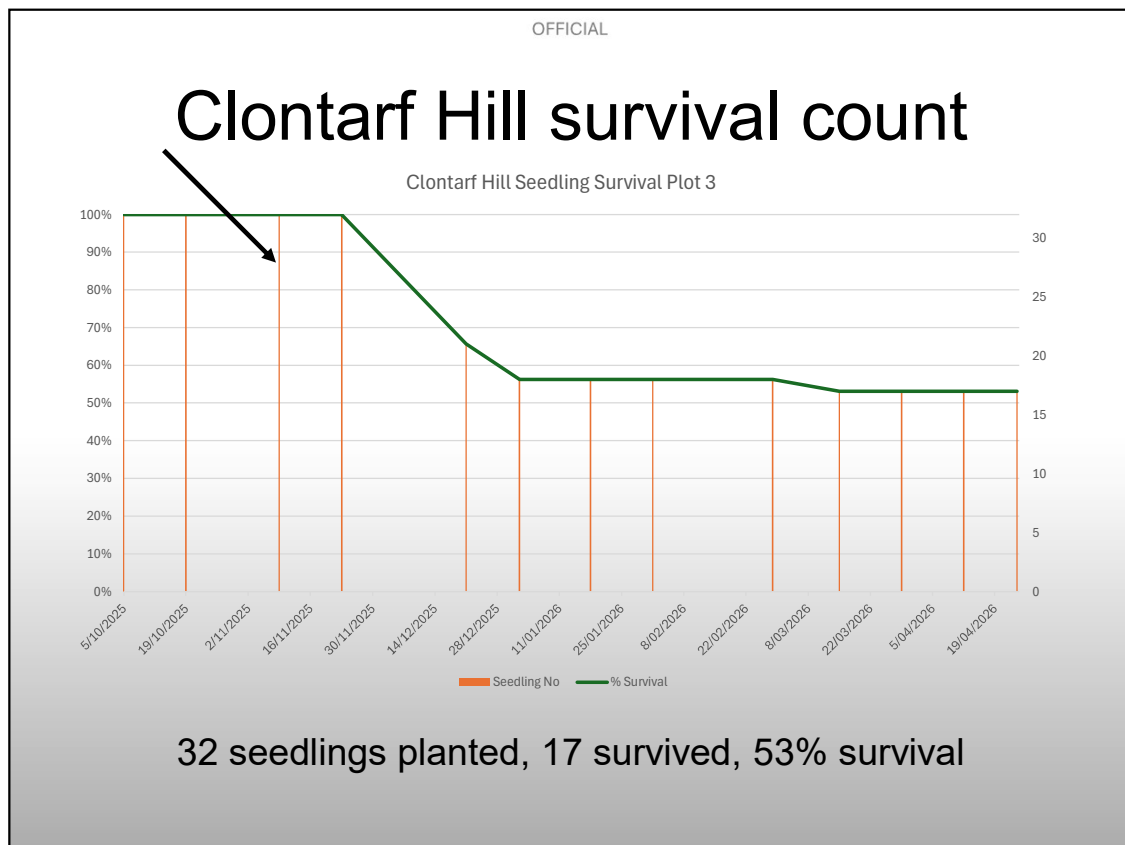


Poor twisted creature!!

In case anyone else is wondering if this is a new phenomena.....

- George Brockway wrote about the problem of J roots in the 50's
- Hardreck and Black mentioned it in the 70's
- Mullan and White wrote a paper on seedling quality in 2003
- Derek Moore from Charles Stuart University has written extensively about the effects on containers on advanced stock for decades.

It is a question as to why we are still confronted with this problem, but that's possible a topic for future discussion.



All plots exhibited the same trend ie die off during late December to February

Seedlings died even though watering had commenced two weeks prior (indicated by the arrow)

All seedling examined had a deficiency, particularly root coil / J root

My assertion is the weak seedling could not cope with drying conditions whereas the properly developed seedlings could.

More study needed



More examples of seedling quality

- No roots, thin stems
- Where did the roots go.....?
- Too tall, needs topping
- Tall soft seedling
- Mmmmmmultiple stems
- Seedlings need to be of good size and sufficiently hardened off

There are numerous other issues associated with seedling quality, from sowing times, to pot filling, seedling colour, diseases, etc

Seedling establishment

- Good initial weed control
- Feral animal control
- Site preparation with proper equipment
- Mounding if necessary
- Planting at the appropriate time
- Planting to an appropriate quality
- Post planting weed and pest control
- Planting site protection

How to get your trees to do really well

Ripping improved moisture penetration and allows for good root expansion

Plants respond to ripping even in sand. A trowel is not adequate.

Mound if necessary – furrow if necessary

Early planting has proven benefits, late planting will only work if there is adequate moisture or a suitable nearby lake

Planting quality – see Bruce and Bills work

Post planting surveillance – starts immediately after planting, not just when you get back of holidays

Basic establishment techniques – this is Reveg 101

Vermin control



Enough said.

Worlds most expensive rabbit poo – markets not well developed for this material

Except – don't commence a project with rabbits present and expect to control them. Rabbits can move several hundred metres in a night – so they may not be your rabbits.

Rabbit bait stations have proved effective but have limitations in urban areas. Tree guards may provide some protection, but rabbits have been known to dig under guards

Change this image to a sheep or a horse



Whatever the equipment that you haveuse it – even if it is a hoe!

- In most instance, selective herbicides are available for post planting weed control, pre-planting has a wider array of cheaper options with much less risk.
- Whilst we do have a reliance on herbicides, it is generally for a very short period of time compared with the agricultural regime that is being replaced. It is necessary on large scale plantings with these establishment techniques.
- Whilst weed control is done with mechanical means, the herbicide control is also effective for inter-row weeds which we manage so they are not an ongoing threat, but it also reduces the fire hazard as this is one of the most vulnerable times in the life of the planting and it reduces the risk of weed spread across the fence into the neighbours prized paddock.
- We have access to a program called Herbiguide which allows us to overspray 6 month old seedlings, controlling the weeds but not causing the plant any damage.
- **Think of weed control as a means of providing your seedlings with moisture – and that every moment a weed occupies the planting site it is using a valuable resource.**

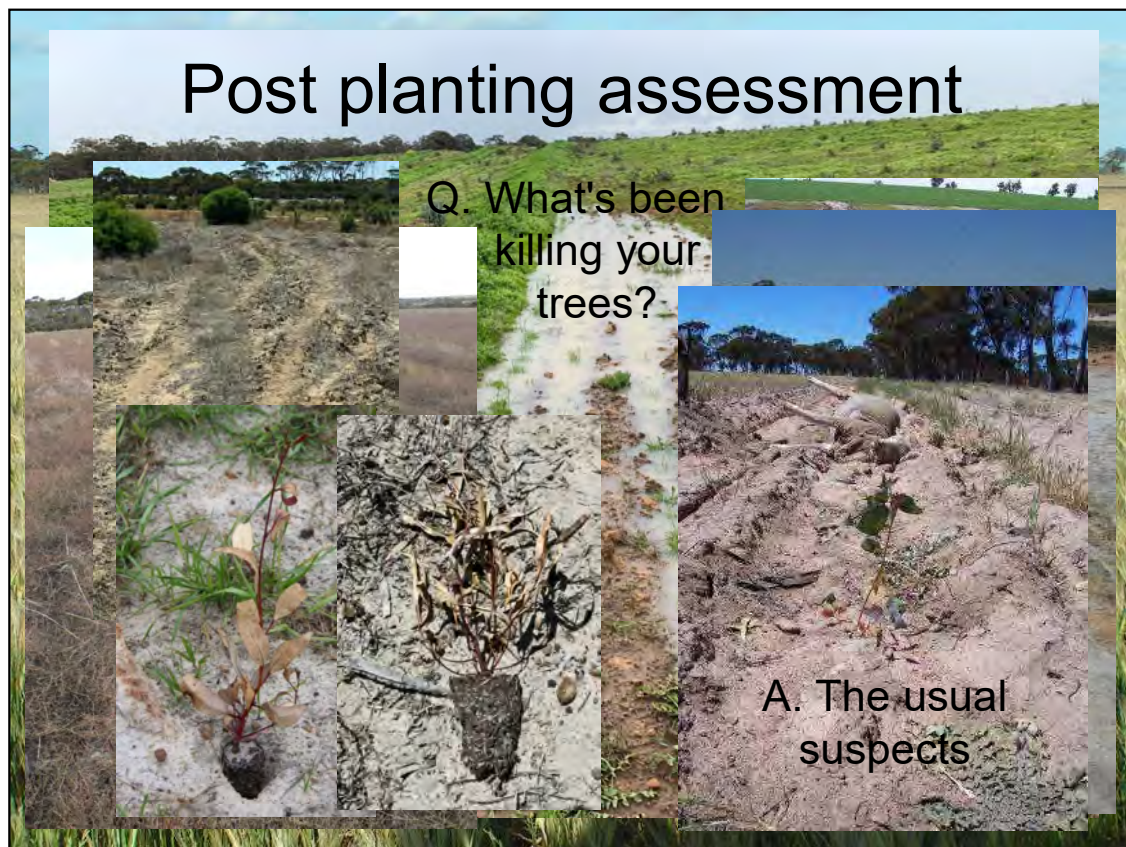
Consequences of poor weed control



There are some plants If you look. This is a waste of a years work.

Effects of weeds suppressing growth because of missed spray.

Trees will fail to establish well, will be slower to shade out weeds / exert a control on ground water / provide whatever benefits that were expected and will need additional effort to coax along.



Yes there are seedlings to be found in this picture

Watch out for wireweed – need to get in early

Seedling not heeled in, sack the planters

Seedling not planted deeply enough – sack the planters

Seedling pulled out by kangaroos, not firmed in well enough – sack the planters

Seedling fell out of the planters bucket – sack the planters.....or perhaps the supervisor?

Summary – or a shortcut to successful tree planting

- Planning site selection / species choice
- Seed and seedling quality
- Site preparation, planting timing and quality
- Vermin and weed control
- Fencing or plant protection
- Post planting weed and pest control
- Monitor and evaluate
- Start planning for the next new site

Keep a few silver bullets for the next time you're visited by a werewolf and gives the rest back to the Lone Ranger.



Happy snap of revegetation, planted in 2013, photographed in 2018 and again in 2025



Some examples of successful revegetation

2012 planting

2006 planting

2020 planting

1 yo tuart seedling at Clontarf hill – we don't know how well we can grow seedlings! It's a most exciting challenge.

My favourite type of tree (© Eleanor White)



May the revegetation gods smile upon your project.