Coastal Propagation & Revegetation Manual

Australian Government

EnviTE Environment

Acknowledgements

This manual has been developed as part of the *Coastal corridor enhancement through restoration, propagation and revegetation* project supported through funding from the Australian Government's Biodiversity Fund.

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Introduction

This manual has been developed as part of the *Coastal corridor enhancement through restoration, propagation and revegetation* project supported through funding from the Australian Government's Clean Energy Future Biodiversity Fund.

The Biodiversity Fund assists land managers to store carbon, enhance biodiversity and build greater environmental resilience across the Australian landscape. Reducing carbon pollution and increasing the amount of carbon stored on the land can improve productivity, protect the environment and increase resilience to climate change.

Funding is provided for activities which restore, manage and better protect biodiversity on public and private land. The Biodiversity Fund provides support to establishing new carbon stores or better managing carbon stores of existing native habitat.

The Biodiversity Fund invests in three main areas:

- Biodiverse plantings: Funding helps land managers expand native habitat on their property through planting mixed vegetation species appropriate to the region. This will help build landscape resilience and connectivity.
- Protecting and enhancing existing native vegetation: Funding supports land managers to protect, manage and enhance existing native vegetation in high conservation areas on their land for its carbon storage and biodiversity benefits.
- Managing threats to biodiversity: Funding supports control of invasive pests and weeds in a connected landscape.

The *Coastal corridor enhancement through restoration, propagation and revegetation* project is restoring 23 sites over the northern NSW coastline from Crescent Head through to Brunswick Heads between 2012 and 2015. EnviTE bush regenerators are working with partners to enhance and protect high conservation value native habitat, undertake biodiverse supplemental plantings to improve structure, floristics and longer term ecological processes and undertake management of key threats such as weeds.

Partners include the Department of Sustainability, Environment, Water, Population and Communities, Byron Shire Council, NSW National Parks and Wildlife Service, Jali Local Aboriginal Land Council, Brunswick Dune Care, Iluka Landcare, Clarence Valley Council, Wooli Dunecare, Red Rock Dunecare, Mullawarra Dunecare, Serenity Landcare, Korora Dunecare and private landholders.

This manual provides a resource which can be used by project partners and others involved in ecological restoration and biodiverse plantings to store carbon. Information is provided on native seed collection, plant propagation, revegetation and project planning and management. Growing and planting local native species provides stock for biodiverse plantings and can enhance and extend existing native vegetation.

1 Ecological restoration

Ecological restoration is the process of repairing damage caused by humans to the diversity and dynamics of ecosystems. The following information has been sourced from the Australian Association of Bush Regenerators (AABR http://www.aabr.org.au/).

The 3 Rs of restoration:

- Retain remnant indigenous vegetation
- Regenerate where there is any potential for natural regeneration
- Replant only where there is no regeneration potential

1.1 Retain and conserve existing natural areas

Australia has lost much of its native vegetation since European settlement. Many native vegetation types and plant species are now threatened with extinction at the regional, state or national levels. Areas of remnant vegetation are important for many reasons including providing habitat for native fauna, nutrient and water cycling, retaining top soil and minimising erosion.

Areas of remnant bushland contain more than just visible vegetation. The soil in even small and disturbed areas of bushland is likely to contain seeds and other propagules of native plants as well as important microfauna such as fungi. Most types of native vegetation rely on the soil for their seed bank, structure, invertebrate fauna and other organisms. Areas of remnant vegetation also contain dead and decaying plant material and surface rock. These features are habitat for many species of fauna upon which continued ecosystem function relies.

Remnant native vegetation and ecosystems should be retained as most cannot be recreated. Some may only be rehabilitated with substantial, long term resources and commitment. The biodiversity benefits of protecting and enhancing existing remnant vegetation far outweigh those of “compensatory” planting in cleared areas.

All existing indigenous vegetation on a site should be retained where possible and protected from degrading influences such as weeds, grazing, stormwater, mowing, etc.

The benefits of protecting and rehabilitating existing native vegetation far outweigh those of establishing new vegetation in previously cleared areas. Regeneration can occur where the soil is relatively undisturbed and native vegetation and/or its propagules (e.g. seeds) are present. Regeneration may be assisted by human interventions such as weed removal. It is quicker and cheaper to protect healthy sites by regeneration than to revegetate degraded sites. It is cheaper and easier to revegetate degraded sites then to revegetate totally cleared land. Australian Association of Bush Regenerators (NSW) Inc. (2005) *Revegetation Policy*

Conserving existing natural areas is the highest priority. In many regions, both urban and rural, there is little bushland remaining. Our native ecosystems are more complex than we yet understand and we are not able to recreate bushland once it has been destroyed.

1.2 Regenerate

Where bushland remains but is degraded by weed invasion or grazing, regeneration should be the primary goal. Damaged bushland is still valuable and is capable of regenerating if given the right assistance. Native plant seed will still be stored in the soil, or will be able to reach the site from nearby bushland (often with the assistance of birds, other animals or the wind). Even cleared or mown areas can sometimes regenerate if the original soil profile is intact. Remember not to clear too much too quickly. As well as native regeneration, lots of weeds usually appear after clearing, and follow up weeding will be needed to maintain the site. It's very important to protect any regenerating bush plants from being swamped by weeds.

Natural regeneration can take time. So after clearing the weeds, give the natives time to come up - two years is often recommended. If you are not sure about your ability to identify young regenerating native plants, enlist the help of someone with more experience. Natural regeneration can often be encouraged by removing excess ground litter and disturbing the topsoil. Allow light and warmth to reach ground level. Mulching should be avoided where there is any chance of regeneration - it will suppress the weeds but it has the same effect on regenerating natives.

Consider using fire. Heat and smoke may be required to stimulate germination of some species. Seek advice on the relevance of fire on your site. If burning is appropriate, plan carefully, considering fire history and recommended fire regime. Fire is a more natural method of intervention than planting because it makes use of one of the bush's inbuilt regeneration triggers.

Weedy bushland that is helped to regenerate naturally has a chance of becoming a relatively balanced ecosystem needing minimal maintenance to remain healthy. Planted areas require more continuing attention (like a garden) and do not have the same potential to recover naturally from future disturbances such as fire. Inappropriate clearing and planting can irreversibly damage the nature of a bushland site and undermine its natural recovery potential. It is better to wait until resources are available to treat the site properly with ongoing follow up than to jump in, clear and plant and thus destroy its potential to ever regenerate naturally (and in NSW, any work in endangered bush must first be approved by the Office of Environment and Heritage).

Bushland in or near urban areas is often disturbed and degraded but it still has many values. Even small patches of remnant bushland are of scientific and educational importance. They provide information about the original natural environment of that area, including its species, their distribution and relationships. Natural ecological interactions between soils, slope, aspect, exposure, rainfall, plants and animals, can be studied in local bushland. In our enthusiasm to see native plants returning to replace weeds, we need to be careful not to cause any unintentional damage. Planting will usually distort the unique character of a bushand remnant, whereas assisted natural regeneration will conserve its intrinsic values.

1.3 Replant last

Planting is sometimes seen as a quick and easy solution to the challenge of restoring bush but it is not necessary where natural regeneration potential exists. Indeed, planting in such sites can work against the aims of restoration by interfering with regeneration. There are some sites which are so highly degraded or altered that natural regeneration is unlikely. In this case planting can be useful but the plants should be grown from seeds or cuttings collected on or near the site to be planted. Planting should only be considered after the site's natural ability to recover has been assessed as very poor - often where long-term disturbance has occurred. Examples of sites which might require planting are areas of fill and sites which are affected by stormwater inflow. Where planting is carried out, good records and maps must be kept so that these areas can be identified in the future.

1.4 Reasons for planting

Planting can be an important component of an ecological restoration project where natural regeneration alone is not sufficient to achieve the desired result. In severely modified sites, such as bare paddocks, planting may be the only way to achieve native vegetation cover (within a reasonable timeframe).The aim of planting projects should be to establish viable, self-sustaining populations with evolutionary potential to adapt to environmental change over time. Planting that is poorly planned and implemented can result in poor conservation outcomes including low success rate, unviable populations, and potential risks to natural populations. Consider carefully whether to plant, as inappropriate planting projects can have unintended outcomes, be of limited ecological value and often do not compensate for losses.

Natural regeneration is usually more cost effective and will often produce more ecologically valuable results. Bush regeneration techniques usually assist natural regeneration by removing threats such as weeds. The adequacy of the regeneration response will depend on the extent of degradation and availability and quality of seed sources nearby. Often, additional planting is unnecessary, but sometimes enrichment is desirable. Planting may also be needed to consolidate edges and provide windbreaks or frost protection, or may be combined with bush regeneration techniques in other ways.

Reasons for enrichment planting could include:

- Adding species that historically are known or highly likely to have been present in the local area (but consider that many species occur naturally in low population sizes, scattered across the landscape)
- Improving viability of populations with low numbers
- Adding plants for species that are poorly represented and/or have ineffective breeding units (only one specimen of a dioecious plant, a monoecious plant or a self-incompatible bisexual species)
- Correcting balances in species composition (e.g. where one or a few species are unusually dominant and the species composition is unusually low)
- Improving food resources for fauna (e.g. koala, rainforest pigeons)
- Improving shelter resources (e.g. dense low growing sedges and shrubs for ground dwelling birds such as the bush hen).

(Source: Byron Shire Council January 2010 with Landmark Ecological Services Pty Ltd and Bower Bush Works. *Byron Shire Bush Regeneration Guidelines*)

Revegetation may aim to increase the size and extent of native vegetation patches and to increase the connectivity of native vegetation across the landscape. It may also aim to incorporate species that have been lost back into an area. For example, natural regeneration may stimulate the growth of plants from the soil seed bank (of species which have a lengthy seed viability) or of plants which are distributed by birds. Wind dispersed species will only travel a certain range. Some species may have seeds which are short lived or distributed by fauna now absent from an area. These species may be under represented. Planting of species missing from a disturbed ecosystem may restore closer to original species composition. Revegetation can contribute to conservation of regional biodiversity and increasing carbon stores.

2 Web-based resources

2.1 Florabank guidelines

Florabank was developed and delivered by Greening Australia in collaboration and partnership with a range of other organisations, in response to recognition that native seed availability was limiting the scope and biodiversity of restoration projects around Australia.

Florabank seeks to provide current information about Australian native seed. Florabank is an initiative of the Australian Government, Greening Australia and CSIRO. Greening Australia has been funding Florabank since mid 2008. First published in 1999 and 2000, the ten Florabank guidelines are the Australian benchmark for best practice for seed collection and use. Updates to existing guidelines and some new guidelines will be added to these web pages as developed.

Copies of Florabank Guidelines can be accessed through: http://www.florabank.org.au/

The ten Florabank guidelines include:

1. Native seed storage for revegetation
2. Basic methods for drying, extraction and cleaning native plant seed
3. Improving on basic native seed storage
4. Keeping records on native seed
5. Seed collection from woody plants for local revegetation
6. Native seed collection methods
7. Seed production areas for woody native plants
8. Basic germination and viability tests for native seed
9. Using native grass seed in revegetation
10. Seed collection ranges for revegetation

Florabank has also developed a model code of practice for community-based collectors and suppliers of native seed.

2.2 Millennium seedbank

The Florabank guidelines are referenced from the Millennium Seedbank at Kew Royal Botanic Gardens. See information sheets for advice on collecting and storing seeds for conservation. Information sheets are available on:

1. Protocol for comparative seed longevity testing
2. Assessing a potential seed collection
3. Seed collecting techniques
4. Post-harvest handling of seed collections
5. Measuring seed moisture status using a hygrometer
6. Selecting containers for long-term seed storage
7. Low-cost monitors of seed moisture status
8. Small-scale seed drying methods
9. Equilibrating seeds to specific moisture levels
10. Identifying desiccation-sensitive seeds
11. Seed bank design: seed drying rooms
12. Seed bank design: cold rooms for seed storage
13. not yet published
14. Cleaning seed collections for long-term conservation

Copies of these information sheets can be found at:
http://www.kew.org/science-research-data/kew-in-depth/msbp/publications-data-resources/technical-resources/technical-information-sheets/index.htm

2.3 Australian seedbank partnership

The Australian Seed Bank Partnership's mission is to safeguard Australia's plant populations and communities by developing a national network of conservation seed banks. Collecting and storing seed in seed banks can assist in combating the global decline of plant biodiversity. It offers an insurance policy against the further extinction of plant species.

The Australian Seed Bank Partnership focus on collecting and storing seed to conserve biodiversity and building and sharing knowledge to support restoration and conservation activities across Australia. The partnership unites the expertise of fourteen institutions, including universities, herbaria, botanic gardens, non-government organisations and state environmental agencies.

See: http://www.seedpartnership.org.au/

Project planning and site assessment

3.1 Site restoration planning

Growing and establishing native plants is one of many actions which can contribute towards achievement of ecosystem restoration. Following a plan can greatly increase the effectiveness of work. A plan may include a combination of activities such as:

- bush regeneration works to systematically control weeds and assist the natural regeneration of native vegetation
- propagation of plants from local seed and revegetation of very degraded sites with low resilience and limited potential for natural regeneration.
- construction of paths, boardwalks, viewing platforms and interpretative trails
- erosion and stormwater run-off control
- monitoring flora and fauna

3.1.1 Site assessment

In order to decide what actions will be most effective, an assessment of the site can be carried out to identify strengths and weaknesses. This would include looking at:

- what remnant native vegetation is present?
- what has caused disturbance to the site?
- what factors are restricting the natural regeneration of the native vegetation? (e.g.: weeds out competing natives, lack of native seed in soil, erosion problems)
- what weeds are present?
- will native plants grow naturally on the site once inhibiting factors are controlled? If this is the case it may be unnecessary to propagate and plant.
- what is the fire history of the site?
- are problems being caused by uncontrolled public access across the dunes?

Useful references for this assessment include *Bush Regeneration*, (R. Buchanan), V*egetation of Australia* (Beadle) and *The Bush* (Ian Read).

3.1.2 Bush regeneration and planting options

Carrying out a site assessment can give an indication of whether the area has good natural regeneration potential. If this is the case, most work can focus on bush regeneration to assist this process. The site assessment may show that an area is very degraded or exposed and has little natural regeneration potential. Planting may be necessary in these situations.

The potential for regeneration is increased if there is remnant native vegetation nearby. Seeds are likely to be naturally dispersed to your site.

Bush regeneration involves strategically controlling weeds to assist remnant native vegetation to regenerate. The seed of many native species is incredibly resilient and will swiftly germinate once weeds are removed. The native plant community will provide improved habitat and attract fauna. Birds and other animals will bring in additional plant species (including weeds which will need to be controlled on an ongoing basis).

Often an area may have an unexpected ability to recover without the need for planting. Carrying out bush regeneration work in a trial area can allow results to be observed over time. Plants which germinate naturally on site are likely be suited to the area.

Encouraging natural regeneration can be more cost effective than purchasing, propagating, planting and maintaining trees. By working with the natural system, the best and most sustainable results will be achieved.

It is important to have a clear idea of what the original vegetation was composed of and to aim to re-establish this. Some of the plant species required may not regenerate naturally. Native species from local seed are often unavailable in commercial nurseries. Groups may decide to propagate plants to meet this need.

Mistakes can be made with both bush regeneration and planting. Volunteers want to see a result at the end of their day's work. Enthusiasm and excess energy in weed removal can sometimes cause problems.

Large areas of weeds such as Bitou or Lantana, can be removed relatively quickly. These weeds may be performing an important role in the protection of understorey species and fauna of the remnant. Other weeds, which are more difficult to control (such as Glory Lily) may take over an area. Rapid clearing of weeds in and around a littoral rainforest may increase exposure to salt ladden winds. This can damage the native vegetation.

A gradual, systematic approach to removal of weeds is recommended. Ongoing control of weed will be required as regeneration progresses. Courses in Conservation and Land Management are available through some TAFE colleges. Interested individuals can gain increased understanding, knowledge and practical skills through completion of such courses.

3.2 Species selection and genetic integrity

If the project is aimed at biodiversity conservation it is important that the correct species are introduced or allowed to re-establish. Using locally occurring species to reconstruct or enrich native vegetation is important, as is using suitable genetic stock. Planting species from outside the area can provide attractive landscaping but may be damaging to remnant native plants and animals. The aim of species selection for planting projects should be to re-establish vegetation communities likely to have been present prior to land clearing and disturbance.

A plant species may grow over a wide area. In each area the species will vary slightly as it has adapted to local conditions. This may include coping with flooding, frost, a certain type of soil, and exposure to salt laden winds. A plant of the same species but from the next isolated valley may have a completely different set of adaptations and will not grow well outside it's local area. The plants may look the same, but their genetic structure is different. Maintaining local genetic types is a necessary part of preserving all the genetic variability within a species, and thus retaining the potential for future evolutionary change and response to changing environments.

To maintain the conservation value of a site it is important to use local seed in plant propagation. Plants spread by birds may have a wider local range than those dispersed by wind. Generally, the closer seed is sourced to the project site, the greater the chance that plants produced will be suited to the site. In this way, genetic integrity can be maintained in planted areas. Consider the natural dispersal capacity of the species when determining if a seed source is local or select seed from within the same catchment.

3.2.2 Keeping collection records

Thorough documentation is essential to ensure the integrity of the seed which has been collected. The documentation should include:

- Site where seed or material was collected.
- Site characteristics.
- Number of trees sampled.
- Amount of seed.
- Species collected.
- Collectors name.
- Soil type.

It is also important to record details such as flowering and maturation times of species present.

Plate 1: Labelling propagation trays

3.2.3 Legal aspects of seed collection

Contact the Office of Environment and Heritage (OEH) NSW National Parks and Wildlife Service to find out who the appropriate authority is and what permits are required to collect seed.

In NSW, native plants are the property of the landholder. However, in the interests of maintaining biodiversity and ecological sustainability OEH has a statutory responsibility to regulate and coordinate the use of protected and threatened native plant species. These plants consist of:

- species which are listed as protected plants in Schedule 13 of the NSW National Parks and Wildlife Act (NPWA).
- native plant species or populations, or plants from Endangered Ecological Communities listed under the NSW Threatened Species Conservation Act 1995 (TSCA)
- plant species individually listed under the Commonwealth Environmental Protection and Biodiversity Conservation Act 1999 (EPBCA).

There are no licensing requirements for:

- the use of protected native plants that occur naturally or are cultivated on a person's property for non-commercial purposes (note this does not apply to threatened species listed under the Threatened Species Conservation Act 1995).

- the commercial use of species that are not listed as protected or threatened in NSW. However there may be restrictions on the removal of vegetation on your property under the Native Vegetation Act 2003 or Tree/Vegetation Management Orders under the Local Government Act 1993, so check these out before taking any other action.

On Crown Land you will be required to obtain a Deed of Indemnity for a specific portion. In a National Park you will require a Scientific License issued by OEH. On land subject to Aboriginal land claim you will need permission from the appropriate Land Council. Permits may also be required to collect on private land, in addition to permission from the owner.

Fruit and seed play an important part in the diet of many animals. In addition to the animals, which directly eat fruit, other species further up the food chain (such as carnivores, which prey on fruit eaters) are ultimately dependent on such fruits.

3.3.4 Recommended seed collection practices

The seed collector should consider the amount of seed that can be taken from an area, or specimen, without damage to the local ecology.

- How many fruiting examples of the species are there?
- Is this a valid representation of the original population?
- Are there many juvenile examples present?
- Is it a protected species (see list in appendix)?
- Are the fruit being eaten on by birds and other animals?
- Do you know how to prepare and propagate the species?
- How many plants of this species does your project require?

Some excellent advice on other seed collecting considerations are detailed by Darcy Duggan of the Indigenous Flora and Fauna Association. When working in an area:

- Move carefully and watch where you walk to avoid damage to native ground flora.
- When collecting seed from shrub and overstorey species, minimise damage to vegetation through excessive pruning or breaking foliage.
- If working with a group, spread out over the site. Small groups are preferable compared with large groups of enthusiastic well intentioned people which can inadvertently cause a lot of damage to the sites.
- Carefully select sites to suit the skills level of groups. Especially sensitive areas should be avoided when working with inexperienced groups such as schools.
- Exercise caution when disclosing the location of rare or endangered species to minimise the loss of these sites through “poaching”. Ensure collection of seed or propagating material of these species is undertaken by experienced and trusted collectors.

It is generally considered that no more than 20% of seed should be removed from a site or individual plant. Care should be taken not to damage the plant when collecting material. This includes using sharp clean tools and employing good pruning techniques that will encourage, not hinder, future growth.

Propagating Plants Safely

4.1 Safety Guidelines

There are some safety issues associated with the propagating of plants. It is important that you are aware of these issues and make allowances for your personal safety and the safety of others.
Personal Protective Equipment (PPE) should be used when required but PPE will not protect you from poor workplace practises.
Things you can do to keep yourself safe include:

1. Wear appropriate cloths for outdoor activities including hats, collared long sleeved shirts and protective footwear.
2. A hard hat may be required if collecting seed from trees
3. Always keep a safe distance from fellow workers
4. Keep an eye out for insects, spiders snakes etc when collecting propagation material
5. Always use safe lifting techniques
6. A first aid kit should be close by at all times and a qualified first aider on site

4.1.1 Handling Potting Mixes

When you handle garden soils, compost and potting mixes there is a potential risk of contracting legionellosis, or Legionnaires' Disease. Legionellosis is a respiratory (lung) infection, caused by the Legionella bacteria. The severity of legionellosis can range from a relatively mild respiratory non-pneumonic illness (Pontiac fever) to pneumonia (Legionnaires' disease) which if left untreated may be fatal. Few who come into contact with the bacteria become sick and symptoms will vary from person to person.
To avoid the risk of contracting legionellosis from soils, compost and potting mix, here are the precautions you should take:

- Water gardens and composts gently, using a low-pressure hose.
- When opening bags of composted potting mix, do so slowly, making sure the opening is directed away from your face.
- When potting plants, wet the soil to reduce dust.
- When working in greenhouses, potting sheds or indoors, make sure that the working area is well ventilated.
- Wash your hands carefully after handling soils.

Ordinary garden soil and products like compost and potting mix may contain a variety of living micro-organisms, some of which on rare occasions can cause illness in humans.
Serious harm is rare. However, for older people or those with reduced immunity, infection can be life threatening. We recommend the following precautions:

- Avoid opening bags in enclosed areas
- Avoid inhaling the mix
- Always wear gloves and wash hands after use.

1.2.1 Safety check list

Long trousers, shirt and safety boots	  
Hat and gloves	 
Sunscreen, insect repellent and glasses	 
Dust mask	
Water	
First aid kit	

Adapted from Nursery Industry Australia

4.3 Tools Required

Buckets		**Fine Nozzle spray**	
Trowels		**Hoses**	
Dibble stick Use ice cream stick, labels or small spoon		**Watering Container**	
Secateurs		**Potting mix**	
Hand garden forks		**Fertiliser**	
Plant labels		**Rooting hormone**	
Pencils		**Broom**	

Knife		**Bleach**	
Wheelbarrow		**Methylated spirits**	
Shovel / Spades		**Trays, pots, tubes**	
Sieve		**Hand float**	

Adapted from Nursery Industry Australia

4.4 Hygiene in plant propagation

Plant propagation is a rewarding process in nursery production. However, the opportunity for pest and diseases to severely impact on propagation success should not be underestimated. Poor hygiene in plant propagation can lead to complete propagation failure or retardation in plant growth. Hygiene matters in all stages of propagation.

4.4.1 Cutting and seed collection

- Use purpose built stock beds or plants in pots
- Ensure stock plants are well fed, watered and free from pests and disease
- Take material from the middle or upper part of stock plants. Do not take from lower parts that might receive splash or come into contact with the ground
- Collect early in the day or in the evening to reduce plant stress
- Use clean secateurs and disinfect between plants – a plastic bottle with a 70% methylated spirits solution works well.
- When collecting propagation material, use new, clean, tagged and separate bags/containers for each variety.
- Always ensure you are clean before returning to the nursery if you go off site to collect material. This includes clothes and, in particular, footwear and tools.

4.4.2 Cutting preparation

- Ensure hands are clean,
- Use clean and disinfected secateurs, cutting tools and containers
- Surface sterilise cutting material (if required)
- Clean and disinfect the tool holders (eg. Pouches or containers)
- De-cant cutting hormone or powder into a smaller container so you can throw it away when finished with a batch
- Disinfect tools between batches or regularly if large batches – a plastic bottle with a 70% methylated spirits solution works well.
- Clean and sterilise benches and other working surfaces before and after use
- Use only clean, healthy and disease free material
- If required, drench with a fungicide

4.4.3 Propagating

- Use only new, premium grade propagating mix that is known to have been prepared and stored hygienically, such as from an accredited growing media supplier.
- Use new trays/pots or tubes. If you must re-use then ensure they are sterilised properly, washing alone is not adequate.
- If dibbling – use a clean and disinfected dibbling stick.
- Ensure the propagating area is free from weeds, liverwort and moss.
- Ensure the propagating area is free from pests and diseases.
- Do not over wet propagating material and promote air movement.

4.4.4 Benches and other working surfaces

One of the most fundamental requirements for healthy propagation is the cleaning and sterilisation of benches and other working surfaces between crops or batches. This must be done religiously, regularly and properly, which means cleaning first and then sterilising. As a result, benches and other working surfaces need to be made of an easily disinfected surface, for example stainless steel or laminate. Timber and other porous surfaces cannot be sterilised properly, however, covering them in a plastic sheet can help maintain hygiene standards.

Plate 2: Clean sterile working surfaces are essential for successful propagation

4.4.5 Floors and pathways

Always keep floors and pathways clean and weed free. Moss and liverwort should be constantly removed. Concrete floors and pathways may incur a high initial outlay, but maintenance costs are minimal. Weed mat or plastic over gravel may incur a lower initial outlay than concrete, but can result in significantly higher maintenance costs.

5 Plant propagation techniques

5.1 Why grow native plants?

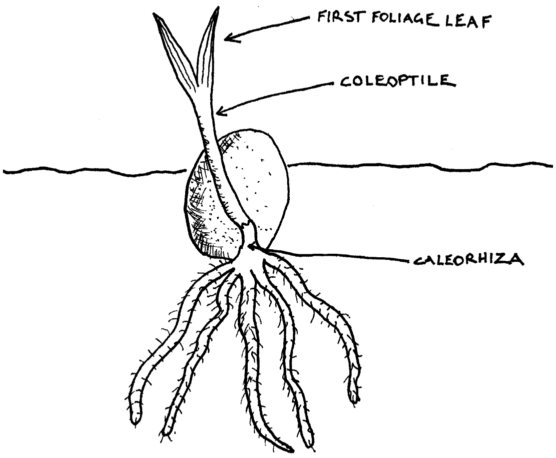
Ecological restoration includes a range of activities to tackle the causes of environmental degradation. On-ground activities include bush regeneration in remnant vegetation, revegetation, controlling weeds and erosion and construction of fencing, paths to protect vegetation.

On sites where planting is required, there is significant environmental value in using local native plants grown from local seed. Plants available from nurseries may be limited in the range of species and often the source of seed for these plants is not known. Some of the benefits from using local native species in environmental restoration work include:

- The conservation and restoration of original native plant communities is assisted. Plantings should be representative of what naturally existed on the site. Introduction of plants from other areas can cause problems (plants may become weeds, plants may not regenerate and only last the life of the planting etc.).
- Local animals depend on local native plants. Habitat for birds, mammals, reptiles and other fauna is improved.
- The use of local seed means that plants are suited to local conditions.
- The genetic integrity (to be discussed later) of the vegetation community is maintained.

5.2 How a seed works

Plants propagated for restoration projects are in most cases Angiosperms (flowering plants) and can be divided into two large classes, Monocotyledon (Monocots) and Dicotyledon (Dicots). Monocots, on germination, initiate only one seed leaf (cotyledon) and can be subsequently recognised by linear leaves with parallel venation and a fibrous root system. Examples of Monocots are palms, grasses and lilies (Figure 1). Dicots initiate two seed leaves and can display pinnate, palmate or reticulate venation; the root system stems from a branched primary root (tap root). Examples of Dicots are Eucalyptus, Acacia and Ficus (Figure 2).



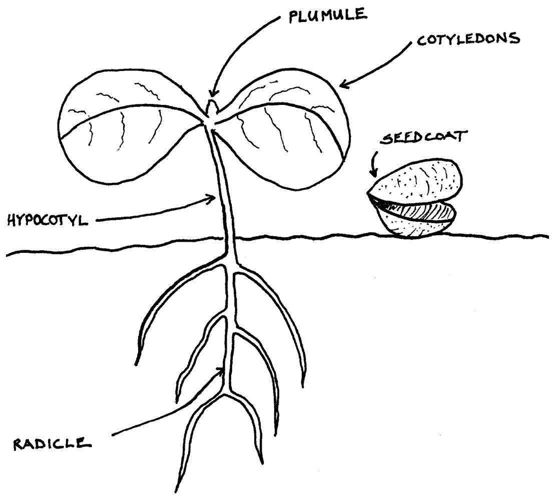
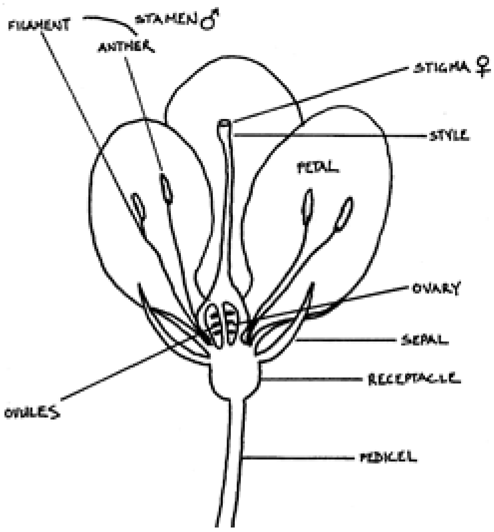


Figure 1:*Germination of a monocot*

Figure 2*: Germination of a dicot*

Angiosperms produce a wide variety of flowers to attract specialised insect or animal pollinators (as opposed to the more primitive Gymnosperms that depend on wind for pollination). When the plant has successfully attracted its pollinator, the conspicuous parts of the flower become superfluous and are shed. The fertilized ovules within the ovary increase in size - becoming seeds - while the ovary itself becomes a fruit. (Figures 3 & 4). When the seed is fully formed the fruit will be in a mature state and will either fall to the ground, to be ingested by an animal disperser, or split open upon the plant to release seed that is dispersed by wind, water, gravity or adherence to an animals' fur.

If large amounts of fruit fall and are not dispersed they could, upon germination, lead to serious competition for the parent plant. To overcome this most plants can inhibit this germination by either heavily shading the area within the drip line or through the introduction to the soil of subtle chemicals via root exudates or fallen leaves that prevent the germination or inhibit growth of the same species. This is known as an allelopathic influence.



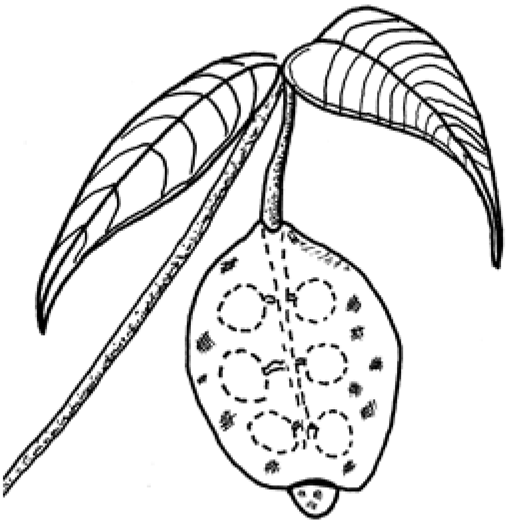


Figure 3: *The parts of a flower*

Figure 4: *Seed formation in the fruit*

5.3 Requirements for germination

If we are to successfully propagate material, it is necessary to consider the actions which seed is subjected to by its natural environment. Over 50% of Australian native seeds require some sort of pre-treatment to remove inhibitors and release the seed from dormancy. Factors in nature that overcome these chemical or physical inhibitors include fire, shifting sands, prolonged soaking, extreme temperatures and the stomach actions of animals. The propagator can simulate all of these influences; methods will be discussed in detail later in this text. The following material has been adapted from *Growing Australian Native Plants from Seed* by Murray Ralph.

The most basic requirements for germination are:

Oxygen: Most seeds require a regular supply of oxygen. The growing structure must be well ventilated and the propagation mix contain plenty of coarse particles to ensure drainage and air circulation. (Details follow in propagation mixes).

Water: The initial roots of a seedling are very small and susceptible to water stress. The propagation mix should contain material that has some water holding capacity and must not be allowed to dry out. Too much water and not enough drainage / aeration may lead to fungal problems resulting in seedling loss. Some seeds benefit from soaking in water before propagation. This can remove chemical inhibitors, soften seed coatings and drown invading insect larvae. Some seed that has been initially soaked should be dried before sowing to prevent fungal problems (see notes on specific genus).

Temperature: All species have an optimum temperature range at which they germinate e.g. plants from alpine regions will have different requirements than those from the tropics. In the sub-tropic region that this manual addresses seed is best sown fresh (as it matures) so optimum temperatures should be apparent. Many plants will stop growing at temperatures above 35°C.

Some propagators use thermostatically controlled heat pads beneath their containers to stimulate rapid germination. This is particularly appropriate if growing plants from cuttings (vegetative reproduction).

Light / Darkness: All plants have different light requirements for optimum germination. In most species light enhances germination but in others it will inhibit development. A rule of thumb for the correct sowing depth of seed, is to cover it with a layer of media equal to the radius of the seed.

If this method continually fails, attempt to locate and observe the subject seed germinating in its natural environment e.g. *Castanospermum australe*, a large seed, germinates amongst the leaf litter of rainforest with most of the seed exposed.

5.3.1 Stages in seed germination

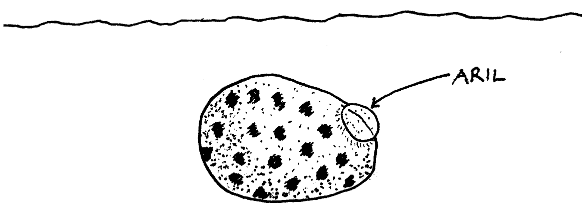


Figure 5: *Seed absorbs moisture*

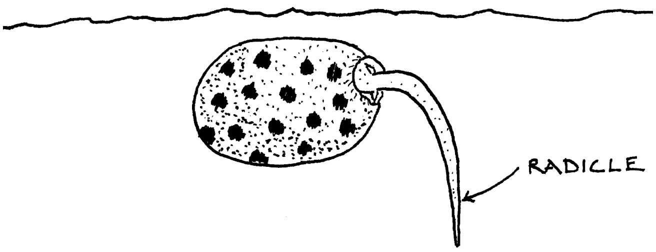


Figure 6: *Seed coat cracks and roots emerge*

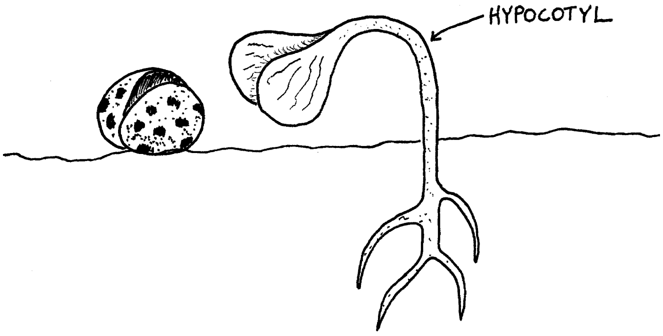


Figure 7: *Roots penetrate further into soil*
Stem and seed leaves emerge.

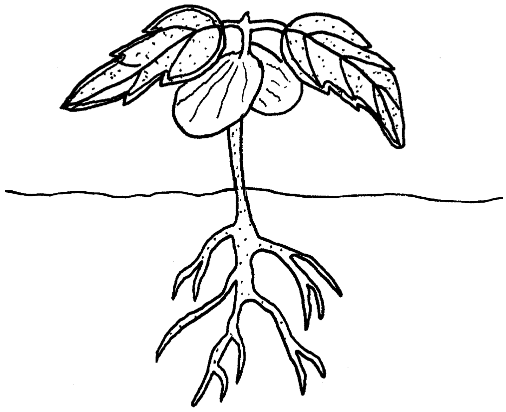


Figure 8: *True leaves develop*

5.4 Overcoming inhibitors

Many native plants produce seed equipped with hard seed coatings. It is necessary to soften this coating before germination can begin. In the wild this occurs through weathering, occasional flooding and violent temperature change.

For example: Coastal heath on the north coast will have flowered and produced seed in the winter months of June, July, August, then follows a prolonged dry period with little germination. The fuel load of the heath increases as grasses and annuals deteriorate. In the summer we experience electrical storms and a lighting strike may ignite the heath. The ensuing fire will stimulate certain species such as *Banksia aemula* into releasing seed. Chemicals within the smoke release others, such as *Patersonia,* from a chemical inhibitor. The heat will be transmitted through the soil to seed that has been buried by ants such as *Acacia* and *Boronia.* If there is lightning about, rain is likely to follow, completing the requirements for germination.

Some seed comes equipped with specialist mechanisms such as *Themeda* and *Erodium*, which have a tail-like attachment that, as it is wet and dries, screws the seed into the soil. Another example is *Boronia* which has a fleshy attachment known as an eleosome. This is considered good food by ants, who will drag the seed underground, detach the eleosome and then discard the seed in nutrient rich dumps within the nest**.**

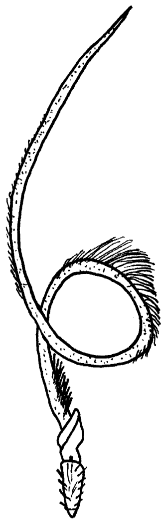


Figure 9*:* *An Erodium seed*
Family Geraniaceae

5.5 Seed Treatments

5.5.1 Hard Seeds

Many hard seeds respond well to soaking in hot water. Water should be brought to the boil and then poured over the seed in a container and allowed to soak overnight. By the next day the seed should have swelled in size and become lighter in colour. If this has not occurred, continue soaking. Seed that floats should be discarded, as it will not be viable. Drying the seed before sowing can reduce the likelihood of fungal diseases. This method works well for *Acacia* and *Parchidendron.*

Some seed requires the hard coating to be physically breached so that it can start imbibition. This can be done in a number of ways.

1) Nicking the seed coat with a pair of nail clippers.

2) Scratching the seed coat by rubbing the seed between sheets of sandpaper. (simulates slow weathering action of shifting sands)

3) Cracking the seed coat by slowly exerting pressure in a vice, this works with *Eleocarpus* and *Macadamia* species. (rolling and crashing river stones in times of flood)

4) Acid Treatment. (simulates the stomach action of birds). Undiluted commercial grade sulphuric acid (95%, 36N) is considered to be the most effective of chemical treatments. To carry out the treatment dried seed is completely immersed in undiluted acid at about 120ml per 100 grams of seed for a duration ranging between 20-60 minutes depending on seed coat thickness. Note that extreme caution should be exercised when handling acid. A solution of sodium or potassium bicarbonate should be at hand to treat any accidental contact with the skin. If diluting, add the acid slowly to stirred water, not water to the acid or it will boil explosively. After treatment the seed should be thoroughly rinsed in running water for 5 to 10 minutes.

5) Germination in some species such as *Polyscias elegans* is noticeably improved after passing through the intestines of a bird. I have known a nursery owner to attempt an equivalent using her own intestine but with no recorded success. It may be simpler to look for bird droppings under fruiting trees and extract the seed from these.

5.5.2 Removing fleshy fruit

The removal of flesh from around a seed may hasten germination. If it is weakly adherent, e.g.: *Dianella*, rub the fruit on a wire sieve to separate seed. If it is difficult to remove flesh, place the seed with some water in a plastic bag and hang in the sun. Fermentation will occur and after 2 to 3 weeks the fruit is easily removed. This is an appropriate treatment for many species of palm. The fruit of some palms can be strongly acidic and can burn skin or eyes if mishandled.

5.5.3 Leaching

Chemical inhibitors can be removed from some species by prolonged immersion in running water. The ideal way to do this would be to secure the seed in a mesh bag in a running stream. If this facility is not available an alternative is to place the seed in mesh or a stocking and place in the cistern of a frequently used toilet for 1 to 10 weeks (Figure 7). For some species within the family *Rutaceae*, soaking in an alkaline solution (pH9) has been found to overcome chemical inhibitors, reducing the need for long periods of leaching.

5.5.4 Smoke Treatments

The chemicals within smoke play an important role in stimulating some seed (notably of heath plants) into germination; examples are *Patersonia, Actinotus* and *Pimelea*. This can be done by burning a mixture of dry and green plant material and then directing the smoke into a structure holding the seed, either naked or sown in trays. The treatment should be carried out for an hour, longer treatments may retard germination. The smoke should not be too hot as this may damage the seed. Water seed trays sparingly after this treatment to avoid leaching out the smoke chemicals.

The device pictured below (Figure 10) is an ideal way to carry out this treatment but there is plenty of room for improvisation. The chemicals from smoke can be trapped and stored by pumping smoke through water, then use the impregnated water to moisten the seed trays.

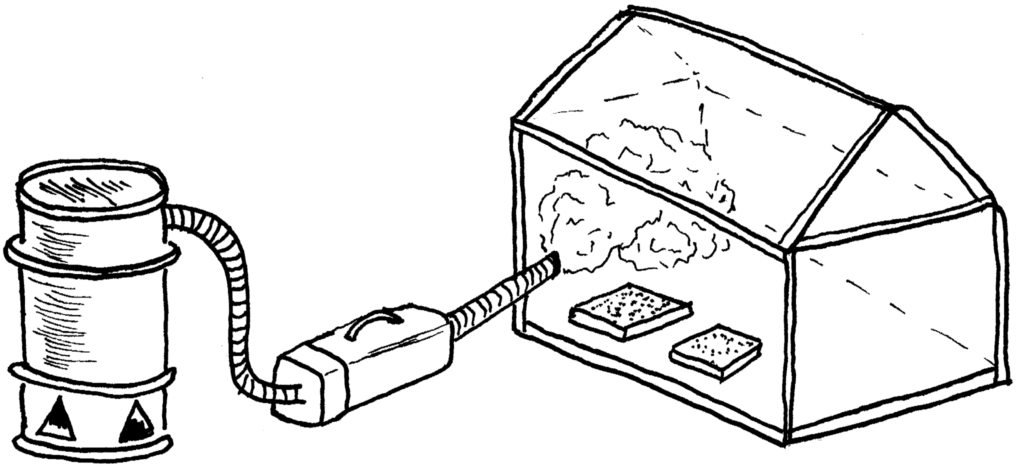


Figure 10: Treating seeds with smoke (adapted from Ralph, 1997)

Figure 11 and Figure 12: Alternative methods for treating seeds with smoke

5.5.5 Opening Banksia Fruit

Many species of local Banksia such as *B. aemula, B.serrata* and *B. ericifolia* will not release seed until the fruit is burnt. A very satisfactory way to stimulate this is simply to pile up collected cones, pour methylated spirits over the pile and ignite. The cones will flare briefly and then smolder for a while, before your eyes you will see the valves of the fruit open.

When fruit cools down, knock them into a tray (avoid a windy area), remove and discard the woody separators and sow seed shallow in a sandy mix. The smoke and heat from this method can be further utilised by treating another species at the same time; for example a metal sieve of *Patersonia* seed can be waved over the fire to introduce scorching.

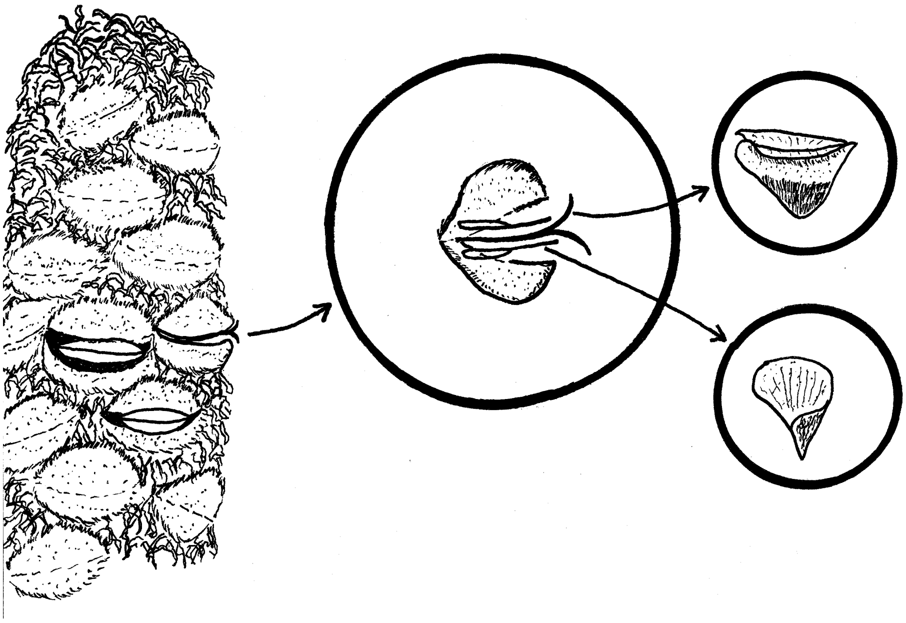


Figure 13: Banksia fruit showing separator and winged seeds

This method has been used successfully with unripe *Banksia integrifolia*, which would not normally require fire to open. Banksia can also be forced open by placing fruit on a BBQ plate or into a hot oven on a metal tray (but it is not nearly as spectacular as the fire method).

5.5.6 Drying woody capsules to release seed

This system is useful for genus that retain their seed or release it all very quickly (often when the collector is not about), examples are *Petrophile, Acacia, Eucalyptus, Melaleuca* and *Callistemon.* Collect fruit when it appears ripe or very close to it. Place in labelled paper bags and then leave it on the dashboard of a car for a day or two. Observe regularly and sow or store as soon as released.

If collecting this type of seed on a larger scale, it may be appropriate to build a specialist drying cabinet (well ventilated with gauze shelves) or to spread fruit on sheets in the sun until opened.

5.5.7 Wetland method

This method may be useful for wetland species. Seed is sown into punnets containing a high content of organic matter, these punnets are then placed in a container of water to a level about 1cm below the seeds. After a week, lower the water level to 2-3cm below the seed. After germination remove the punnets from the tray and water as normal.

5.5.8 Multiple seed treatments

There are still many native genera and species where the secrets of breaking dormancy are still unknown. It may be the case that the seed requires a combination of treatments. There is plenty of room for experimentation by plant growers but the truth will most often be found in close observation of the desired species and its interactions with its ecology.

Don't commit all of your collected seed to a particular method until you have trialed a small batch.

The majority of native seed found in northern NSW is best sown very fresh, particularly rainforest species. Exceptions are some of the heath species that, if properly dried and treated against insects, can be stored for some years.

5.5.9 Seed Storage

Seed to be stored should be well dried in paper bags or open trays placed in sunlight and breeze. Separate seed from other matter by putting through a set of sieves or winnowing. Next, find the smallest jar or container that will accommodate the amount of seed you have collected. You want minimal air left in the jar when full.

To avoid damage caused by insects that may hatch in stored seed, glue a small piece of Shelltox© pest strip or similar (Naphalene flakes) to the inside of the lid. Label jars with relevant details and store in a cool place away from direct sunlight. Black film containers are ideal for small amounts of seed. Label jars with relevant details and store in a cool place away from direct sunlight. Useful information would include:

- Seed name
- Where see was collected
- Date of collection
- Name of collector

5.6 Vegetative reproduction

This process is also known as “cloning” or “taking cuttings”. It will not work with all species of plants but those that prove difficult will often produce abundant viable seed e.g. *Eucalyptus* & *Acacia.* Conversely, species that are hard to grow from seed are often easy to grow from cuttings (with exceptions such as *Persoonia* and *Acronychia*).

Plants grown from cuttings will display the same genetic features as one of the original parent strains from which the cutting came. This is of particular benefit to Horticulturists who, through a breeding program, have created a hybrid which displays particular characteristics such as form, flower colour or disease resistance. Hybrids such as Grevillea “Robyn Gordon” are sterile and produce no viable seed, while others may revert to the original strain if grown from seed.

Cutting-grown plants are not ideally suited to large scale use in bush rehabilitation projects as they may all come from the same genetic source and could decrease diversity within the local gene pool.

Vegetative propagation is an appropriate method where a species is under-represented or in danger of being lost altogether and viable seed is not available.

5.6.1 Collecting cuttings.

The plant you collect cuttings from should be characteristic of its species (if it's to be used in a bush regeneration project), be free of disease and insect problems and in an active vegetative growth phase, <u>not flowering or in fruit production phases.</u>

Collect cuttings ideally in the cool of morning and transport to the preparation area in wet newspaper, a bucket of water or a chilled esky (don't let material come into contact with ice). Cutting material may be stored for up to a week if bundled in damp newspaper soon after collection. It is a good idea to label the bundles, especially if you are dealing with several species.

5.6.2 Hygiene

Hygiene is a very important consideration in vegetative propagation. Sterilise of all implements and containers that are likely to come into contact with the cutting material by soaking in a mild bleach solution - one part bleach to 19 parts water - for 30 minutes. This can reduce the likelihood of pathogenic contamination. Media used for propagation may be sterilised by placing small amounts in an oven at 90°C for 30 minutes. Larger amounts may be treated by placing media in plastic bags and leaving in the full sun for 3 to 5 days, turning the bags daily.

5.6.3 Preparation of cuttings.

Basically there are 3 main types of cuttings used in the propagation of native trees, shrubs, herbaceous plants and monocotyledons.

1. Stem Cuttings

Stem cuttings is probably the most common method of vegetative reproduction and one which can offer a high degree of success depending on the species. Stem cuttings can be taken as: a) heel cuttings, b) tip cuttings, c) near-tip cuttings

a) Heel cuttings - possibly gives the least satisfactory result mainly due to the risk of lifting the cambium layer during preparation and subsequent fungal attack at the base of the cutting.

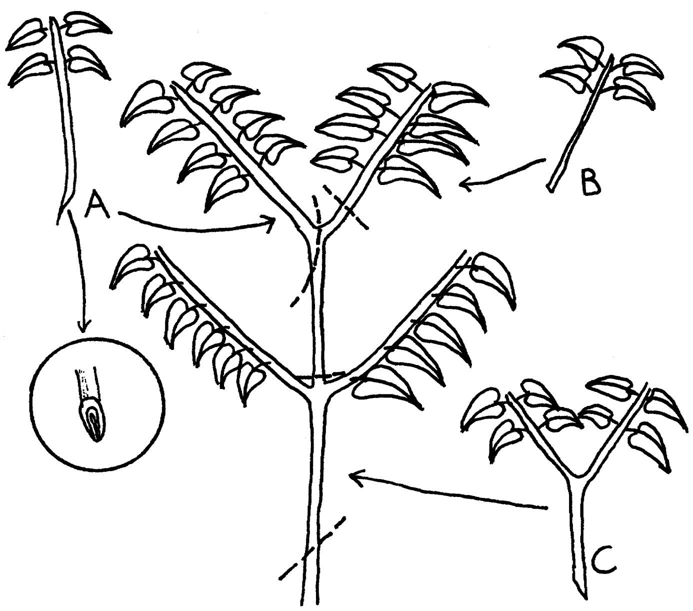


Figure 14: Stem Cuttings
A. Heel, B. tip, C. Near tip

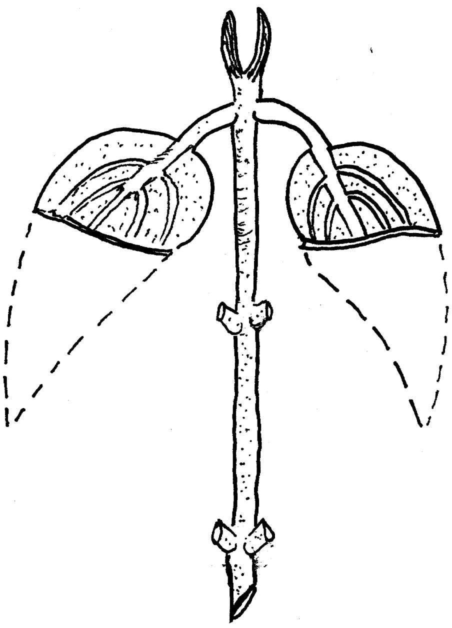


Figure 15: Preparation of cuttings from large-leaf species

Method: As with most other stem cuttings, the wood should be semi-hardwood and taken during summer and early autumn. Select a section of a branch with plenty of side shoots or branchlets.

a) Heel Cuttings - the heel area is that where the side shoot joins the main stem. Cut this side shoot down to roughly 10cm, making the cut above a node. The side shoot should be between about 3mm and 7mm thick. Carefully cut above the heel area, only cutting halfway through the branch and downward with a semi-circular cut finishing 1cm underneath the base of the side shoot. Reduce the leaf surface area by 1/2 to 2/3 (by cutting each leaf in half) on species with a large leaf. Species with a fine leaf may be carefully stripped. This type of stem cutting is best done with a budding knife.

b) Tip Cuttings - usually a very successful method with most species.
Method: As the term suggests, cuttings are taken from the tips of the branches and are usually from 5cm to 15cm long depending on the species. Make a cut below a node and at reasonably sharp angle to expose maximum cambium from which callusing should occur and then hopefully root development (Figure 11). Once again, remove 2/3 of the leaf area to reduce moisture loss. If the wood is semi-hard then a second cutting below the tip may be taken.

c) Near-tip Cuttings - semi-hardwood is preferable especially on woody shrubs.

Method: Make the top (distal) cut above a node at an angle ensuring the base of cut finishes above and behind the node. (Figure: 10).

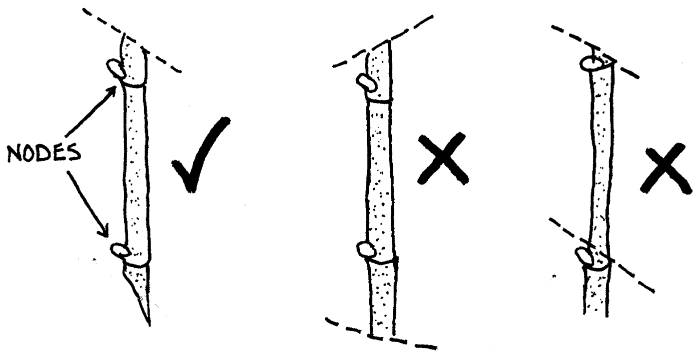


Figure 16: Near tip cuttings
Make the top (distal) cut above a node at a slight angle. Ensure the basal cut is beneath the node.

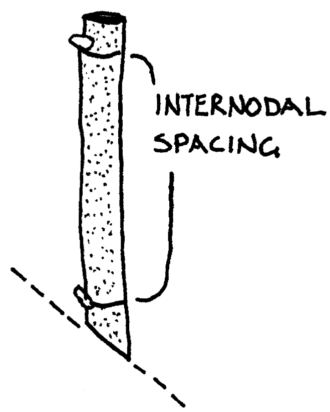


Figure 17: Sharp angled base cut

Make the cuttings about 7cm to 10cm long depending on the internodal spacing - these may be much longer in some species. The sharp-angled base (basal) cut is made below and slightly into a node - in most species this is where the root development will begin and some root stimulation may occur by slightly injuring the basal node. By making a sharp-angled base cut you will avoid the risk of accidentally setting the cutting into the media upside down (See figure 13*)*

Remove 2/3 of the leaf area by cutting large leaves or carefully stripping finer leafed species. Less importance is placed on the position of the lower cut in more herbaceous species as roots may develop from <u>between</u> the nodes as well as <u>from</u> the nodes.

Leaf Cuttings

This technique is mostly used on exotic species but has been successful in propagating *Peperomia*, *Drosera*, and *Hoya* spp.

Method: A single semi-mature leaf is set at a slight angle in the medium about 1cm deep usually with a small section of the petiole intact. A new plant will form at either the base of the petiole or where the lamina and petiole meet. Roots normally appear in 6 to 8 weeks.

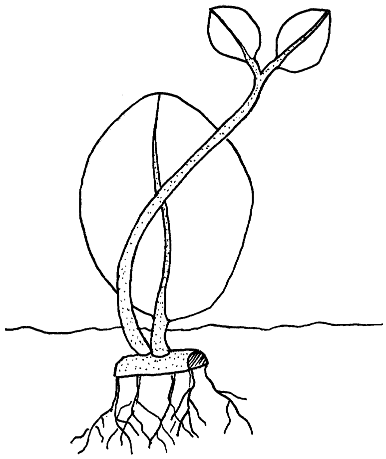


Figure 18: *Development of roots and shots on leaf cutting, Hoya australis*

Rooting Hormone

There seems to be little doubt that the success of cuttings is greatly improved with the use of growth stimulants or rooting hormones. These are commercially synthesised compound acid substances and are available as a dilute solution, a concentrated dip or powder.

Growers may firstly soak the prepared cuttings in a dilute solution of “hormone” and as the cuttings are removed the last centimetre or so of the stem is dipped in either a gel or powder form of concentrate before settings the cuttings in the medium.

The author has noticed best results using Clonex© “Purple” Gel for semi-hardwood cuttings and uses Auxinone© liquid for division and vine cuttings such as *Ipomoea pes-caprae*.

Always read the directions on the label.

Setting Cuttings

When setting the cuttings it is a good idea to moisten the medium beforehand as this gives better stability to both the medium and cuttings. A light watering afterwards helps to settle the particles around the cuttings also.

The spacing of cuttings is about 20 cuttings to every 10 square centimetres dependent on the thickness of the material. Very fine cuttings with small leaves such as *Baeckia virgata,* for example, can be set much closer than some species of the Proteaceous family having a thicker stem and much larger leaf.

Some people advocate the use of a small stick or dibbler when setting cuttings. While this may be time consuming it does reduce the likelihood of the rooting hormone being rubbed off, especially the powder form, dibbling also avoids the risk of the cutting being injured unnecessarily when being pushed into the medium.

The depth at which the cuttings are set will depend largely on the internodal spacing of the particular species. Ideally, a number of nodes set in the medium will have a greater chance of developing roots than a single node so try at least two nodes buried.

Keep your cuttings irrigated and warm, if possible, and hopefully you will soon have some new plants, identical to the parent or stock plant, grown by vegetative or asexual propagation.

5.6.4 Division

Propagation by division can only be practiced on certain types of plants namely grasses, irises and lilies or plants which produce suckers, stolons, bulbs, tubers or rhizomes. The advantage of this type of propagation is that the roots are already present. Suckers are removed from the parent plant with a sharp knife and placed in potting mix to establish, e.g. *Dampiera, Scaevola striata, Helichrysum scorpioides.*

Stoloniferous plants are cut from the parent plant and lifted from the ground and potted up, e.g. *Viola hederaceae, Hydrocotyle* spp., some *Goodenia* spp. Bulbs and tubers are usually removed from the parent plant after flowering and kept in fairly dry mix until the next growing season when watering can be increased, e.g. some *Thysanotus* spp., *Bulbine bulbosa* and some terrestrial orchids - *Pterostylis* spp.

Rhizomes are underground stems and vary in length from quite long, as in some exotic irises to very short as in the Kangaroo Paw. New plants are easily divided with the use of a sharp knife or spade and placed into pots e.g. *Cordyline congesta*, most *Dianella, Lomandra, Alpinia* and many native grasses.

5.7 Propagation mixes

These differ from general potting mixes in being of a finer consistency and often not containing any organic materials or fertilisers (the initial nutrients required by seedlings are contained within the cotyledons). You must have a material that has some water holding capacity as well as excellent drainage and air filled porosity. Typical mixes may be;

- 1 part peat moss to 2 parts course river sand (free of salt)
- 1 part vermiculite or perlite to 1 part peat
- 1 part sifted potting mix to 2 parts course river sand.

Hygiene is particularly important for mixes used in cutting production, commercially this is achieved through steaming or methyl bromide treatment of large quantities but small amounts can be sterilised using an oven, micro wave or solarisation (see Vegetative Reproduction for more details).

For some particularly difficult species it may be of benefit to incorporate into the propagation mix a small amount of the soil that is found around the original fruiting plant, this is thought to contain beneficial michorhizal fungi that may retard pathogenic fungi. Ground Eucalyptus bark from local species is also reputed to provide this benefit.

The chosen medium should be kept quite moist until germination and then watered less frequently as the seedling develops to encourage plenty of air around the roots. Seedlings are usually potted on as the second set of true leaves establishes.

Propagation mixes should have a pH of neutral to slightly acid, if germination repeatedly fails in your chosen mix try growing some radish seed which will usually germinate very readily, failure of radish seed will indicate a toxicity in the mix.

Punnets, trays or polystyrene fruit boxes (ensure adequate drainage) are commonly used to raise seed, the size of the container should be relative to the quantity and size of the seed. Clean these containers in bleach solution before use and avoid reusing old propagation mix.

5.8 Seed raising structures

Considered as the ideal for germination, is an environment that can provide warm roots and cool leaves. High tech commercial set ups may have heated benches, humidified interior, frost protection and CO2 injection (which can be economically achieved by brewing beer in your seedling house).

The seed raising structure should have some facility for ventilation and a maximum / minimum thermometer placed inside will give guidance as to when and how much ventilation is needed. Plants will stop growing at temperatures over 36°C.

An initial propagation structure can be readily constructed from household materials such as a remodeled tea chest, a piece of plastic and a tomato stake (see figure 19).

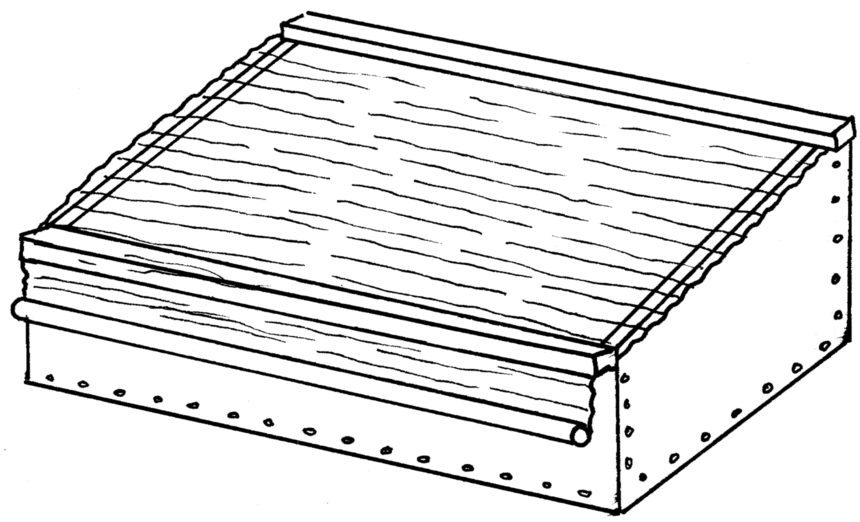


Figure 19: *Propagation frame with roll up heavy duty polythene cover*

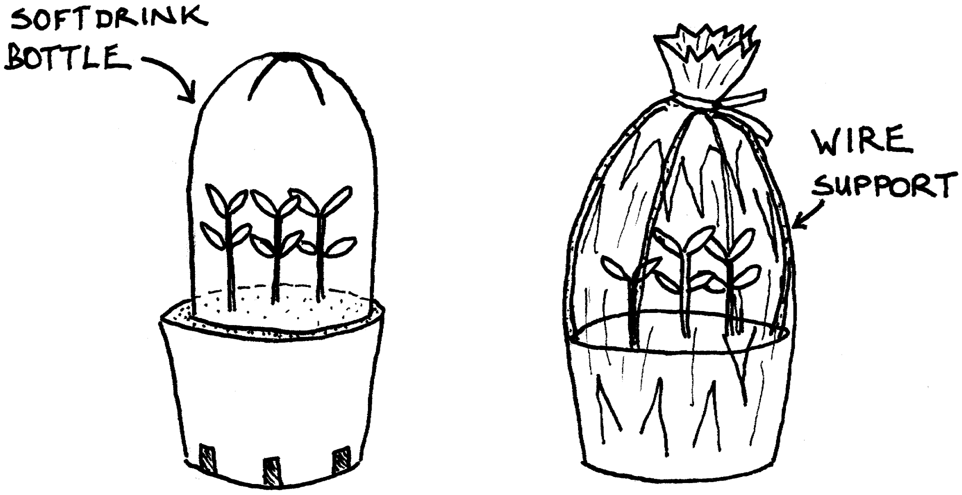


Figure 20: Raising small cuttings in a humid atmosphere

The success of vegetative propagation can be greatly enhanced by the setting up of a balance arm misting system.

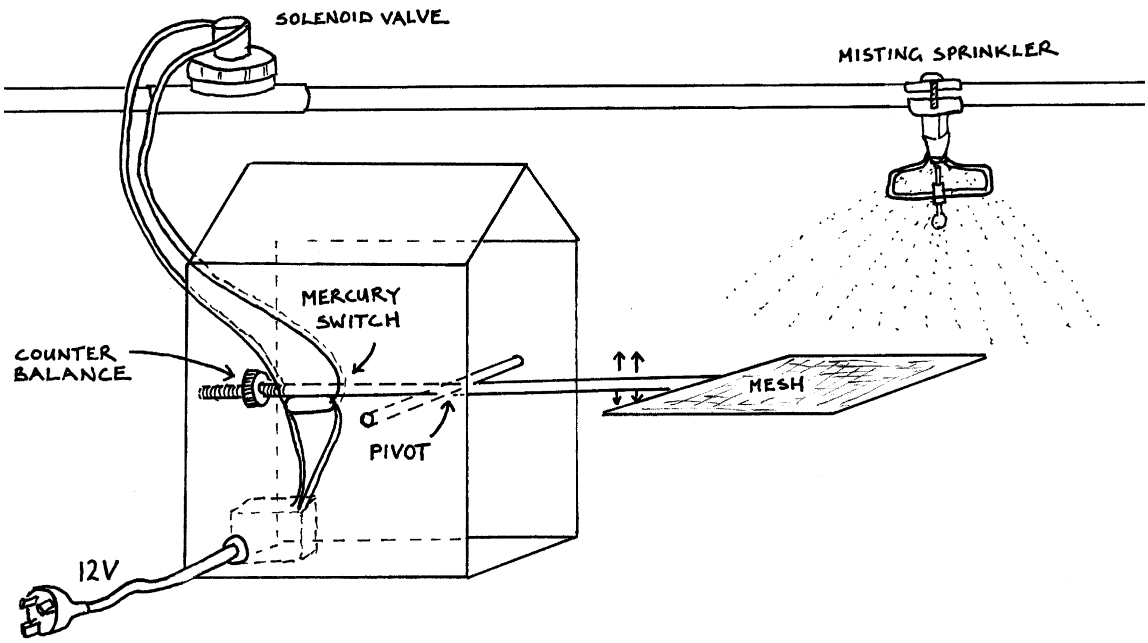


Figure 21: *Balance arm misting system:*
Moisture evaporates from mesh pad allowing arm to rise, mercury switch will then activate solenoid. Mesh will accumulate droplets and arm will descend, deactivating mercury switch. Watering will stop until mesh dries out again.

5.9 Potting on seedlings

When the seedlings have reached a point where their cotyledons have shrivelled up it is time to transfer them to a more substantial container, most commonly used is a small pot called a tube.

These pots are designed specifically to encourage a deep, healthy root system. Growers may be tempted to pot directly into large pots to minimise the root disturbance inherent in a number of transplants, but this can present a number of problems.

a) Wastage of substantial amounts of potting mix should the seedling die.
b) Organic matter in pots will break down over time, leaving the pot only half full and roots exposed.
c) Large pots will take up a lot of space within the nursery and require more water and weeding.
d) Root hairs develop better when trained in appropriate sized pots.

Seedlings should be carefully “dibbled” out of the tray, suspended over the tube and then have potting mix poured carefully around their roots encouraging them downwards. There will be a discernible mark on the stem of the seedling that indicates the depth of soil that the seedling has come from; pot to this same point, potting deeper will cause stem rot. Fill the tube to its maximum and do not compact the mix, the level will sink below the tube’s rim with subsequent watering. Newly potted seedlings are normally left in a shade house for a week or so to overcome any transplant shock.

The practice of filling the tubes with media and then creating a hole in this for the seedling can lead to a problem called ‘ J rooting’ where roots grow distorted and upwards rather than downwards.

Plate 3: Germination igloo

Potting mix differs from a propagation mix in being courser, containing more organic material and may have a source of nutrient incorporated.
Examples of appropriate potting mix.

A Suitable Soil Based Mix
1 part river sand
1 part loam
1 part leaf mould or peat moss
A fine sprinkling of slow release fertiliser

U.C. (University of California) Mix

River sand	75 %
Peat moss	25 %
Nutrient (per m^3 of basic mix)	
Calcium carbonate	1200 g
Dolomite	370 g
Superphosphate (single)	1200 g
Blood and bone	1200 g
Potassium sulphate	75 g
Potassium nitrate	75 g
Ressminal (trace elements)	110 g

Note: The mining of peat is causing environmental damage in those parts of the world where deposits occur. An alternative to traditional peats is a product derived from coconut husks called Coco peat.

Plate4: Newly potted seedlings in the shade house

PROPAGATION METHODS

6.1 Coastal plant propagation

Acacia. (Mimosaceae). Local coastal Acacia species will germinate readily after soaking seed. Water is bought to the boil and then poured into a vessel containing the seed. Soak overnight and by morning the seed should have increased in size, be lighter in colour and have sunk to the bottom of the vessel. Discard floating seed if it continues to float after being momentarily submerged. Drain through a strainer and mix with a little river sand to enable even distribution onto seed trays.

Seed production by parent plants may be sporadic. When plenty available, dry and store for future needs.

Acmena / Syzgium. (Myrtaceae). Check that fruit contains seed, some individuals don't produce it. Soak fruit in water (cold) until ready to use, this will drown any resident insect larvae. Sow fruit in deep trays to allow root development. Removal of fruit from seed prior to sowing may speed germination. Can also be grown from cuttings.

Acronychia. (Rutaceae). Proves very difficult from seed. May require passing through a bird. Success may be improved by removing fruit and leaching seed. Cuttings from *Acronychia imperforata* have been partially successful but are very slow to develop.

Allocasuarina / Casuarina. (Casuarinaceae). Germinates readily but you will have to watch trees closely to catch seed before it is released. When first capsules can be seen opening collect sufficient fruit and put into paper bags, store these on your cars dashboard or similar and they will quickly open releasing seed. Sow fresh.

Archontophoenix. (Arecaceae). Seed germinates readily whether sown with flesh or slightly aged with no apparent flesh.

Austromyrtus. (Myrtaceae). Reliable germination from fresh seed. It is best if fruit is removed by rubbing across a sieve. Can also be grown from cutting.

Banksia. (Proteaceae). See details in *Opening Banksia fruit.* Will germinate readily if not sown too deep (should be just beneath the surface of medium). Prone to damping off if left in high humidity structure too long. May need protection from rat predation.

Carpobrotus. (Aizoaceae). Ripe fruit are deep pink in colour. When squeezed a succulent white pulp is extruded (which tastes very good). Separate seed from fruit by squashing into a fine sieve and then rinse with running water. Seed can then be mixed with sand to ensure even distribution onto trays. Grows easily from cuttings also. Prone to damping off,

Cassine. (Celastraceae). Sample parent trees widely, as germination appears erratic. Widely varying success has been experienced, sometimes fast, sometimes slow or non-existent. Scarification of seed may help. Can be grown from cuttings.

Commersonia. (Sterculiaceae). Fruit, when ready, cracks open revealing small red seed, these can be tedious to separate but a method we have found to work well is to place fruit in a blender. After blending for a couple of minutes the fruit has broken up.

Pour boiling water over the pulp and seed can be removed. Can also be grown from cuttings.

Seedlings are often prone to attack from grasshoppers and red spider mites.

Cordyline. (Agavaceae). Germinates readily from seed. Good results too from cuttings or in the case of *Cordyline congesta* by division.

Cryptocarya. (Lauraceae). *Cryptocarya triplinervis* has been found to germinate readily if sown fresh after a couple of days soaking in water. Removal of fruit may hasten germination. Sow in deep trays to allow for root development.
Very slow to germinate. Cuttings should be possible.

Cupaniopsis. (Sapindaceae). Check ripe fruit (deep orange in colour) is not predated by insect larvae. Crack fruit open and separate seed which should be sown fresh. Germination is reliable but protect seedling trays from rats and mice.

Dianella. (Liliaceae). Remove mature fruit (which tastes good) by rubbing across a wire sieve, separate seed and sow fresh. Can also be grown from stem cuttings and division.

Dodonaea. (Sapindaceae). Remove seed from papery capsules and soak in hot water prior to sowing.

Duboisia. (Solanaceae). Germination from seed may be erratic. Can be grown from cuttings.

Elaeocarpus. (Elaeocarpaceae). Very slow to germinate from seed (1 to 2 years). Cracking seed coat or lengthy fermentation may improve results. Success from cuttings variable.

Eucalyptus / Lophostemon. (Myrtaceae). Collect fruit when some are just starting to open and use paper bag on dashboard method to open remaining capsules. The fine seed should be mixed with sand prior to sowing and then applied to surface of trays via a pepper or spice shaker. This will ensure even distribution. Eucalyptus seed can be stored for long periods.

Ficus. (Moraceae). Ficus seed is very small. Ripe fruit is scraped out and the skin discarded. Mix the remaining pulp with sand and spread on surface of seed trays. Seed collected from bird droppings may improve results. Ficus can also be grown from cuttings and aerial layering.

Glochidion. (Euphorbiaceae). Fruit will go reddish purple and then split open when ripe. Remove seed from fruit and sow very fresh. Most seed is predatorised.

Gompholobium. (Fabaceae). Treat the hard seed with hot water before sowing. Avoid seedlings damping off.

Guioa. (Sapindaceae). Germinates readily from fresh seed.

Hibiscus. (Malvaceae). Most species should germinate readily from fresh seed. Scarification of hard seed coatings will speed the process. While most Hibiscus can be grown from cutting I have had little success with *H. tiliaceus*.

Hoya. (Asclepiadiaceae). The feathery seed is not often seen but will germinate quickly with no special treatment. Cuttings are easily grown by taking a small piece of stem with opposite leaves attached, split the stem down the middle and plant each piece with leaf protruding from soil (Figure 13).

Ipomea. (Convolvulaceae). Can be grown from seed after soaking in hot water. A method I prefer which hastens the process enormously is to collect cuttings of about 45cm in length, place these into a jar or bucket of water with a liquid hormone such as Auxinone©. Within a week the cuttings will develop roots and can be planted amongst the dunes. They will start running very quickly.

Juncus. (Junaceae). Fresh seed mixed with sand should germinate readily. The wetland method of setting up seed trays may be useful. Can also be grown through division.

Leptospermum. (Myrtaceae). See Melaleuca for appropriate method.

Livistonia. (Arecaceae). Seed germinates readily but is slow. Removing flesh by fermentation may hasten process.

Lomandra. (Xanthorrhoeaceae). Grows readily from fresh seed or established plants can be divided.

Macaranga. (Euphorbiaceae). Germinates reliably from fresh seed and reputedly from cuttings also (although I have not had much success with regular method).

Melaleuca. (Myrtaceae). Remove mature unopened capsules from tree and place in paper bag on dashboard until open. Mix fresh seed with sand before sowing to ensure even distribution. Germination should be very reliable. Only a small quantity of fruit is needed to raise a lot of plants.

Myoporum. (Myoperaceae). Mixed results have been had from seed. It is suggested that flesh is removed before sowing. Cuttings work well.

Neolitsea. (Lauraceae). Remove flesh from seed before sowing. May take some months to germinate.

Omalanthus. (Euphorbiaceae). Often self occurs as pioneer after removal of weeds. Birds have a keen eye for ripe fruit sometimes making collection frustrating. Can be grown from seed and cuttings.

Pandanus. (Pandanaceae). Fresh seed is sown by laying flat on sandy medium and pushing the lower side slightly into the soil. Cover seed boxes with hessian or straw mulch, water once thoroughly and then leave the boxes undisturbed with no supplementary water other than rain. Germination is reliable but propagation in the summer months will speed the process. We are currently trialing very large Pandanus cuttings (20cm diameter) but cannot comment on success yet.

Polyscias. (Araliaceae). *Polyscias elegans* is difficult to propagate. Many trees bear infertile fruit and it appears that the seed must pass through the stomach actions of a bird to release from inhibitors. If possible collect bird droppings from beneath a fruiting tree and sow seed obtained from these.

Pultenaea. (Fabaceae). Scratch seed coat by rubbing seeds between sheets of sandpaper then allow to soak in hot water until obviously swollen. Drying seed on paper towel before sowing may reduce risk of damping off.

Restio. (Restionaceae). Most easily grown by division. Seed sown using wetland method may be successful.

Ricinocarpus. (Euphorbiaceae). Difficult to grow from seed, smoke treatment and leaching may help. Difficult from cuttings also.

Rhodomyrtus. (Myrtaceae). Fruit is a yellow berry 10-15mm when ripe and contains numerous wedge shaped seeds. Seed is sown with the squashy pulp and should germinate within 6 weeks.

If working around a mature tree it is likely that through root disturbance and bruising, the tree will send up numerous suckers.

Spinifex. (Poaceae). Usually direct seeded by burying whole flower heads to a depth of about 30cm. Seed will not germinate in presence of light. Severed runners soaked in Auxinone© should also produce roots, speeding up the planting out process.

Synoum. (Meliaceae). Seed should be sown very fresh and will germinate within a couple of weeks. Can also be grown from cuttings.

Themeda. (Poaceae). Local coastal forms germinate readily from fresh seed. It can also be direct sown through broadcasting but if doing this make sure the seed awn is intact as this helps the seed to burrow beneath surface.

Typha. (Typhaceae). The brown “bullrush” flower will crack up into many fine feathery seeds when ready. These have a high percentage of viability and are best sown using the wetland method. Can also be grown by division.

Xanthorrhoea. (Xanthorrhoeaceae). Seed should be sown fresh but may have a long germination period. Resultant seedlings are very slow.

6.2 Littoral Rainforest Plant Propagation

Prepared by Mike Delaney

PLANT NAME		FRUIT RIPE	PROPAGATION TECHNIQUE
Agauaceae			
Cordyline stricta	**Narrow Leaved Palm Lilly**		**seed, stem cuttings, divisions**
Annonaceae			
Polyalthia nitidissima	**Canary Beech**	**Nov-Mar**	**seed**
Araciaceae			
Polyscias elegans	**Celerywood**	**Mar-July**	**seed, may be difficult**
Polyscias murrayi	**Pencil Cedar**	**Apr-June**	**seed, may be difficult**
Arecaceae			
Archontophenix cunninghamiana	**Bangalow Palm**	**Dec-May**	**Place seeed in plastic bag and keep moist until roots shoot**
Livistona australis		**May-June**	**seed**
Celastraceae			
Cassine australis	**Red Olive Plum**	**Mar-July**	**seed - slow to germinate 7 to 26 months, poor germination below 50%**
Denhamia celastroides	**Orange Boxwood**	**Feb-June**	**seed**
Ebenaceae			
Diospyros fasciculosa	**Grey Ebony**	**April-July**	**seed**
Diospyros pestamera	**Myrtle Ebony**	**Feb-Dec**	**erratic**
Elaeocarpaceae			
Elaeocarpus obovatus	**Hard Quandong**	**Jann-April**	**cuttings, seed difficult and erratic**
Elaeocarpus reticulatus	**Blueberry Ash**	**April-Oct**	**Cuttings, seed takes 1--2 years to germinate with a 30% germination rate**
Euphorbiaceae			
Baloghia inophylla	**Brush Bloodwood**	**Feb-May**	**seed & cutting, many pods are empty**
Claoxylos australe	**Brittlewood**	**Jan-Mar**	**seed**
Drypetes australasica	**Yellow Tulip**	**Feb-April**	**seed, slow germination**
Glochidion sumatranum	**Umbrella Cheese Tree**	**April-May**	**cuttings, treat seed**
Macaranga tanarius	**Macaranga**	**Jan-Feb**	**cuttings, seed**
Mallotus discolor	**Yellow Kamala**	**Jan**	**cuttings, seed variable**
Mallotus philippensis	**Red Kamala**	**Sept-Feb**	**fresh seed only**
Omalanthus populifolius	**Bleeding Heart**	**Dec-Mar**	**cuttings, seed**
Lauraceae			
Cryptocarya foetida	**Stinking Cryptocarya**	**Jan-May**	**seed - remove flesh - slow**
Cryptocarya laevigata	**Glossy laurel**	**Jan-May**	**seed - remove flesh - slow**
Cryptocarya rigida	**Rose Maple**	**Jan-May**	**seed - remove flesh**

PLANT NAME		FRUIT RIPE	PROPAGATION TECHNIQUE
Cryptocarya triplinervis	**Three Veined Cryptocarya**	**Feb-May**	**seed**
Endiandra muelleri	**Mueller's Wallnut**	**Mar-April**	**seed**
Endiandra sieberi	**Pink Walnut**	**Mar-Oct**	**seed**
Litsea leefeana	**Brown Bolly Gum**	**Sept-Nov**	**seed**
Maliaceae			
Hibiscus heterophyllus	**Cottonwood**	**Dec-June**	**seed, cuttings**
Dysoxylum mollissimum	**Red Bean**	**Nov-Mar**	**seed**
Melia azedarach var australasica	**White Cedar**	**Mar-June**	**seed, slow, stored at low temperature**
Synoum glandulosum	**Scentless Rosewood**	**Aug-Dec**	**seed**
Mimosaceae			
Acacia melanoxylon	**Blackwood**	**Dec-Feb**	**seed, boiling water treatment**
Archidendron grandiflorum	**Pink Laceflower**	**Apr-May**	**seed, scarified**
Archidendron muellerianum	**Laceflower**	**Apr-Dec**	**seed, filed before sowing**
Pararchidendron pruinosum	**Snow Wood**	**Feb-June**	**seed, scarified**
Moraceae			
Ficus fraseri	**Sandpaper Fig**	**May-Feb**	**seed, cutting**
Ficus macrophylla	**Moreton Bay Fig**	**Feb-May**	**seed, easily grown**
Ficus obliqua	**Small Leaved Fig**	**Apr-June**	**seed, layering**
Ficus superba var henneana	**Decicuous Fig**	**Jan-July**	**seed, cuttings**
Ficus watkinsiana	**Strangler Fig**	**Sept-Apr**	**seed**
Myrsinaceae			
Rapanea variabilis	**Muttonwood**	**Nov-Dec**	**seed**
Myrtaceae			
Acmena hemilampra	**Broad-Leaved Lillypilly**	**May-Aug**	**seed, cuttings**
Acmena smithii	**Lillypilly**	**April-Sept**	**seed, collect before fully ripe**
Lophostemon confertus	**Brush Box**	**Nov-Feb**	**seed stored for 8-10 years**
Pilidiostigma glabrum	**Plum Myrtle**	**Mar-Oct**	**seed, cuttings-slow to strike**
Rhodamnia argentea	**Malletwood**	**Mar-June**	**seed**
Rhodamnia rubescenns	**Brush Turpentine**	**Oct-Dec**	**seed**
Rhodomyrtus psidioides	**Native Guava**	**Jan-May**	**seed**
Syzigium australe	**Brush Cherry**	**Dec-June**	**seed**
Syzgium luehmannii	**Riberry**	**Dec-Feb**	**seed, cuttings**
Syzygium oleosum	**Blue Lillypilly**	**Mar-Sept**	**seed, cuttings**
Pittosporaceae			
Pittosporum undulatum	**Sweet Pittosporum**	**Feb-Aug**	**seed**
Proteaceae			
Grevillea hilliana	**Whitee Silky Oak**	**Feb-July**	**seed - stored at room temperature for 12 months**

PLANT NAME		FRUIT RIPE	PROPAGATION TECHNIQUE
Helicia glabriflora	**Brown Oak**	**April-Nov**	**seed**
Stenocarpus sinuatus	**Wheel of Fire Tree**	**Jan-July**	**seed**
Rhamnaceae			
Alphitonia excelsa	**Red Ash**	**Oct-May**	**cuttings, seed difficult**
Alphitonia petriei	**Pink Ash**	**Feb-July**	**cuttings, seed**
Helicia glabriflora	**Brown Oak**	**April-Nov**	**seed**
Rubiaceae			
Canthium coprosmoides	**Coast canthium**	**Oct-Dec**	**cuttings, seed - slow to germinate**
Canthium lamprophyllum	**Shiny-Leaved Canthium**	**July**	
Rutacae			
Acronychia imperforata	**Beach Acronychia**	**Aug-Dec**	**seed difficult, cuttings slow to strike**
Acronychia littoralis	**Scented Acronychia**	**May-Aug**	**Cuttings, seed difficult**
Acronychia oblongifolia	**Hard Aspen**	**May-Nov**	**seed, cutting**
Acronychia wilcoxiana	**Silver Aspen**	**Mar-May**	**seed difficult to germinate**
Euodia micrococca	**White Euodia**	**Jan-June**	**seed**
Flindersia bennettiana	**Bennetts Ash**	**Nov-Feb**	**seed**
Flindersia schottiana	**Cudgerie**	**Jan-Feb**	**seed**
Flindersia xanthoxyla	**Long Jack**	**June-Oct**	**seed**
Halfordia kendack	**Saffron Heart**	**May-Jan**	**seed, germination erratic**
Medicosma cunninghamii	**Bonewood**	**Jan-May**	**seed, germination erratic**
Pentaceras australis	**Crows Ash**	**Nov-Jan**	**seed very difficult**
Sapindaceae			
Alectryon coriaceus	**Beach Bird's Eye**	**Mar-July**	**seed, remove aril**
Alectryon subcinereus	**Wild Quince**	**April-Aug**	**seed, remove aril**
Arytera distylis	**Twin Leaved Coogara**	**Oct-Feb**	**seed**
Cupaniopsis anacardioides	**Tuckeroo**	**Oct-Dec**	**seed**
Diploglottis australis	**Native Tamarind**	**Oct-Jan**	**seed**
Guioa semiglauca	**Guioa**	**Jan-May**	**seed**
Mischocarpus pyriformis	**Yellow Pear Fruit**	**Oct-Dec**	**seed**
Sapotaceae			
Planchonella australis	**Black Apple**	**Sept-Jan**	**seed**
Planchonella chartaceae	**Thin Leaved Coondoo**	**May-Dec**	**seed**
Planchonella laurifolia	**Brush Condoo**	**Aug-Dec**	**seed**
Simaroubaceae			
Ailanthus triphysa	**White Bean**	**Mar-April**	**seed**
Guilfoylia monostylis	**Native Plum**	**May-Aug**	**seed - slow**
Commersonia bartramia	**Brown Kurrajong**	**Mar-July**	**seed, boiling water, cuttings**
Verbenaceae			
Gmelina leichhardtii	**White Beech**	**Feb-May**	**seed, poor germination**

Planting Guidelines

7.1 When is planting required?

Planting may be required to re-establish vegetation in areas which are more degraded and lack resilience. The aim of a planting project should be to establish viable self-sustaining populations with evolutionary potential to adapt to environmental changes over time and to restore vegetation communities likely to have been present prior to site clearing and disturbance. Revegetation (planting or seed introduction) should be considered only where:

- a site has failed to respond to attempts to trigger regeneration over a period of at least two effective growing seasons
- the regeneration potential (resilience) of a site has been severely depleted or completely lost
- key missing species cannot be naturally recruited to an area
- there is insufficient genetic diversity amongst surviving species
- a buffer is required to reduce the 'edge effect' on a remnant

An important attribute of a restored ecosystem is that it is integrated into the larger landscape to minimise fragmentation. A remnant should be connected to other areas of vegetation wherever possible.

Revegetation projects need clear and realistic goals and objectives with a time line that is likely to go for several years.

Degrading influences such as erosion, salinity, nutrient inflows or weed infestations should be adequately controlled prior to revegetation work. If these influences cannot be adequately controlled the revegetation project may need to shift to using species that can cope with the prevailing environmental conditions. This community may not be the same as the original vegetation.

Revegetation projects should aim to restore a range of ecosystem functions e.g. fauna habitat, even where it may not be possible to restore the original vegetation community.

7.1.2 Supplementary coastal planting for species diversity

Sometimes there is a need to supplement weed control activities with planting of targeted native species. Native species chosen for revegetation planting should include all components of the vegetation community (forbs, grasses, shrubs, trees) to rebuild habitat complexity and ecosystem resilience. Replanting that only includes larger shrubs and trees will be inadequate to restore ground layer richness, which is one of the most affected strata in weed invasion (French et al 2008).

Coastal ecosystem restoration requires long term management and funding (for a minimum of five years).

In coastal areas where Bitou Bush has been controlled many species expected to occur in coastal vegetation communities are absent when compared to the nearby undisturbed vegetation communities. Supplementary planting to restore species diversity/abundance is therefore necessary.

Determining the actual numbers of what species and where on the site these are to be planted invariably involves many considerations including deciding whether to plant to maximise structural integrity, floristic composition, environmental tolerance and future climatic conditions, cost, plant supply and provenance and the likelihood of natural recruitment of certain species through dispersal from nearby source areas.

It may not be possible to address all site requirements in a single planting but monitoring planting success and species representation and abundance at a site over time can help inform whether further planting is necessary and if so, the required species.

Other information on species composition and replanting of targeted species for coastal foredune scrub and Littoral Rainforest can be found in French (2010). Other information on approaches to developing biodiverse plantings suitable for changing climatic conditions are outlined in Booth and Williams 2012 and Booth *et.al*. 2012.

To ensure the protection and conservation of the genetic diversity of nearby areas, only plants sourced with local provenance should be used. The choice of locally occurring native species will depend on the goal of your project, site conditions, location and stage of development of any existing vegetation at the site. Species used in a revegetation site should include all the strata of the community e.g. shrubs and ground covers, as well as trees and they should be grouped or spaced in a way that resembles the native vegetation community. Plants should be selected to replicate a natural ecosystem; for example in a littoral rainforest incorporating lower, mid and canopy strata with a mix of pioneer and secondary species. A graphical representation can be seen in **Figure 1**

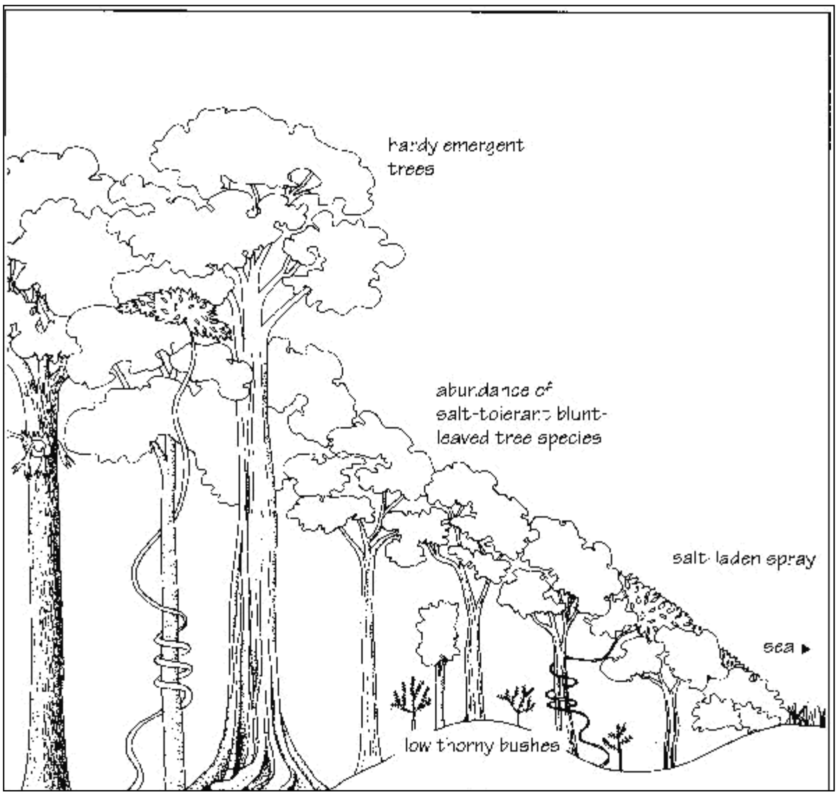


Figure 1: A graphical representation of a Littoral Rainforest ecosystem
Source: Big Scrub Rainforest Landcare Group, 2005

Plant species may be introduced by various techniques: direct planting of tube stock, propagating by division or cuttings then transplanting, direct seeding or brush matting.

Local experience, specialist nurseries, landcare groups and local council can provide valuable advice. When planning your project it is important to consider the time of year, frost resistance, water availability, mulching options, fencing for stock exclusion, wallaby guards and that there are adequate resources available for site maintenance (Byron Shire Council 2010).

7.2 Direct propagation methods

Plants can be established directly on site without prorogation in a nursery through approaches including direct seeding, bush matting, transfer of leaf mulch and transplanting seedlings and groundcovers.

7.2.1 Direct seeding

Direct sowing of seed can save a lot of time and labour, however it will work with relatively few genus. Insect predation may be high and much larger amounts of seed are required than if plants were grown in the nursery. Success may be increased by pre-treating seed before sowing. Methodology may be as simple as broadcasting seed into an area by hand or as complex as hydro-seeding where a mixture of seed, fertiliser and water holding material are sprayed from a specialised machine. Reliable rainfall and heat will enhance success.

At a local scale hand casting is most likely to be used and involves collecting the seed, treating it if needed to break dormancy and scattering the seed.

Genus that can be direct seeded.

- Most Fabaceae
- Archontophoenix
- Banksia
- Themeda (retain awns on seed to allow self drilling into soil)
- Acacia (scarify or treat with hot water prior to broadcast)
- Spinifex (bury whole seed heads)
- Casuarina
- Eucalyptus (mix fine seed with sand to improve distribution)
- Leptospermum
- Canavalia
- Melaleuca
- Hardenbergia

7.2.2 Brush-matting

Brush-matting is where branchlets that have persistent woody fruits (e.g. Eucalyptus spp; Melaleuca spp., Leptospermum spp., Casuarina spp. and Callitris spp.) are cut from the live plant and are immediately laid on the site where they are to establish (Buchanan, 1989). The site should be weed free prior to laying the brush matting and the surface should be raked if necessary so that the small seeds can come in contact with soil. It also helps to peg the branchlet down so that it doesn't blow away.

Caution is needed when harvesting the branchlets so that all the available fruits are not over-exploited and their seed banks depleted on site. Secateurs used in brush matting should be cleaned so that disease is not spread. (*Byron Shire Bush Regeneration Guidelines* 2012).

7.2.3 Transplanting

Transplanting of seedlings or vegetative portions of plants can also be an effective means of introducing plant material to a site. Transplanting of seedlings of trees, shrubs and vines can be useful means of relocating some species that are in sites where they will be unable to grow to maturity for reasons such as development, stock grazing or clearing.

7.3 Planting Methodolody

7.3.1 Planning and timing of plantings

Planning should be started well in advance of the commencement of planting so that there is sufficient time to allow:

- the sustainable collection (following Florabank guidelines) and propagation of a range and quantity of local provenance material for the planting,
- all necessary site preparation

Plants are ready for planting out when they display vigorous growth and roots have established enough to allow the plant to be removed from the pot without falling apart. Sun harden stock for at least two weeks prior to planting. Before attempting to remove the pot check drainage holes for healthy white roots. Deciding at what size your stock should be before planting will depend on the nature of the site, if, for instance you were planting amongst chopped up Bitou Bush, tube stock could be lost amongst this mulch. It would be wiser to pot tubes on to the next pot size and wait for them to grow proportionally before planting. Young vigorous plants will outgrow super advanced stock that is generally only used for landscaping where an instant effect is desired.

Sufficient resources must be available to prepare a site adequately, implement the revegetation work, monitor and report on the successes and failures and carry out ongoing maintenance work.

Plantings in or near bushland should ensure that no plant pathogens or weed propagules are introduced via potting media, on boots, gloves, tools, materials, equipment, vehicles, etc. (Australian Association of Bush Regenerators (NSW) Inc. (2005) *Revegetation Policy).*

Plan the planting well in advance to take advantage of wet weather, usually February, March on the NSW North Coast. Supplies of mulch, fertiliser, trees, tools and labour must all be on hand to make the operation run smoothly. It is important to consider if the area is prone to frost and choose species accordingly. If planting in a frost–prone area earlier planting may be appropriate to ensure plants are well established prior to first frost. Planting in spring may require additional watering but spring plantings are worth considering if water is available on site and time for possible follow up watering is available.

7.3.2 Site preparation

Site preparation is essential to ensure planting success. Preparation varies from site to site and will include tasks such as:

- control of competitive weeds, this may involve slashing the planting area and spot spraying around where each tree will be planted
- any necessary erosion control,
- fencing to exclude stock,
- dealing with soil compaction and other factors

7.3.3 Planting

The best way to plant large numbers of trees is to have planters closely following hole diggers so that valuable ground moisture is not lost to evaporation. One person will be dropping fertiliser into the holes and another with a hose filling the holes with water just in front of the planters. The excavated soil is pushed back into the holes and allowed to become thoroughly sodden, break up clods with fingers and form a space large enough to accommodate the tree. Ensure that the plant is not buried too deep or has any root ball exposed and then, firm soil around the plant. A saucer like depression around the plant will help capture and retain moisture from future rain or watering. Mulch the plants quickly after planting to reduce evaporation and if possible wet the mulch after spreading. A step by step method for planting is detailed below:

- Dig or auger holes at recommended spacings. Only dig enough holes for the day's planting so that soil does not dry out. Dig holes slightly deeper than the depth of the plant container and as least twice as wide.
- Add fertiliser to the hole and mix into soil ensuring that plant roots will not be in direct contact. Commonly used fertiliser in plantings are slow release fertiliser tablets or granules.
- Half fill holes with water, replace half of the soil.
- Remove the plant from the container by turning upside down and tapping the base firmly so that plant slides out. Place the plant in the hole, return remaining soil to hole and press the soil around the plant. Do not over compact the soil.
- Make sure the plant is vertical and at same depth in the hole as it was in the container.
- Water immediately after planting in hot or dry weather. Even if the ground is very wet you will still need supplementary watering at planting to properly bed the plant into the soil. The ideal state of the soil would be when at "field capacity" (maximum absorption before water starts pooling up on the surface) soil that is too wet is easily compacted by traffic and may be lacking in air.
- Mulch around plant.

7.3.4 Guards

Tree guards to protect individual plants from predation by wallabies or other animals may also be required and will add a considerably to establishment costs. A variety of types of guards can be used including corflute guards or mesh guards. Hardwood stakes can be used to secure firmly. If plastic tree guards are used as wind protection be sure that there is no way that they can be blown into the sea where they will endanger marine creatures. When trees are well established guards can be removed and reused as required.

When planting on the coast it is very desirable to protect the plants initially from the wind, this can be done by erecting wind breaks either from wire and shadecloth or woody material such as bitou stems and palm fronds. Windbreaks should attenuate the wind, not provide a physical barrier to it as this will result in increased turbulence in the lee of the fence.

7.3.5 Mulching

Mulching is the process of creating a layer of organic matter on the soil surface around the plant to improve the retention of soil moisture and to encourage growth. A good mulch will:

- Eliminate weeds and grass competition in the early stages
- Increase soil moisture retention
- Insulate roots and encourage the development of feeder roots
- Encourage soil micro organisms (in particular fungi which assists in the growth of trees) and
- Improve soil structure
  (Big Scrub Rainforest Landcare Group, 2005)

Mulch should only be used if it can be guaranteed to be weed free. There are many materials that can be used as mulch but if it is of an organic nature ensure that it is aged to cut down on Nitrogen being robbed from the soil. If the mulch is to play its role of reducing evaporation and weed suppression it must be spread quite thickly say 10 to 15 cm deep. If using bails of hay use a sixth of a bale per tree, with tea tree mulch about a 20 litre bucket full.

There are a number of options for mulch including; baled straw mulch, chip bark, in situ sprayed grass and sugar cane mulch. The choice of a mulch medium will be site specific and depend on relative costs and available resources.

Plate 5: Plant guard options for plantings to deter wallaby grazing, left: corflute guard, right: mesh guard

7.3.6 Maintenance

Time and resources are required for maintenance of planted areas. Maintenance is essential until plants are well established. Weeds and grasses growing around plants will need to be controlled (by hand, spraying or with machinery) to ensure successful establishment. In dry conditions, watering may also be required. Thorough but infrequent follow up watering will encourage a deep root system. Frequent shallow watering will result in a root system unable to handle the rigours of drought.

Plants should be watered in at planting but further watering can be on an as needs basis with the aim of achieving maximum survival rates. If no substantial rain occurs in the first three weeks after planting plants may need to be watered. Plantings and soil moisture should be checked at regular intervals to determine if further watering is required.

Maintenance such as spraying herbicide around rainforest species is a specialist area and should be undertaken by workers with good plant identification skills. Timely site maintenance which frequently involves spot spraying of weed species is ongoing. Frequency of visitation during maintenance will vary according to the resilience of the native vegetation, viability of weed seed in the soil and the proximity of weed sources for re-infestation of the site. It is important not to underestimate the amount of time and resources that are required to maintain a new planting.

Without maintenance to ensure survival, propagation and planting efforts will be wasted if trees die. Ensure that adequate resources are available to maintain the scale of planning undertaken.

8. Monitoring and Evaluation

Monitoring is recording and measuring the state of a community and associated natural resource management practices. Evaluation is a linked but distinct process which analyses monitoring data to assess the efficacy of a natural resource management project.

It is important to record, monitor and evaluate the progress of any rehabilitation project. This is necessary to demonstrate the outcomes achieved from the work carried out and the relative success or otherwise of different methods that have been used. Monitoring and evaluation (M&E) provides the information required to learn from experience and improve on methods thereby facilitating adaptive natural resource management.

Key areas for monitoring and evaluation of rehabilitation works and examples of associated indicators include:

- Weed control outcomes (changes over time of number of weed species, density/cover of priority weeds; cost/hectare of weed control)
- Time, area and planting species list
- Planting success rate; including time and species of trees that died
- Weather at the time of planting
- fertiliser type and application rate
- Plantings in or near remnant vegetation should be recorded including a map, date, names of species planted, number of plants of each species installed, provenance of each species, source nursery and a record of follow-up work and any replacement plantings.
- Site observations including improvements in vegetation structure (changes over time in the size of the largest stems and % cover and abundance of both native and weed species; Floristic changes (changes over time in species diversity and composition including recruitment);Fauna usage and habitat enhancement (changes over time with the presence and abundance of fauna species /specific habitat attributes/resources)
- Any other changes to site, eg bushfire, flood event, frost

Relevant performance indicators should be monitored by recording field data. This can then be supported by a photographic record.

References

Australian Association of Bush Regenerators. 2012. draft *Philosophic statement on ecological restoration and management*. http://www.aabr.org.au/

Australian Association of Bush Regenerators. 2005. Planting in bushland?.. but what about natural regeneration AABR http://www.aabr.org.au/

Australian Association of Bush Regenerators. 2005. *Revegetation Policy* http://www.aabr.org.au/images/stories/about_files/policy/PolicyRevegetation.pdf

Big Scrub Rainforest Landcare Group, 2005. *Subtropical Rainforest Restoration A practical manual and data source for Landcare groups, land managers and rainforest regenerators.* 2nd Edition BSRLG. Mullumbimby , NSW.

Booth, T.H. and Williams, K.J., 2012. *Developing biodiverse plantings suitable for changing climatic conditions 1: Underpinning scientific methods.* Ecological Management & Restoration Vol 13 No 3 p 267 - 273

Booth, T.H., Williams., K.J., & Belbin, L. 2012. *Developing biodiverse plantings suitable for changing climatic conditions 2: Using the Atlas of Living Australia*. Ecological Management & Restoration Vol 13 No 3 p 274 - 281

Buchanan, R.M. 1990. *Bush Regeneration: Recovering Australian Landscapes*. T.A.F.E. Learning Publications, Sydney.

Byron Shire Council, 2010. Threatened Species Profile Endangered Ecological Community Littoral Rainforest in the NSW North Coast, Sydney Basin and South east Corner Bioregions
http://www.byron.nsw.gov.au/threatened-species-and-communities

Bushland Restoration Services, 2010. *Landscaping and Biodiversity Conservation Management Plan Old Kingscliff Sewerage Treatment Plant Lots 2 and 3 DP 1111554Tweed Coast Road Chinderah*. Tweed Shire Council

Byron Shire Council January 2010 with Landmark Ecological Services Pty Ltd and Bower Bush Works. *Byron Shire Bush Regeneration Guidelines*

Duggan D. *Seed Collecting Guidelines.* Indigenous Flora and Fauna Association.

Debenham. C. *The Language of Botany*. The society for growing Australian Plants.

French, K. 2010. *A Framework to Guide Ecological Restoration: Coastal Foredune Scrub and Temperate Littoral Rainforest. South Coast of NSW*. University of Wollongong.

French, K., Ens, E., Gosper, C. R., Lindsay, E., Mason, T., Owers, B. & Sullivan, N. 2008. *Management implications of recent research into the effect of bitou bush invasion*. Plant Protection Quarterly Vol. 23(1) 2008.

French, K., Mason, T. J. & Sullivan, N. *Recruitment limitation of native species in invaded coastal dune communities.* Plant Ecology 2011. 212:601-609..

Kooyman R.M. 1996,*Growing Rainforest Rainforest Restoration and Regeneration Recommendations for the humid sub-tropical region of northern New South Wales and south east Queensland* . Greening Australia, Brisbane, QLD.

New South Wales Department of Land and Water Conservation (1998), *Attack of the Killer Weeds.* Coastcare, Department of Land and Water Conservation, Sydney.

New South Wales Department of Land and Water Conservation (1997), *Volunteers Working on the Coast.* Department of Land and Water Conservation, Sydney.

Nicholson, N&H. 1992. *Australian Rainforest Plants*. Self Published, The Channon, NSW.

Robinson, L. 1994. *Field Guide to the Native Plants of Sydney*. Kangaroo Press, NSW.

Ralph, M. 1997. *Growing Australian Native Plants from Seed*. Bushland Horticulture. Victoria.

Williams, J. Harden, G & McDonald, W. 1984. *Tress & Shrubs in Rainforests of NSW & Southern QLD*. The University of New England, Armidale.

Wrigley, J & Fagg, M. 1989. *Australian Native Plants*. Collins Australia.