- Local extinction or reduction of animal species responsible for pollen and seed dispersal; and/or
- High degree of degradation of the site e.g. loss of topsoil due to erosion.

In these circumstances, it may become necessary to introduce propagules (seed, spores and vegetative material) to a site, in order to obtain the necessary vegetation composition to restore a vegetation community or to establish a new, functional vegetation community.

There are several means of reintroducing plant material to a site, and choosing which technique to use is dependent on many factors, including:

- Availability of locally sourced seed and vegetative material;
- Accessibility to the site, and its topography;
- Availability of a water source;
- Degree of degradation of the site;
- Level of soil fertility;
- Necessity to quickly stabilise erodible soils;
- Budget; and
- Resources and time available for follow-up work.

Quick result?

Often planting is suggested as a means of obtaining quick, highly visible results – especially where the site is easily viewed by members of the local community. The introduction of good condition tubestock, tree guards and mulch to a site clearly suggests that work is underway. However, bear in mind that planting can actually hold back the reinstatement of natural processes on a site, particularly where there is adequate regeneration of native species already occurring or likely to occur. If you are uncertain about whether it really is necessary to plant on your site, refer to the flowchart in the SEQ Ecological Restoration Guideline to help you determine which of the four ecological restoration techniques is best to adopt. When choosing the best approach, keep in mind that some sites may need a long period of weed control before the native seed bank becomes apparent. If you are unsure about the recovery potential of the site, adopt a precautionary approach, using Assisted Natural Regeneration for at least 2-3 years before making a decision to plant. Although using Assisted Natural Regeneration techniques may not have instantaneous results, the long-term outcomes, when used on an appropriate site, can outweigh those obtained through planting.

5.9.1 PLANTING PROPAGATED MATERIAL

Planting is generally undertaken as part of Reconstruction or Fabrication.

5.9.1.1 SPECIES SELECTION

Determining which plant species should be selected for re-introduction to your site requires consideration of the following issues:

- Examine the reference site to determine which species might have been expected to have historically occurred at the planting site;
- Access RE information, historical records, and anecdotal information to gain ideas about the vegetation previously occurring on the site;
- Consider weather conditions at the site – susceptibility to frost, salt-spray from the ocean, heat, drought and wind. Plants vary in their tolerances to these conditions, so choose those which are suited to your site. Less tolerant plants can be planted in sheltered niches if they exist or be introduced during a secondary planting after vegetative structure has been created;
- Pioneer and early secondary species (those that grow quickly and are adapted to colonising disturbed areas) are ideally suited for a planting. These plants have the characteristics of:
    - Quick formation of canopy e.g. Mmacaranga (*Macaranga tanarius*), brown kurrajong (*Commersonia bartramia*) in rainforests; wattle, eucalypts and casuarina (*Allocasuarina*) species in sclerophyll communities;
    - Fixing of atmospheric nitrogen in the soil e.g. *acacia* species;
    - Rapid growth, resulting in early 'capture' of the site; and
    - Early senescence, making way for other species (late secondary and mature phase) to establish and eventually dominate;

- Mature-phase species (representative of the climax vegetation) in some circumstances may be introduced during the initial planting. However, these plants are slower-growing and may not exhibit rapid bursts of growth until changing site conditions (e.g. senescence of pioneers) become right for them;
- Choose early flowering and fruiting species to attract birds and bats to the site, resulting in the introduction of seeds that will promote natural regeneration;
- Choose species in all vegetative layers e.g. ground covers, shrub layer, and trees. However, ground covers can be difficult to maintain and often establish naturally on a site. Consider whether it may be better to rely on natural regeneration of ground covers; and
- Availability of stock – lead-in to a planting must be planned carefully to ensure good condition plants grown from locally collected seed are available.

The planting species list may not necessarily reflect the expected composition of the climax community. Using ecological restoration techniques ensures that birds, bats, insects and other animals will assist in the re-introduction of seeds to the site over time.

For Fabrication, species selection will not have a historical basis. The goal here (as with Assisted Natural Regeneration and Reconstruction) is to create a functioning system; however, this system will not necessarily have a connection with the vegetation that previously existed at the site. There are two ways of achieving the required functionality:

1. Copy an existing vegetation community if conditions are suitable; and
2. Create a vegetation community, formed around vegetative elements and conditions that could be expected to interact together to produce a self-sustaining system.

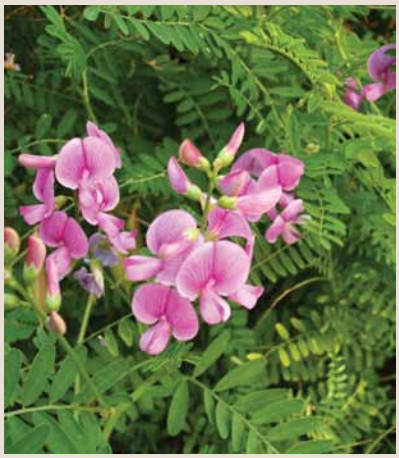
5.9.1.2 SOURCING PLANT MATERIAL

Limiting resources such as time, finances and available skill-base will determine if you choose to propagate your own plants, or purchase them commercially. In all but the largest organisations, purchasing plants from a commercial native plant nursery is the commonly-chosen option. This has the advantage of allowing you to draw on the seed-collecting, propagating and plant raising skills of a reputable native plant nursery.

Using a specialist native plant nursery has the following benefits:

- Awareness of genetic considerations when collecting seed and vegetative material;
- Experience with breaking dormancy mechanisms in hard-to-germinate seeds;
- Highly successful propagation techniques;

In sclerophyll communities a greater diversity of species occurs in the understorey and ground covers than in the canopy. Despite this, relatively few ground layer species are commercially propagated. Further work is needed in the propagation of ground layer, and some shrub species, so that a greater level of diversity can be introduced to Reconstruction and Fabrication projects where there is little likelihood of these diverse layers returning by natural means.



- Ability to provide high-quality stock to order when it is required;
- Provide a wide range of stock for purchase; and
- Draw on the resources of Greening Australia's Florabank, for best practice native species seed management.

However, it is advisable for you to check the quality of the plants you are purchasing. For example:

- Provenance of the plants – was seed or vegetative material for propagation collected from within the same catchment as the planting site, and generally within a 10km radius? (See Section 5.9.9 for more guidelines on genetic considerations.) ;
- Health of the plants – are plants in good condition and vigorous without having overgrown their pots, and do they have a well-developed root system without being pot-bound? Are plants free from pest and disease?; and
- Sun-hardening – have plants come straight from a shade-house? If so, sun-hardening for a minimum two weeks prior to planting is necessary in order to minimise transplant shock.

Plants are available in a variety of sizes of tubes and pots. The table below compares the advantages and disadvantages of each.

Table 5. Advantages and disadvantages of various plant sizes.

TYPE OF CONTAINER	ADVANTAGES	DISADVANTAGES
Seedling trays (i.e. trays containing multiple small containerised seedlings)	✓ Cheap ✓ Lightweight ✓ Easy to plant ✓ Rapid establishment	× Easily 'lost' during follow-up maintenance × Difficult to mulch around × Only suitable if large numbers of just a few species are being planted
Small tubes (approx 250mL capacity)	✓ Relatively cheap ✓ Fairly lightweight ✓ Easy to plant ✓ Suitable for most fast-growing species ✓ High rates of establishment	× May be overlooked during follow-up maintenance × Can dry out quickly on planting day – several wettings required if not planted immediately
Large tubes (approx 500mL capacity)	✓ Suitable for slower-growing species	× More expensive × Heavy to carry around a large or steeply-sloping site × Require a large hole to be dug – can be a problem on rocky sites
Pots/bags	✓ Creates an 'instant forest' – useful for creating a good show in high visibility areas	× Very expensive × Heavy to carry × Difficult to transport (take up a lot of space) × Require a large hole × Large bags may not transplant successfully

5.9.1.3 TIMING OF PLANTING

Planting should be timed to coincide with the wet season in South East Queensland. Planting conducted in summer and autumn will have reduced need for manual watering. If possible, planting should be done from February to May to avoid the worst of the heat while still having the likelihood of receiving good rainfall. Late spring plantings will be likely to require additional watering.

5.9.1.4 SITE PREPARATION

Frequently, actions will need to be taken in order to prepare the site ready for planting. These may include:

- Fencing to exclude grazing animals and people;
- Pre-spraying of exotic grasses and other weeds e.g. if planting into a previously grazed paddock;
- Providing an adequate source of water for planting, initial planting and maintenance if required;
- Arranging delivery of mulch and tree guards to the site (if required – see Section 5.9.1.5);
- Pre-treatment of heavy or compacted soils by deep ripping and/or application of gypsum. Care with erosive or dispersive soils, (be careful to 'Dial Before You Dig' on 1100 before undertaking ripping); and
- Inoculation of soil with micro-organisms (if necessary) – usually micro-organisms are introduced to the soil with the potting mix from the plant containers.

5.9.1.5 PRE-PLANTING PLANNING

Many decisions need to be made prior to planting day:

- What materials will be needed? e.g. plants, water crystals, fertilizer;
- What equipment will be needed? e.g. pumps, hoses, water tanks, buckets;
- What tools will be needed? e.g. auger, mattocks, shovels;
- How will the holes be dug? Mattocks, shovels, powered auger, tractor-mounted auger? A rocky site can really only be dug by hand (mattock or shovel). A steeply-sloping site will be inaccessible by tractor;
- How will water be provided to the site? On-site dam or creek, truck-mounted tank?;
- Will mulch be spread over the site before or after the planting? If so what type of mulch? Will the mulch affect a waterway?;
- How large is the area to be planted? At what density? How many plants will be required?; and
- Has a supervisor/team leader been selected to assign tasks, check quality control, and make sure nothing is overlooked?

Fertiliser can assist in giving planted stock a head start. However, it can have a negative affect on some species such as the non-rainforest Proteaceae species. Use of fertiliser in wetland plantings is not always desirable. Water crystals are useful on very dry sites (e.g. sandy soil with little organic matter) and should be utilised strictly according to the manufacturer's instructions.

5.9.1.6 PLANTING DENSITY

The density at which plants are spaced will be dependant on the aim of the project. However, when starting with an area devoid of native vegetation cover, the plantings should be established at a density that will result in rapid canopy closure so that exotic species are excluded. Experience has shown that planting trees and shrubs spaced at 1.5m centres achieves this aim. Wider tree spacings often mean there is a longer time before canopy closure and therefore a prolonged period of weed control.

The same principle applies to the establishment of ground layer and open wetland vegetation where there is an absence of overstorey elements. In this instance, to achieve the closure of vegetation and reduction of weeds it is necessary to plant at much tighter centres of at least 2-5 plants/m^2 (approx. 0.7 - 0.4m centres).

Higher density planting is also desirable at the edges of revegetation areas to reduce edge effects.

The sites illustrated below are adjacent to one another and were planted at the same time at different densities.

Ground cover under the densely planted site

Same location looking upward

Ground layer under the area that was not planted as densely (note abundance of weeds)

Same location looking upward

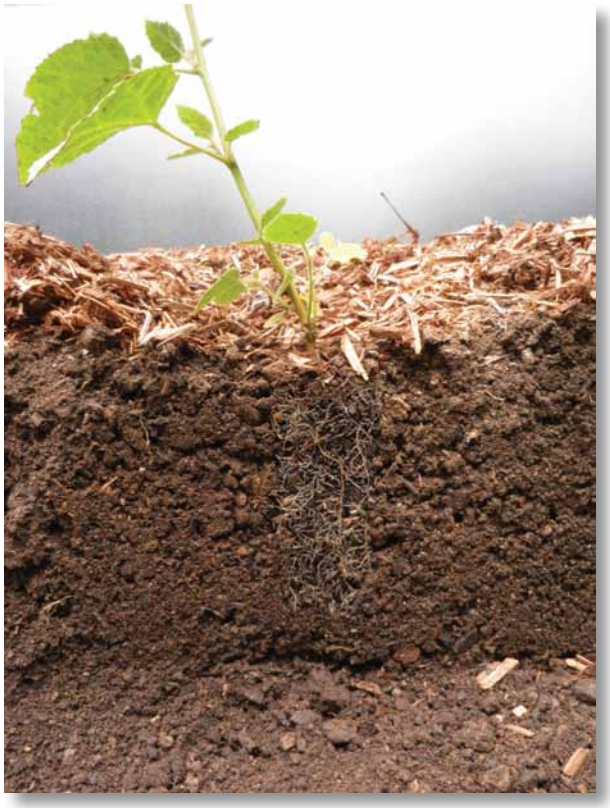
5.9.1.7 PLANT INSTALLATION

Here are some pointers on things to be aware of on planting day:

- Have all materials/plants/equipment ready on the day;
- Pre-sort the trees prior to commencement of planting.
    - Group plants according to the section of the site that they are to be planted in. E.g. sedges, rushes and lomandras along creek lines, and sclerophyllous plants in drier, rocky areas. This will make movement and laying out of plants easier.
    - Have a representative mix of species in each tray – this too will help with easy laying out of plants;
- Assign a specific task to each person – perhaps a few people digging holes, a few laying out plants, one person filling the holes with water, and yet another adding fertiliser. Make sure tasks are rotated periodically to avoid fatigue. Once each hole is ready, planting can commence;
- Holes dug should be slightly larger than the plant container size. In clay soils, check that the edges of the hole are not glazed – this often occurs when augers are used and will prevent the roots of the plant from spreading. Roughen the edges of the hole if this occurs or use a different tool;
- Moisture control is of paramount importance to the success of a planting – pre-water plants; fill dug holes with water before planting and allow water to soak in; on hot and/or dry days small tubes will dry out quickly and will require watering throughout the day; water plants in well after they have been planted;
- If using fertiliser and water crystals, place in the bottom of the hole and mix with soil prior to planting the tree. Do not allow the fertiliser to directly contact the plant roots;

- Slow release fertiliser is often used in restoration plantings. Note that some native species do not require fertilizer;
- When removing the plant from its container, handle the roots carefully to avoid dislodging the potting mix;
- Trees should be planted so that the top of the potting mix is just covered over by the back-filled soil from the hole. This will prevent the plant from drying out. Firm the plant gently into the soil using pressure from your hands, but be careful to avoid over-compaction of the soil;
- Creating a shallow dish using soil around the plant will help to retain water close to the plant's roots;
- Commercially available deterrents may protect the plants from native animals. Due to the use of fertilisers during propagation, the leaves of the newly planted trees are highly nutritious and very attractive to browsing animals; and
- Plants can be protected from sudden change, e.g. heat or frost, by adding an anti-transpirant.

Cross section of planted tubestock



Scattered plantings or trees in rows?

Most ecological restoration plantings space trees such that they are scattered. This is done in an attempt to mimic the distribution of vegetation within a natural community. But, do planting plants in rows affect the ecological outcomes? There has not been a great deal of research in this area. However studies in native monoculture and mixed native plantations (i.e. plantings in rows) have found that native flora and fauna are recruited in such plantings over time, particularly at the boundary of mixed plantations and natural systems (Kanowski *et al.*, 2005).

5.9.1.8 TREE GUARDS

Tree guards are useful for a variety of reasons, including:

- Protecting plants from browsers such as wallabies and hares;
- Protecting plants from desiccation, due to exposure from wind and sun;
- Protecting plants from frost;
- Creating a micro-climate that conserves moisture around the plant;
- Preventing off-target damage through follow-up herbicide applications during maintenance;
- Minimising flood damage providing they are secured correctly (e.g. secure hard wood stakes); and
- Easy identifiable location of plants.

Types of tree guards available, and the stakes required to support them, range from low-cost homemade creations to more expensive, commercially available guards. Examples include:

- Wire or plastic netting (small mesh) looped into a cylinder and secured with two wooden stakes;
- Corflute sleeve and single stake (variety of sizes available);
- Plastic sleeves stretched into a triangular formation using three bamboo stakes; and
- Cardboard cartons (such as from an empty 2L juice container) held in place with a single stake.

Which type of tree guard you select will depend on the purpose for which you require it. For example, a 1.5m high guard of wire netting, secured by two long wooden stakes would be required if your site is frequented by grazing macropods, but would be much less useful on an exposed, sandy coastal site. In this situation, a plastic guard to conserve moisture may be more appropriate.

Tree guards in use

Keep in mind that using tree guards will add greatly to your planting costs, as well as requiring additional labour to install. Make sure that guards are essential before undertaking this extra expense. There are sometimes negatives associated with their use, such as high humidity potentially increasing the risk of fungal infections or damage to trees in flood if inadequately installed or not removed.

Don't forget to budget for the removal of the tree guards, once the protection provided by them is no longer required. Gathering, transportation, storage and disposal of the guard components all add significantly to planting costs. Some degradable materials (such as wooden stakes) may be left on the site indefinitely, but it is never acceptable to leave plastic sleeves behind, as they can eventually become unsecured and create a litter problem.

5.9.1.9 MULCHING

Mulching of the planting site fulfils two main requirements:

- It suppresses weeds around the plants, reducing competition for resources such as light, moisture and nutrients; and
- It assists in water retention, keeping plant roots cool and moist.

Depending on the type of mulch used, mulching may also help improve soil structure by increasing the organic content. Types of mulch available include:

- Organic materials, such as hay, sugarcane waste bark, wood chips, cardboard, newspaper, and natural woven cloths such as jute or hessian; and
- Inorganic materials, such as polyethylene woven cloth and geotextiles.

The relative benefit of the various types of mulch will depend on the circumstances at each site.

The use of mulch may reduce the need for follow-up herbicide spraying by suppressing weeds, but keep in mind that mulch could also prevent the seeds of native plants from germinating.

Apply mulches such as hay and wood chips to a depth of approximately 75-100mm, as this will prevent light penetration while still allowing movement of air and moisture to the soil and plant roots. Be aware that mulch applied too thickly will prevent water (from rainfall or irrigation) from saturating the soil.

You may choose to simply mulch around individual plants (say to a radius of 50cm) or blanket mulch the entire site. With most native species it is important to prevent the mulch from touching the stems of the plants as this may lead to decay, this will depend on the type of mulch and the species planted.

As with tree guarding, mulching can be an expensive addition to your planting budget. Consider if it is really necessary. For example, a planting of pioneering rainforest species in productive soils will rapidly create a canopy shading out competing weeds, thus reducing the need for mulch. In this situation, scheduling maintenance sprays to control weeds while the plants are establishing may be all that is required. This approach also allows for natural recruitment to occur.

5.9.1.10 MAINTENANCE OF THE PLANTING

Maintenance, as with all ecological restoration work is fundamental in ensuring project success. Maintenance of the planting includes tasks such as:

- Herbicide spraying to control competing weeds;
- Watering while plants are establishing. This is often highly variable and depends on the suite of species planted, weather conditions and time of year when planted. A watering schedule may consist of watering every day for week 1, twice per week for weeks 2-6 and then weekly from weeks 6-12;
- Repair of tree guards if they become damaged;
- Replenishment of mulch;
- Maintaining exclusion fencing; and
- Additional planting if required.

Additional planting may be required to replace plants that do not survive (e.g. to meet survival rate requirements, or to fill gaps), but it may also be necessary to introduce new species at different stages of vegetation succession. For example, in a rainforest planting, mature-phase species that do not tolerate frost, sun or wind exposure are best introduced after a canopy of pioneer species has formed. Use an adaptive management approach, if one plant species consistently dies on a site, you should consider using in its place a species that is performing well.

Take time to visit your planting site regularly to observe how it is progressing and to ensure timely scheduling of required tasks. Maintenance will be required for several years following installation of the plants, although if maintenance is regular and thorough during the first 1-2 years, maintenance requirements are likely to taper off significantly in the following years. Getting the plants in the ground is just the first step. Only ongoing maintenance will determine if the planting will ultimately be successful.

5.9.1.11 CONCLUSION

It is important to bear in mind that reintroducing plant material to a site simply kick-starts the restoration process. The planting itself is not the end-product. Despite the warm feeling of satisfaction that we experience when we stand back and survey a planting that we have contributed to, it is vital to remember that the end result we hope to achieve is a well-structured, complex, functioning vegetation community. Planting the trees is merely the starting point.

As time passes, the plantings mature and natural regeneration begins to occur, and changes will be observed. At some point along the way, the site will change from a purely human-created construct to one which naturally includes elements which are not introduced deliberately to the site.

Events such as those listed below, will all help create a dynamic natural system:

- Competition between planted and regenerating plants will constantly change the mix of species present;
- Flowering and fruiting of both planted and regenerating plants, once they have reached maturity;
- Succession, resulting in changes to the structure and complexity of the vegetation;
- Increased numbers and diversity of animals using the site, as leaf litter and fallen branches accumulate, and tree hollows form; and
- Mature trees senescing, dying, and eventually contributing to the soil organic content.

This is the desired end-product – a fully-functioning system that can support itself in perpetuity, with minimal maintenance and input required. Take the time to think about the big-picture aspects of your planting when establishing the aims of the project; and the long-term results that are possible.

5.9.2 DIRECT SEEDING

Unfortunately direct seeding has had a chequered history in SEQ. Although widely accepted as a viable method of establishing vegetation, there have been mixed results in SEQ and as such many land managers have disregarded it.

Direct seeding can be a cost effective method of establishing vegetation costing around $0.40-0.60/m^2$ (Kraatz *et al.*, 2009).

There are a number of factors that determine the success of direct seeding and these are best considered well in advance of undertaking a project. The major considerations are:

- **Weeds**. Competition with weeds is one of the major determining factors of success. Once weeds have gained dominance over the sown natives it is difficult to regain control. Therefore good site preparation is required followed by vigilant maintenance by operators skilled in differentiating between germinating native and exotic species.
- **Soil/seed contact**. Many seeds of native species, particularly those in the Myrtaceae, are small and unless adequate contact is made with the soil will not germinate. Conversely, such seeds planted at depth will also struggle to germinate. Site preparation is therefore very important.
- **Fertility**. The greater the fertility the greater the likelihood that weeds will gain dominance over sown natives. It has been observed that less fertile sites are more successful than highly fertile sites. This said, direct seeding has been shown to be a viable technique for establishing some rainforest species in basaltic krasnozem (red podsolic) soils of the Atherton Tablelands (Doust et al., 2006).
- **Viability**. Care must be taken to ensure the seed utilised is viable. Attaining a certificate of viability from the seed merchant is a prudent step or if you have collected seed yourself undertake your own viability tests. Florabank provides details on how to conduct seed viability tests (ATSC and Mortlock, 1999) (see http://www.florabank.org.au)
- **Watering**. Watering is not advised. Provided there is good site preparation and sowing is undertaken at the correct time of year then watering is unnecessary and may compromise the project.
- **Time of year**. In SEQ the most appropriate time of year to sow is autumn. The gentle autumn rains followed by the cooler months of winter results in better establishment of the small seeded natives than the pounding summer rains that are often followed by hot days.
- **Harvesting**. Large numbers of seeds can be lost to foraging ants and other fauna. It is best to treat the seed with insecticide prior to sowing to deter harvesting.
- **Monocot/dicot**. Mixing monocotyledon species with dicotyledon species is not advised. Young native grass seeds are difficult to distinguish from exotics and as such will be difficult to manage. This said, seeding of pure monocotyledonous mixes is likely to be easier to manage. Although some work has been undertaken in the establishment of native grasses in the context of agronomy (Waters et al. 2000) and rangelands (Scholz, 1996) there appears to be little literature on establishing grasses in the sclerophyll ground layer and should be the subject of further investigations. Cole *et al.*, (2000) and Chivers (2006) provide some good information (see http://www.florabank.org.au/ and http://ga.yourasp.com.au)

There are a number of different approaches to direct seeding. Direct seeding machines are frequently utilised in the southern states.

Many projects in SEQ have used machines to create broad seed beds. The approach has often included the following steps:

- Spray the area with a non-residual herbicide. If necessary, slash the area prior to spraying in order to remove bulk. Wait for resprouting to occur and then spray. In an endeavor to reduce the weed seed bank, it is sometimes advisable to await the germination of a second generation of weeds and treat these again;

- Rip the area. It is preferable to cross rip the area to generate a seed bed with clods the size of golf ball to tennis balls;
- Sow immediately. Sowing into the active soil surface will enable seeds to fall into niches in the active soil surface. The seed mix is discussed below;
- Fence the area to prevent grazing or trampling; and
- Regularly monitor and treat weeds. At least for the first 6-12 months, treatment of weeds in direct seeding beds should be more frequent than in planting beds.

A freshly prepared seedbed with an 'active' surface

The seed mix should consider the following:

- The seed mix should include a good mix of large seeded and small seeded species. A mix dominated by wattle species is likely to achieve good site coverage for a number of years, but may not have adequate secondary species to allow the persistence of canopy cover following wattle senescence;
- Heat-treat or scarify all hard coated seeds (e.g. Acacia and Dodonaea species and most species in the Fabaceae). Do not boil the seeds;
- An ant deterrent should be added to the seed mix (e.g. a Permethrin powder). A slurry of 5gms of powder mixed with 20ml of water is sufficient to cover around 1kg of seed (Dalton, 1993);
- Immediately prior to sowing, bulk the seed mix with dry sand or saw dust. This enables easy sowing of the mix; and
- Hand sow the mix evenly across the active soil surface to achieve an even rate.

The left plot was direct seeded at the same time as the right was planted as part of a trial in Redlands. The photo represents a little over 2yrs of growth.

The appropriate volume of seed to use is variable depending on prevailing circumstances. In high rainfall areas of southern states, a rate of 150-250gms/km is applied in seeding machines, which equates to 300–1,000gms/ha (= 0.03-0.1gm/m^2) (Bonney, 1998). Good results have been achieved at high rates (up to 0.8gm/m^2), but it is likely that some of these sites are too dense and now require thinning. Kraatz *et al*., (2009) recommends 0.5gm/m^2 as a 'rule of thumb' in northern Australia.

8 yr old direct seeding in Slacks Creek. Sown approx. 0.3gm/m^2

Direct seeding can also be undertaken by placing only a pinch of seed (0.2-0.4gms) (Dalton, 1993) into a niche created by a tool such as a rake-hoe which can be used to both expose and cultivate the soil prior to seeding.

5.9.3 BRUSH-MATTING

Brush-matting requires that a supply of seed-bearing stems and branches be available which will provide the source of propagules to stimulate regeneration. The stems may be stockpiled briefly, or transferred immediately to the reintroduction site. Care must be taken to harvest the stems at a stage when they hold viable seed, and to monitor storage to ensure seed does not drop prior to use.

The harvested stems are laid over the area to be restored. Preparation of the site prior to brush-matting may be necessary e.g. ensure soil micro-organisms are present. Eventually the seed from the branches will drop to the ground, be covered over with soil by the movement of wind and wildlife, and germinate. Of course, follow-up maintenance, including weed control, will be required while the plants are becoming established.

This technique is frequently used in extractive industry such as sand mining in coastal heath. Vegetative material bearing seed, together with the retained topsoil layer are returned to the re-contoured site during post-mining restoration.

However, brush-matting is not restricted to this situation. For example, it may be possible to collect and broadcast the seed-bearing heads of native grasses such as kangaroo grass (*Themeda triandra*) as a quick and easy means of stimulating regeneration at a restoration site.

The following should be considered in relation to attaining brush-matting:

1. Don't collect from threatened Regional Ecosystems or from sites where threatened species are present; and
2. Don't cause damage to the donor site by over-harvesting. Ideally, harvest only from sites which are going to be cleared anyway e.g. for development.

Brush-matting is particularly useful in situations that are prone to wind erosion, as the vegetative material acts as a stabiliser, as well as delivering the seed to the required location. Brush-matting also helps to provide habitat, as well as increasing the texture of a site by creating micro-niches.

5.9.4 HYDROSEEDING AND HYDROMULCHING

Hydromulching and hydroseeding (often referred to as one and the same) are effective methods of surface stabilisation and/or seed application for landscapes (such as large or inaccessible areas), where more traditional means of mulching or planting would be costly and/or difficult.

Hydromulching entails combining cellulose, tackifiers and water in a hydromulching machine (JB Hydroseed, 2010). This resulting slurry, transported in a tank on a truck or trailer is then sprayed over prepared ground in a uniform layer for the purpose that it is intended. Sometimes a dye is added to assist in identifying areas that have been covered.

When seed and fertilisers are included in the hydromulch mix, the process can be defined as 'hydroseeding'. Because the mix is applied to the ground surface, the cellulose can separate seed from direct soil/seed contact. As such, the germination of small seeded species (e.g. Myrtaceae) is often prohibited, and therefore the technique is primarily suited to large seeded species (e.g. Mimosaceae).

5.9.5 TRANSPLANTING

Transplanting, also termed translocation, involves moving established plants from one site (donor site) to another (receiving site). Plants may be either transferred directly to the receiving site, or placed in pots in order to be cared for in a plant nursery prior to planting. Plants that spend an intermediate period of time in pots are more likely to be successfully transplanted.

Transplanting is best suited to grasses and soft herbaceous plants such as rushes, sedges, groundcovers, ferns and lilies. Trees and shrubs are more difficult to transplant due to the need to keep the roots relatively intact. Clumping plants that can be broken up into a number of smaller clumps for transplantation are ideal. Case Studies 7 and 10 describe situations where translocation of suitable plants were undertaken. Note that permits under the *Nature Conservation Act 1992* and possibly also under the *Environment Protection and Biodiversity Conservation Act 1999* must be obtained prior to translocation of native plants.

5.9.6 TRANSLOCATION OF TOPSOIL

Stripping and stockpiling the top 50 to 100mm of topsoil from mining sites is a well-accepted means of carrying out post-mining restoration. This topsoil layer contains seeds, rootstock, rhizomes, tubers and soil micro-organisms. Stripped soil can only be stored for a limited time period due to the loss of viability of soil organisms and propagules, and the risk of decomposition.

Case Study 8 describes a situation where translocation of sections of intact topsoil was used to move an entire vegetation community.

CASE STUDY 7

TRANSLOCATION OF SHINY PLECTRANTHUS

Raising the height of the wall of the Hinze Dam in the Gold Coast hinterland is due to result in the inundation of hundreds of hectares of vegetation. As part of the rehabilitation works associated with this project, transplanting of threatened species was undertaken in order to conserve genetic diversity. One species, the endangered shiny plectranthus (*Plectranthus nitidus*), was particularly suitable for translocation, as it is a small, soft herbaceous plant that occurs in the ground layer of riparian areas, moist rainforests and rocky outcrops. The plants were collected from the inundation zone and transplanted to receiving sites higher up in the catchment area of the dam. Ongoing monitoring of the transplanted shiny plectranthus is being undertaken to ensure success and to date, the initial population size transplanted has doubled.

5.9.7 LONG-STEM PLANTS

A technique which is becoming more widely used is the planting of long-stem plants. These trees are propagated in small tubes in the nursery for 10-18 months, after which they have developed long woody stems more than 1m high. Careful use of slow-release fertilisers ensures plants do not become pot-bound. The long-stem trees are then planted to a depth of 1m, and an extensive network of roots develop from the buried stem. This technique has the advantage of:

- No post-planting watering required;
- Increased growth rates;
- Higher survival rates; and
- Reduces plant losses, as plants are less likely to be ripped out by flood.

Experimentation has shown that this technique can be used successfully in riparian areas and sand-dunes (where long-stem plants are able to resist erosion, access reliable soil moisture, have less root competition, and a stable soil temperature) but long-stem plants are now also used on rainforest and saline sites. The main reason for its success appears to be that it encourages development of a robust root-network. It is suitable for most hard-tissue plants.

There is reduced use of resources because site preparation is lessened, tree guards are not necessary, post-planting maintenance is minimal, and use of fertiliser and water is restricted. However, more time is required to allow plants to grow to a suitable height in the nursery, and more time and energy are expended digging 1m deep holes.

A guide on how to grow long-stem seedlings and the planting technique can be found at: http://www.australianplants.org

CASE STUDY 8

SIPPY DOWNS HEATH TRANSLOCATION

BACKGROUND

The development site "Brightwater Estate" at Bundilla on the Sunshine Coast, Queensland in part supported broad areas of heath habitat for several at risk species including *Blandiflora grandiflora, Acacia baueri*, *Schoenus scabripes, Boronia rivularis* and *Acacia attenuata*.

The developer, Stockland, worked in conjunction with the University of the Sunshine Coast to undertake a large scale translocation of the heath that was otherwise at risk of being lost to development.

IMPLEMENTATION

A total area of 12.2 hectares of heath was translocated to a 15 hectare plot located at the University. 'Biscuits' or 'turves' of soil from the heath were moved in 2m square pieces of 300-400mm deep. This included plants, seed stock, animals and trees (trees were pruned to 1.5m tall prior to transport). An excavator was used to lift turves intact and load them on to trucks to carry them to the University site.

The 15 hectare plot at the University was prepared to receive the translocated turves by removing soil to ensure the water table was maintained and by monitoring nutrient levels.

The project cost approximately $5 million to implement.

The University of Sunshine Coast has been undertaking monitoring of the plots and is the subject of a number of PhDs.

Visual assessment during the author's site inspection indicated that there were little differences between the diversity and structure expected in the undisturbed community.

LESSON LEARNT

The method appears to be an effective approach to establishing heath, however, the situation is unique in that large areas of heath are rarely available for removal and the cost is highly prohibitive. Nonetheless, the project demonstrates that with good planning and an understanding of ecosystem processes that soil can be transferred from one site to another for the purpose of establishing vegetation.

Receiving site prior to translocation in 2007

Receiving site following translocation in 2008

On ground image of the translocated heath in 2010

5.9.8 LAYERING

Layering is a useful technique to apply when planting to stabilise coastal dunes. Simply dig a 20cm deep trench, drop in a 50cm length of stolon taken from beach spinifex (*Spinifex sericeus*), yellow beach bean (*Vigna marina*) or goat's foot morning glory vine (*Ipomoea pes-caprae* subsp. *brasiliensis*), and back-fill the trench. No watering is necessary, and the rapid colonisation ability of these species will quickly stabilise newly formed or disturbed dunes.

5.9.9 GUIDELINES FOR COLLECTING SEED AND VEGETATIVE MATERIAL

Guidelines for collecting seed and vegetative material for planting in restoration projects in or near natural areas are detailed below. Make sure that the appropriate permits have been obtained if collecting seed from plants listed under the *Nature Conservation Act 1992* or collecting from a National Park. Collecting from council owned land is also likely to need prior approval from the relevant council.

5.9.9.1 SEED COLLECTION

It is important to consider the issue of genetics in the selection of seeds and seedlings. The following Guidelines have been developed to provide practical assistance when collecting seeds for use in restoration projects (Playford, 1998; Gold Coast City Council, 2007):

- Collect in an area within the local catchment, preferably with the same aspect, generally no further than a 10 kilometre radius. The extent of the collection area will vary depending on the method of seed dispersal (which influences the ease of gene flow). For example, fig seed can be more widely dispersed by flying fox than seed from a lomandra that drops straight from the parent plant;
- Collect from as many 'wild' growing plants as possible to ensure variation. Seeds should not always be gathered from a favourite or easy-to-access site, nor should they be picked only from well-laden or easy-to-reach specimens (all of which ensure lack of variation);
- Collect seed from several (at least 10) well-spaced plants to reduce the possibility of them being related. Mix together equal amounts of seed from each plant before sowing. This is particularly important if planting uncommon or rare species;
- If the planting program is to be ongoing, identify each seed collection plant so that different plants can be used in the following years;
- Do not collect only from "good looking" specimens. Such plants may be in this condition because they are responding to certain favourable environmental conditions present at the time. If these conditions change in any way so may their ability to survive;
- Try not to collect from isolated plants, as self-pollination and/or inbreeding may have occurred and this can often yield low quality seed;
- Seed collection from plantations and other planted specimens requires caution. A plantation will be a poor source of seed if it was derived from the seeds of a single plant, or from seeds of unsuitable provenance;
- Seed collected from woodlands or forests where only a few trees have flowered well will also tend to be more inbred than seed collected after a heavy flowering year when it is likely that greater rates of out-crossing have occurred; and
- Be careful not to strip plants of their seeds as they may be important food for wildlife. Over-harvesting may also negatively impact on the local seed bank available for natural regeneration in the area of collection.

5.9.9.2 COLLECTION OF VEGETATIVE MATERIAL

The use of vegetatively propagated plants in restoration projects may be necessary if insufficient local viable seed is available or if germination of seeds is prolonged, erratic or difficult. Vegetative propagation can be a useful tool, especially when propagating ground layer plants that spread by bulbs, corms, rhizomes or stolons, such as native grasses, matrush (*Lomandra* spp.), flax lilies (*Dianella* spp.), and native ginger (*Alpinea* spp.).

Vegetative propagation includes the use of stem or root cuttings, aerial layering or division, and plants produced through these methods are genetically identical to parent plants. There is a lack of genetic variability within a planting and thus the possibility of increased susceptibility to disease and insect attack.

Guidelines for collection of vegetative material are similar to those for collection of seed.

6 MAINTAINING SITE RECORDS

"It is important to bear in mind that reintroducing plant material to a site simply kick-starts the restoration process."

6.1 DAILY RECORD SHEET

A record of the work undertaken at a site each day when visited should be maintained. This Daily Record Sheet includes details such as:

- Date and staff who worked that day;
- The work done, area covered, weeds controlled and the methods used to do it;
- Weather conditions, including temperature, wind speed and direction and humidity;
- Growing conditions;
- Fauna observed at the site;
- Flowering and fruiting of native plants;
- Observation of results of previous works; and
- Any other observation of interest and relevance to the restoration of the site.

The purpose of keeping a Daily Record Sheet is predominantly to allow a long-term, accurate record of actions taken and changes in conditions at a site over the time that it is being restored. This information can be used to determine the costs of restoration at a site. Daily Record Sheets are a valuable tool for learning, as techniques which have shown to have been successful can be further refined and used on other sites. (see *Appendix B*)

6.2 CHEMICAL USAGE

In addition to the daily record, legislation requirements under the *Agricultural Chemicals Distribution Control Act 1966* specify that a record must be kept of herbicides applied – such as the name of the herbicide, quantity used, dilution rate, method of application and weather conditions. This record can be incorporated into the Daily Record Sheet in order to reduce time required to record the day's works and keep all relevant information together.

7 MONITORING AND EVALUATION

"Evaluation helps determine if project goals and objectives have been met, and provides the opportunity to analyse what has worked really well, and what may have gone wrong.."

7.1 INFORMAL MONITORING

For most ecological restorationists concerned primarily with hands-on restoration work, informal techniques will be sufficient to meet monitoring needs. One of the best ways to do this is with photopoints. A permanent photopoint can be set up using a star picket marked with fluorescent yellow safety cap, so that a photograph may be taken of the site at regular intervals as it is being restored. A time series of photographs, from a degraded state prior to the commencement of restoration, through the transition stages, to the minimum maintenance stage, can be a powerful reminder of the changes that have been achieved by restoration. Photos can also inspire others by showing what can be achieved at one site is certainly possible at another.

Daily Record Sheets (as described in section 6.1) are another means of informal monitoring (see *Appendix B*).

7.2 FORMAL MONITORING

Formal monitoring, using carefully collected quantitative data from plots (quadrates and transects) is time-consuming, and the data may require painstaking analysis. As such, this may be better undertaken by restoration ecologists, independent from the project. However, formal monitoring is able to provide additional information that informal observations cannot. This is likely to be important when determining whether Performance Indicators have been achieved and whether the project is heading in the right direction to achieve project goals.

One potential approach is to measure the progress of the site utilising the BioCondition tool. BioCondition is a terrestrial vegetation condition assessment tool for biodiversity in Queensland. This method involves assessing, scoring and weighting various vegetative attributes (such as native plant species richness, tree canopy cover and fallen woody material) and landscape attributes (such as size of patch, context and connection) in order to obtain a final BioCondition score. The score ranges from a rating of 1 (for 'good' biodiversity condition) to 4 (for 'poor' biodiversity condition). BioCondition was designed to allow comparisons to be made of biodiversity between sites, and to enable rigorous decision-making at State, regional, and local levels, but it could also be adopted as a way of assessing the progression of restoration on a site over time. Measurements may also be compared against benchmarks determined from reference sites and/or the base condition of the subject site prior to commencement of ecological restoration works. More details are available at: http://www.derm.qld.gov.au

Other detailed methods can be utilised such as fauna survey/trapping to ascertain whether the fauna assemblage is tending toward that expected in an undisturbed community, although this is an expensive option and needs to be undertaken by specialists in possession of relevant licenses.

Whatever approach is adopted, it is important that it serves the purpose of determining whether Performance Indicators and aims of the project have been or will be achieved.

7.3 EVALUATION

Evaluation helps determine if project goals and objectives have been met, and provides the opportunity to analyse what has worked really well, and what may have gone wrong. Carrying out restoration works without taking the time to assess on a regular basis, the progress that has been made may result in costly mistakes being made both ecologically and financially.

7.4 ADAPTIVE MANAGEMENT

Adaptive management involves learning from previous management actions in order to improve future management. There are two types of adaptive management:

- **Passive adaptive management**. The responses of the system are monitored and used to improve management e.g. an unplanned fire triggers a flush of germinating seeds, resulting in the decision to send a team of restoration workers to spot-spray herbicide to control new weed growth.
- **Active adaptive management**. Management actions are taken partially to improve learning about the system e.g. a decision is made to conduct a planned burn in a section of a restoration site, in order to observe the germination response of both native and non-native plants in this particular vegetation community to fire. This results in a massive establishment of weeds and hence is not pursued as a viable technique.

7.5 REPORTING

Practically every funded restoration project will have a requirement for regular reporting. Stakeholders will want details about the work undertaken, funds expended, and whether the objectives of the project are being met. There is usually a standard format for such reports.

Another important aspect of reporting is to share an account of a project (successful or not) with other practitioners. This could be published in a journal (e.g. Ecological Management and Restoration), newsletter (e.g. Land for Wildlife) or a presentation can be made at a relevant conference or meeting. Either way, the vital point is that knowledge gained, through both successes and failures, is of great value to restoration workers, in helping them to refine techniques and gain new understandings of how to influence ecological processes to bring about restoration.

8 PRACTICES FOR PARTICULAR ECOSYSTEMS

"In most instances at least 2-5 years are required to ensure the success of a project."

Whilst the techniques outlined in this Manual are applicable to a range of ecosystems, it is worthwhile considering some of the practices that should be considered when undertaking ecological restoration in particular ecosystems.

8.1 FRESHWATER WETLANDS AND RIPARIAN CORRIDORS

Although freshwater wetlands and riparian corridors cover a broad range of ecosystems there are a number of considerations common to all including:

- These environments frequently provide habitat for frogs. Globally there has been a decline in frog numbers which has been attributed to the spread of Chytrid fungus. To minimise the likelihood of further spreading this disease, equipment and boots should be sanitised prior to commencing work in wetland and riparian/waterway environments;
- Given impacts of herbicides on aquatic life there should be restricted use of herbicides in these environments with preference given to aquatic fauna 'friendly' products; and
- Weeds are difficult to address in wetlands and waterways. Frequently native and exotic species look similar and as such great care must be paid to their management. In some circumstances native species will act like weeds such as *Phragmites australis* or *Typha orientalis*, and depending on the goal of your restoration project, may require management. Manual control is often required in the first instance so as to avoid eutrophication of waters particularly in the instance of floating aquatic weeds. That is, the use of chemicals to overspray a large mass of weeds results in the material sinking to the bottom resulting in massive and rapid input of nutrients into the system.

There are some issues particularly relevant to riparian corridors/waterways. Although erosion is a natural process in waterways we are frequently faced with rapidly eroding banks due to the historic clearing of vegetation and altered hydrological patterns. 'Scour' of banks is one of the most common forms of erosion targeted for treatment.

Some considerations when dealing with erosion include:

- Frequently geotextiles (e.g. jute) are used in favour of mulch in waterways because they are less likely to wash away in flooding events. These are often used where the bank has been re-contoured;
- In many instances the re-contouring of banks is either difficult and/or cost prohibitive. Planting directly into the bank is a solution, but the key to most bank erosion problems is the actively eroding toe and as such this area must also be addressed (Price and Lovett, 1999). Planting in this zone is difficult and to maximise success it has been recommended that the roots of species are matched with the size of the slump; and
- The use of long-stem plants are useful in creek bank restoration as they are less likely to wash away during floods.

Case Study 9 demonstrates use of the Fabrication approach, where erosion control was achieved using a combination of re-contouring and jute matting while planted seedlings became established.

With regard to artificial wetlands the guide "Planting Wetlands and Dams" by Nick Romanowski (2009) provides many useful tips. Some of these include:

- Only using a limited range of plants in the initial planting followed by introducing additional species overtime through staggered plantings; and
- Care must be given in wetland environments to protect plantings from grazing during establishment.

CASE STUDY9

HOMESTEAD PARK, LOGAN WATERWAY PLANTING

BACKGROUND

A tributary of Slacks Creek within Homestead Park, Shailer Park, was rehabilitated as part of Logan City Council's Waterway Rehabilitation Action Plan.

The tributary was deeply incised with banks very steep to cliffed and undercut. Due to the urbanisation of surrounds and modification to the waterway, a pre-European vegetation community was not likely to be attained and hence a fabrication approach to restoration was adopted.

IMPLEMENTATION

A 432 square metre section of the north bank was selected for rehabilitation.

The stream bank was graded to a 45° angle and weeds controlled. Immediately following stream bank remodelling, thick jute mat was laid to prevent soil erosion and control weed growth.

Seedlings were planted along the bank through the jute matting by cutting X-shaped slits.

LESSON LEARNT

The technique of controlling weeds, applying jute and subsequent planting with a mix of riparian species proved effective at bank stabilisation, preventing weed re-establishment and establishing a fabricated habitat.

Above - Project implementation in 2004

Below - The site in 2010

CASE STUDY10

SALTWATER CREEK RECONSTRUCTION OF SALTMARSH

BACKGROUND

This project was undertaken by the Department of Transport and Main Roads in conjunction with FRC Environmental to offset the impacts of the Houghton Highway duplication on saltmarsh. Four species of the saltmarsh community (*Sporobolus virginicus*, *Sesuvium portulacastrum*, *Suaeda australia* and *Sarcocornia quinqueflora*) were transplanted to a degraded site on Brenner Road, Rothwell using a number of experimental treatments, including the use of 'plugs'.

IMPLEMENTATION

In March 2008 the plugs of saltmarsh were attained using a shovel from the donor site. Plugs were individually transplanted into two transects with or without geotextile matting. Two years following transplantation, saltmarsh survival was compared between the two transects. It was found that only 33% of the plugs without geotextile matting survived compared to 80% of those planted with geotextile matting, which had begun to spread.

Monitoring of epifauna (crabs, gastropods) showed an increase in use of rehabilitated areas compared to bare patches.

LESSON LEARNT

FRC Environmental made the following recommendations at the end of the trial in relation to transplanting plugs of saltmarsh:

- Future transplanting of saltmarsh should be undertaken on geotextile material; and
- Saltmarsh plants should be planted as close together as possible to aid in coalescence.

Installing the plugs. With geotextile on the left and without on the right.

Same area in 2010. Without geotextile on the left and with on the right.

Results and implementation photograph courtesy of the Department of Transport and Main Roads in conjunction with FRC Environmental.

8.2 SALTMARSH AND MANGROVE

Any work in saltmarsh and mangrove communities is likely to require a permit under the *Fisheries Act 1994*.

Laegdsgaard (2006) undertook a review of ecology, disturbance and restoration of coastal saltmarsh in Australia. In the review made several key points that are pertinent to saltmarsh restoration:

- *"Actions such as fencing to remove cattle from saltmarsh areas, diversion of stormwater away from saltmarsh and weed removal are the most common rehabilitation methods for saltmarsh.";*
- *"Zonation of saltmarsh plants requires a specific combination of land gradients (to ensure inundation) and soil salinity.";*
- *"The best results from restoration are generally achieved where the environment has been prepared for the natural recolonisation or regeneration of saltmarsh plants.";*
- *"In transplantation from natural sites, it is important to consider the impacts to the donor sites and that the effects of harvesting may take some time to recover."; and*
- *"Saltmarsh areas that are restored using transplants from donor sites may establish a compliment of fauna faster as some may be transported in with the transplant. This is effectively inoculating the site with fauna."*

Many of the approaches and techniques outlined in the NSW Saltwater Wetlands Rehabilitation Manual (DEEC, 2008) are applicable in SEQ (see http://www.environment.nsw.gov.au)

Case Study 10 (on previous page) describes restoration of a degraded saltmarsh site by transplanting 'plugs' of suitable species.

8.3 HEATH

Heath is a community occurring in diverse locations including mountains and in wet and dry areas of the coastal plain. Most montane heath in SEQ occurs in protected estate (e.g. Glass House Mountains, Mt Coolum, Lamington) and because of its location has not been subject to significant levels of disturbance, although impacts from recreational use of these areas can be severe.

Lowland heath of the mainland has been all but lost from the Gold Coast and is frequently impacted where it occurs near urbanised areas on the Sunshine Coast. Heath can be significantly impacted by changed hydrological and nutrient regimes. Given this, before any work is undertaken in these systems these abiotic impacts must be addressed prior to biotic impacts such as weeds. Site assessment is critical in this community to identify the source of the abiotic impact such as nutrient sources from urban runoff, inappropriate fire regimes etc.

8.4 SCLEROPHYLL FORESTS

The most common vegetation communities in SEQ are sclerophyll forest. Sclerophyll can be broadly grouped into three sub categories in the region:

- Swamp sclerophyll forest (e.g. melaleuca forests);
- Wet sclerophyll forest (e.g. flooded gum forest with rainforest understorey); and
- Dry sclerophyll forest (e.g. spotted gum forests).

Significantly, the desired fire interval in each of these communities is quite different and as such influences how fire should, or shouldn't, be used in each as a restoration tool. Protection from fire may be necessary while saplings are establishing.

Carr *et al*., (2010) outline a number of considerations for eucalypt woodland plantings, most of which have been discussed in this Manual. Of note however is the recommendation to deplete soil nutrients (particularly nitrogen and phosphorus) before planting to resist re-invasion by exotic weeds through:

- Weed harvest, scalping, sugar (or organic carbon) application;
- 'Mining' of nutrients using unfertilised crops; and
- Subsequent establishment of dense kangaroo grass (*Themeda triandra*) swards to continue 'locking up' nutrients.

Although these recommendations apply to woodlands as opposed to open forest, there are likely to be situations in the SEQ region where similar approaches may prove beneficial.

8.5 RAINFOREST

There are numerous rainforest associations in the region including:

- Coastal or littoral rainforest (notophyll vine forest);
- Warm temperate rainforest (simple notophyll vine forest);
- Dry rainforest (araucarian notophyll vine forest or araucarian microphyll vine forest);
- Subtropical rainforests; and
- Cool temperate rainforest (microphyll vine/fern forest).

As the latter occurs at altitude, it is largely protected in national parks and is infrequently the subject of ecological restoration in SEQ.

The Manual emphasizes a preference for the use of Natural Regeneration or Assisted Regeneration where regeneration capacity exists. There are instances where this capacity has been lost and it is necessary to undertake planting. Kooyman (1996) identifies a number of considerations when undertaking rainforest reconstruction work including:

- When planting is required, the preferred size is 200mm/1 litre bags or similar. Plants should be 60-70cm tall;
- Frost hardy species can be used as a nurse crop where necessary. Known frost hardy species include black wood (*Acacia melanoxylon*), brown kurrajong (*Commersonia bartramia*), native quince (*Guioa semiglauca*, *Mallotus* spp.), sweet pittosporum (*Pittosporum undulatum*) and corduroy tree (*Sarcopteryx stipata*);
- Wind breaks and edge plantings are useful; and
- Vine species should not be planted until canopy species have grown sufficiently so that they can be supported.

8.6 BEACH FOREDUNE

The beach foredune is a harsh environment in which to establish plants being subject to salt spray, onshore winds and a sandy substrate. At times there may be a need to stabilize sand through a variety of methods including matting.

Where planting is required it may be necessary to commence with ground cover species such as beach spinifex (*Spinifex sericeus*), yellow beach bean (*Vigna marina*) or goat's foot morning glory vine *(Ipomoea pes-caprae* subsp. *brasiliensis*) to assist in stabilising the site. Trees and shrubs may require protection from wind and sand blasting through the use of tree guards.

Where moisture retention is poor consider using water retention crystals and/or regular watering.

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WEBSITES

AABR website:
www.aabr.org.au

Australian Plants website:
www.australianplants.org

DERM Website:
www.derm.qld.gov.au

DPI Website:
www.dpi.qld.gov.au

DSEWPC Website:
www.environment.gov.au/biodiversity

Florabank:
www.florabank.org.au

NSW Department of Environment and Climate Change:
www.environment.nsw.gov.au

Sunshine Coast Council:
www.sunshinecoast.qld.gov.au

Wildlife Friendly Fencing Project:
www.wildlifefriendlyfencing.com

GLOSSARY

Abiotic: Non biological influences such as light, wind, modified hydrological regimes and changed soil conditions.

Biodiversity: The variety of life and its processes, including diversity of organisms, genetic diversity, and the communities and ecosystems in which they occur.

Biotic: Biological influences such as pests (weeds and animals) and 'rogue' native plant species.

Ecological restoration: The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. Compare with Rehabilitation.

Ecologically sustainable development (ESD): Development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends. The targets of the South East Queensland Natural Resource Management Plan 2009–2031 represent the outcomes of ESD.

Ecosystem services: The goods and services provided by ecosystems that benefit, sustain and support the wellbeing of people. They include production of food and medicines, regulation of climate and disease, provision of productive soils, clean water and air, opportunities for recreation and spiritual benefits. (from SEQRP)

Ecosystem: Consists of the biota (plants, animals, microorganisms) within a given area, the environment that sustains it, and their interactions.

Environmental Weeds: All weeds impacting the environment including those listed under the *Land Protection (and Stock Route Management) Act 2002* and local council ordinances.

Function: The dynamic attributes of an ecosystem, including interactions among organisms and interactions between organisms and their environment.

Indigenous species: The biota that occur in a particular location such as in a reference ecosystem (see also *Local provenance*).

Local provenance: Indigenous species established form the seed sourced from natural populations within a particular site or area (see also *Indigenous species*).

Niche: The part of the environment into which a species fits (i.e. its specific habitat), and to which it is adapted.

Performance Indicators: Provide very clear goals and are used to establish if the aims and objectives of the ecological restoration plan are being met.

Precautionary principle: Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

Reference ecosystem (or reference community): An ecosystem that serves as the model for planning an ecological restoration project and as a reference against which the success of the project can be evaluated. The reference ecosystem has not been subject to extensive past disturbance.

Regional Ecosystems (REs): Communities of vegetation that is consistently associated with a particular combination of geology, land form and soil in a bioregion. The Queensland Herbarium has mapped the remnant extent of regional ecosystems for much of the state using a combination of satellite imagery, aerial photography and on-ground studies.

Rehabilitation: Emphasises the reparation of ecosystem processes, productivity and services, without necessarily re-establishing the pre-existing biotic integrity.

Resilience: The ability of an ecosystem to regain structural and functional attributes that have suffered harm from stress or disturbance.

Self-sustaining: A restored ecosystem which is resilient to disturbance and requires minimal long-term management input.

Structure: All vegetative elements within an ecosystem either dead or alive including, but not limited to, trees, shrubs, ground covers, lianes, logs and leaf litter.

Succession: The directional non-seasonal cumulative change in the types of plant species occupying an area through time. It involves the processes of colonization, establishment, and extinction. Most successions contain a number of stages, each of which are characterised a particular dominant species assemblage.

Threatened species: Plants or animals which have been listed as extinct, extinct in the wild, critically endangered, endangered, vulnerable, rare or conservation dependant under either federal or state legislation.

Vegetation community: An assemblage of particular populations of different plant species within a specified location in space and time.

ACRONYMS

ACDC: Agricultural Chemicals Distribution Control

BFP: Brisbane Forest Park

BRAIN: Brisbane Rainforest Action and Information Network

CSP: Cut-Scrape-Paint

DEEDI: Department of Employment, Economic Development and Innovation

GCCC: Gold Coast City Council

IWM: Integrated Weed Management

MSDS: Material Safety Data Sheet

PPE: Personal Protective Equipment

RE: Regional Ecosystem

SEQ: South East Queensland

SEQFBC: South East Queensland Fire and Biodiversity Consortium

SERI: Society for Ecological Restoration International

APPENDIX **A**

EXAMPLES OF PROJECT CHECK LISTS AND SITE RISK ASSESSMENT /INDUCTION RECORD

- Project Checklist modified from Sunshine Coast Regional Council Natural Areas Project Checklist
- Site Risk Assessment courtesy of Sunshine Coast Regional Council

Natural Areas Project/Activity Checklist

1. PROJECT DESCRIPTION

Project/Activity Title	

Officer undertaking Project/Activity	

Planned commencement and end date for Project/Activity	
Provide an overview of Project/Activity	

Risks (Identify the risks associated with this project/activity

Officer undertaking this check	
Same as above	**Date**

Is this activity to occur on Council managed land	

Note for a project to be undertaken on property not managed by Council. Approval from the Manager is required.

Is this project identified in your current annual plan?	

Has this activity been budgeted for?	

(If the project has not been included within the annual work plan or does not have an identified budget this project cannot proceed).

What is the identified budget for this project/activity	$

What is the job number for this project/activity	

2. COUNCIL MANAGEMENT

Property Number	
Owner	
Legal Description (as per Proclaim)	
Property Type (as per Proclaim)	

Check Emap

What is the property shown within Councils Mapping System – Open Space Layer
Gazetted

Is this activity to occur on Amenity Reserve Undeveloped	

FOLLOW <u>ADDITIONAL STEPS</u> BELOW SECTION 8

Will this project/activity require Public Consultation?	

3. STAKEHOLDERS

Identify who might have an interest in this project/activity of site

Community Group*		Strategic Planning	
Parks Field Leader Hinterland		Environment Policy Waterways	
Parks Field Leader Coastal		Environment Policy Biodiversity	
Arboricultural Services		Development Assessment	
Parks Foreman Area		Road Management Services Construction	
Asset Manager Environmental Operations		Marketing and Media	
Councillor			
*Community Group name			

4. ENVIRONMENTAL & CULTURAL CONSIDERATIONS

Environmental
Does this project require a permit or legislative approval?
Have you checked that your activity does not trigger the following Act(s) which may require a permit? Check with Development Assessment to see if an application maybe required to be submitted for the works.
Permits maybe required under the following Commonwealth and State Acts
ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999 NATURE CONSERVATION ACT 1992
WATER ACT 2000
VEGETATION MANAGEMENT (REGROWTH CLEARING MORATORIUM) ACT 2009
VEGETATION MANAGEMENT ACT 1999
ENVIRONMENTAL PROTECTION ACT 1994
ABORIGINAL CULTURAL HERITAGE ACT 2003
FISHERIES ACT 1994
COASTAL PROTECTION AND MANAGEMENT ACT 1995
Wetlands Assessable
Check Emap Fauna Wetlands Impact Assessable layer
Coastal zone assessable
Check EPA website for requirements
Koala Management Area
Check Emap Fauna – Koala Mngt Area
Fish Management Area
Check Emap Fauna – Fish Management Area

Are Acid Sulphate soils present		Will these be disturbed	

Any EVR species present onsite

If Yes what considerations will be required to ensure that EVR's are not impacted or appropriate management considerations have been included within project implementation.

What are the proposed working hours.

Cultural
Heritage Significance

Does a recognised site of significance exist within the work area or adjacent to it.

5. SAFETY CONSIDERATIONS

Will a Minor Work Safety Plan be required (If no got to next Q)	

Has the Minor Work Safety Plan be prepared (a minor works safety plan is required to be prepared and sited before works can commence)	

Will a Job Safety Analysis be required for this activity?	

All current Safety information can be accessed from this link

Dial Before You Dig (DBYD)

Does a Dial Before You Dig check need to be undertaken for this Project?	

Site Hazards Present
(Other than Services)
Confined Space Asbestos

Other (list)

Services
Telecommunications Gas Water

Sewerage Survey Energex

Roadway Bikeway

Other

6. COMMUNICATIONS

Will there be any promotion of this activity	
Will you need to advise anyone of this project	

Who should be advised of the project/activity?
Customer Services Media and Marketing
Local Councillor Residents
Community Group(s) Police, Fire, Ambulance
Public transport companies

How will these groups be advised?

Group	How * **(see descriptors below)**	When	Confirmed (Insert date)

Other Identify:

7. ONGOING MAINTENANCE

Who will be undertaking maintenance once this project/activity is finished?
Have funds been identified to undertake ongoing maintenance
Yes

8. ASSET MANAGEMENT UPDATE

Will Asset Management Systems need to be advised to update data held against this asset?

Yes	(If yes provide confirmation of who will be contacted and when)

Contact Person:	Date Contacted

Additional Checks

Do you require to undertake additional checks	

Check with the Strategic Planning Team to see if this site has been identified for a future use
Provide details of contact with Strategic Planning

Check with Development Assessment (Development Assessment Duty Officer) to confirm that no approval has been given for operational works to occur on this site
Provide details of contact with DA

Check with relevant section within Council to confirm any future plans associated with this site
Provide details of contact with relevant section within Council

Supervisor undertaking check	Project/Activity Approved

Reasons for not approving Activity

# #	Communication Type:	To Whom	Format	How Often	Responsibility

The following set of questions provides a guide to assist in determining whether some form of public participation should be considered for your project, plan or strategy.

- Is there a legislative trigger that requires public participation e.g. Local Government Act & IPA?
- Does the Corporate Plan require there to be public participation?
- Has the Council asked for community input on this decision or similar ones in the past?
- Has the community asked the Council to talk to them about an issue associated with a pending decision?
- Does the Council need to understand community values and priorities to inform policies, planning and service delivery (eg what the community sees as sustainable outcomes from development)?
- Will the decision have significant social, environmental and/or economic sustainability impacts for one or more stakeholders?
- Would the Council decision be significantly improved by input from community stakeholders?
- Is there already – or will there be – media and/or community concerns/expectations (eg. from past experiences) about the issues?
- Is this a complex or difficult case with widely divergent alternatives and views to consider?
- Is there an opportunity to build community capacity and improve the understanding between Council and the community?
- Is there an opportunity to establish partnerships (eg. Private sector/government agency/community organisations) to collaboratively address issues?
- Is there an opportunity to build community capacity and improve the understanding between Council and the community?
- Does the community need to be informed about a Council decision, or pending process?

Sunshine Coast Regional Council

Site Risk Assessment and Site Induction Record – Environmental Operations

SAFE PLAN

Property Name		Site Supervisor	
Property Address		Date	
☐ Communications available on site?	☐ Mobile	☐ Two Way Radio	☐ Other ……

IDENTIFIED HAZARDS	SCORE BCM	SCORE ACM	CONTROL MEASURES IMPLEMENTED	CONTROL MEASURES IMPLEMENTED
CLIMATIC HAZARDS				
☐ Lighting/Glare			☐ Mobile Phone ☐ Communication options ☐ Emergency evacuation plan ☐ Check weather forecast ☐ PPE, rest, water, sunscreen ☐ Work in pairs/groups ☐ Work method statements	☐ Appropriate & Protective Clothing ☐ First aid response/Kit ☐ Training & competency Other control measures:…….... …… ……
☐ Extreme Temperatures				
☐ Hail/Severe Storm/Lightning				
☐ Rainfall/Flooding				
☐ Dehydration				
☐ UV				
☐ Fire				
PHYSICAL HAZARDS				
☐ Working In Public Areas			☐ Mobile Phone ☐ Other communication devices ☐ Navigation device ☐ Minimal level of supervision ☐ Moderate level of supervision ☐ High level of supervision ☐ Void fall protection system ☐ Reconnaissance ☐ Work in pairs/groups ☐ Emergency evacuation plan ☐ Use warning signs/barricades ☐ Adequate drinking water ☐ Temporary Guarding ☐ Maintained/checked (plant and equipment ☐ Hearing protection ☐ Licenses ☐ Dial before you dig ☐ Work in pairs/groups ☐ PPE ☐ Traffic control ☐ Silt trap/erosion sediment ☐ Site assessment ☐ Emergency evacuation plan ☐ Work method statements	☐ Additional resources ☐ Training & competency ☐ Emergency details ☐ First aid response/Kit ☐ Adhere to exclusion zones ☐ Protective footwear ☐ Safety Harness and davit ☐ Dust mask/respirator/SCBA ☐ Spill kit ☐ Sharps kit and training ☐ Training & competency ☐ First aid response/Kit Other control measures:…….... …… …… …… …… …… …… …… …… ……
☐ River Or Stream Crossing				
☐ Heights > 2 Metres				
☐ Cliffs Or Crevices				
☐ Concealed Holes				
☐ Slippery Surfaces				
☐ Plant And Equipment				
☐ Loss Of Communications				
☐ Soft Sediments (Mud, Quick Sand)				
☐ Falling Objects (Trees, Rocks)				
☐ Depths Over 1.5m				
☐ Unstable Slopes				
☐ Working Over Or Near Water				
☐ Dust				
☐ Uneven ground				
☐ Confined Spaces				
☐ Contaminated Environment				
☐ Unexploded Ordinances				
☐ Working On Or Near Roadways				
☐ Inadequate Amenities (Water…)				
☐ Over Head /High Voltage				
☐ Noise				
☐ Underground Services				
☐ Driving				
FLORA AND FAUNA				
☐ Bites (Ticks, Leeches, Ants)			☐ Emergency/medical details ☐ Training & competency ☐ First aid response/Kit ☐ Protective Clothing ☐ Insect repellent	☐ Emergency evacuation plan ☐ Site assessment ☐ Communication device Other control measures:…….... ……
☐ Allergies – Plant/Animal				
☐ Stinging Plants				
☐ Animal Attacks (Dogs, Snakes)				
☐ Plants With Spikes, Thorns Etc				

Overall Risk Assessment

☐ Insignificant risk

☐ Significant risks but can be effectively controlled using control measures outlined above

☐ Risks are significant and not easily controlled. Seek further help on control measures. Do not proceed with activity until risks are adequately controlled including change of proposed venue for activity. Repeat assessment with new information.

Sunshine Coast Regional Council

WH&S RISK CALCULATOR

Consequences

Likelihood	Insignificant None or very minimal injuries	Minor First aid treatment only	Moderate Medical treatment required	Major - Major medical treatment required	Catastrophic Life threatening injuries or death
Almost Certain: Expected to occur at most times (eg, 3 per year)	M-28	M-40	H-60	E-88	E-100
Likely: Will probably occur at most times (eg, 1 per year)	L-16	M-36	H - 56	E-84	E-96
Possible: Might occur at some time (eg, 1 per 5 years)	L-12	M-32	M-52	H-72	E-92
Unlikely: Could occur at some time (eg, 1 per 5 to 15 years)	L-8	L-24	M-48	H-68	H-80
Rare: May occur in rare conditions (eg, unlikely during next 15 years)	L-4	L-20	M-44	H-64	H-76

Sunshine Coast Regional Council

WH&S RISK CALCULATOR

Risk Process	
Identify	Identify the hazards/risks of the work
Assess	Assess the likelihood and consequence of the hazards/risks
Control	Control the hazards/risks using control measures considering the hierarchy of control
Monitor	Monitor the effectiveness and use of implemented control measures

Risk Score Legend		Hierarchy of Control	
E	Extreme risk – immediate action required	ELIMINATION	*Eliminate* the process, material or substance completely
H	High risk – prioritised action required	SUBSTITUTION	*Replace* the process, material or substance with a safer one
M	Moderate risk – planned action required	ISOLATION	*Isolate* the person(s) from the process, material or substance
L	Low risk – actioned by routine procedure	ENGINEERING	*Design or re-design* the process, material or substance
SCRC – 04/2009		ADMINISTRATION	*Limit exposure* to the risk by job rotation, work procedure and/or providing adequate training
		PPE	Use of *personal protective equipment*

Comments: (attach additional pages if required) ……
……
……
……
……
……

Sunshine Coast Regional Council

Site Risk Assessment and Site Induction Record – Environmental Operations

Site Induction Record - The undersigned have participated in the risk assessment process for the particular site and agree to abide by all instructions given for this location.

All staff must possess and show evidence of a blue/white card safety induction

NAME	SIGNATURE	DATE

APPENDIX **B**

EXAMPLES DAILY RECORD SHEET

- Daily Record Sheet courtesy of Gold Coast City Council

Corresponding Invoice #:

Daily Record Sheet

for Ecological Restoration Works on Gold Coast City Council Land

Location:		**Date:**	
Work zones:		**Total hours:** (workers x hours on site)	
Contractor name:			
Personnel:			
Work completed: (description of work done)	**Primary work (inc. initial spray run)** Area worked: m2, Hours spent: hrs		
	Follow-up work Area worked: m2, Hours spent: hrs		
Comments on previous works & reminder for follow-up works			
Native fauna notes (sightings, behaviour)			
Flora notes (e.g. flowering, fruiting, germinating, threatened species)			

	Reportable incidents	**Details**
☐	**Environmental Issues** (significant erosion, fires etc.)	
☐	**Animal Management** (cattle, pigs, foxes, dogs etc.)	
☐	**Illegal Dumping** (Garden waste, cars, rubbish etc.)	
☐	**Illegal Access** (motorbikes, cars, mtn bikes, camping)	
☐	**WH&S** (accidents, near misses, safety issues)	
☐	**Other** (Public comments,	

Name:_____ Signature:_____

Corresponding Invoice #:

Herbicide Distribution Sheet

Environmental Conditions			
☐ Clear	☐ Dry	Wind speed (*km/hr*):	
☐ Overcast	☐ Mild	Wind direction (*N,E,S,W*):	
☐ Showers	☐ Humid	Temperature (^{O}C):	
Zone Vegetation Type	☐ Rainforest	☐ Coastal	
☐ Dry Eucalypt	☐ Riparian	☐ Dune system	
☐ Wet Eucalypt	☐ Wetlands	☐ Other:	

Location:		**Time start:**	
Date:		**Time finish:**	
Personnel using herbicide			

Equipment Used	Chemicals Used (trade name)	Total quantity applied on site		Rate:	Plants treated	Method
☐ Knapsack	☐ Glyphosate:	→ amount used ?	*ml.*			
☐ Power spray	☐ Metsulf. methyl:	→ amount used ?	*g.*			
☐ ATV unit	☐ Surfactant:	→ amount used ?	*ml.*			
☐ Poison Pot	☐ Penetrant:	→ amount used ?	*ml.*			
☐ Injector Kit	☐ Dye:	→ amount used ?	*ml.*			
☐ Applicator Bottle	☐ Other:	Tot. volume of mixture:	Litres			
☐ Other		Total area treated:	m^2			

Equipment Used	Chemicals Used (trade name)	Total quantity applied on site		Rate:	Plants treated	Method
☐ Knapsack	☐ Glyphosate:	→ amount used ?	*ml.*			
☐ Power spray	☐ Metsulf. methyl:	→ amount used ?	*g.*			
☐ ATV unit	☐ Surfactant:	→ amount used ?	*ml.*			
☐ Poison Pot	☐ Penetrant:	→ amount used ?	*ml.*			
☐ Injector Kit	☐ Dye:	→ amount used ?	*ml.*			
☐ Applicator Bottle	☐ Other:	Tot. volume of mixture:	Litres			
☐ Other		Total area treated:	m^2			

Equipment Used	Chemicals Used (trade name)	Total quantity applied on site		Rate:	Plants treated	Method
☐ Knapsack	☐ Glyphosate:	→ amount used ?	*ml.*			
☐ Power spray	☐ Metsulf. methyl:	→ amount used ?	*g.*			
☐ ATV unit	☐ Surfactant:	→ amount used ?	*ml.*			
☐ Poison Pot	☐ Penetrant:	→ amount used ?	*ml.*			
☐ Injector Kit	☐ Dye:	→ amount used ?	*ml.*			
☐ Applicator Bottle	☐ Other:	Tot. volume of mixture:	Litres			
☐ Other		Total area treated:	m^2			

Name:____________________________ Signature:_________________________

APPENDIX **C**

CONTROL TECHNIQUES AND HERBICIDE APPLICATION RATES FOR PARTICULAR WEED SPECIES

DISCLOSURE

At the time of publication the following chemicals and techniques are registered for use and are commonly utilised. Other chemicals and techniques are used in the ecological restoration industry. Laws and best practice techniques change over time and as such it is best to check with your local government as to the current preferred approach.

Under label or off-label permits 11463 and 9868. Permit 9868 requires that persons who can use the product under the permit are "All persons who are trained in the use and handling of agricultural chemicals and who are performing weed control as part of a bush regeneration/restoration project". Operators are legally obliged to read the label before using any herbicides. If the species you wish to treat is not on the label it will be necessary to read the off label permit. Always consult the ecological restoration plan for the projects.

Additional useful references include the Weeds of Southern Queensland (Dight et al., 2011) and PUBCRIS (http://services.apvma.gov.au/PubcrisWebClient/welcome.do).

HERBICIDE (+ E.G. TRADE NAME)	PRINCIPLE USES	ECOTOXICOLOGY	GROUP	SCHEDULE	UPTAKE AND RESIDUAL AFFECT
Glyphosate 360gl (Weedmaster® or Roundup Biactive®)	Non- selective weed control	Full Aquatic registration (in **most formulations**),	M	5	Absorbed through the leaf via spraying and through the cambium when applying techniques such as stem injection and cut, scrape and paint. Extremely short-lived and rapidly immobilised (both in soil and water). Degraded within hours in most environments
2,4-D 625 gl amine (Amicide 625)	Selective of broad-leaved weeds in native grasses (limited effect on deep rooted dicots, legumes etc.)	Aquatically registered formulations **available**	I	5	Mainly absorbed through leaves and stems. Fairly immobile and reltively short-lived in the soil. (degraded within days in most environments)
Fluroxypyr 333gl (Starane advance)	Selective broad-leaf control (particularly effective on undersown legumes weeds)	N (demonstrated toxicity to aquatic organisms)	I	NS	Absorbed through the leaves. Relatively short-lived in the soil though highly persistent in water
Metsulfuron Methyl (Brush-off, Ally, Associate)®	Selective of broad-leaved weeds but also able to control a variety of monocots when applied at higher rates especially Liliaceae and Commilinacea. Lower rates do affect monocots.	N (demonstrated toxicity to aquatic organisms)	B (potential resistance rotate with other herbicicdes)	NS	Mainly leaf absorbed. May persist for 3-6 months in the soil profile.
Metsulfuron + Glyphosate	Non-selective weed control and used with particular weeds or combination of weeds.	N (demonstrated toxicity to aquatic organisms)	MB (potential resistance rotate with other herbicicdes)	5	Mainly leaf absorbed, may persist for 3-6 months in the soil profile.
2,2-DPA	Grass (monocot) selective herbicide suitable for targeting dense weedy grass infestations amongst desirable native vegetation.	Yes (limited)	J	NS	Leaf and root absorbed

***Aquatic reg indicates that formulations of this herbicide may carry and aquatice registration, some formulations do not and individuals should check PUBRCRIS prior to assuming they have an aquatically regitered formulation. Addition of non-aquatically re...**

Gly	Glyphosate	eg. Weedmaster Duo®, Roundup Biactive®					
MM	Metsulfuron methyl	eg. Brushoff ®, Brushkiller®, Associate®					
S	Surfactant	eg. LI700®, Prosil®, Pulse®					
A	Spray Adjuvant	eg. Agral®, Protec®, Codacide®,					
D	Colour Marking Dye	eg. Herbi (red or blue) Liquid Dye®					

COMMON NAME	SCIENTIFIC NAME	APPLICATION METHOD	CHEMICAL	RATE	ADJUVENT	SURFACTANT	COMMENTS
TREES							
Cinese Celtis	*Celtis sinensis*	Stem Inject	Glyphosate	1:1.5 Gly:water			
		Cut, Scrape and Paint	Glyphosate	1:1.5 Gly:water			
		Basal Bark (saplings)	Fluroxypyr	210ml:10L diesel			
		spot-spray	Glyphosate	200ml:10L water + A + D			
			Glyphosate + Metsulfuron Methyl	200mL Gly + 1.5g MM in 10L water + S + A			
Camphor Laurel	*Cinnamomum camphora*	Stem Inject	Glyphosate	1:1.5 Gly:water			
		Cut, Scrape and Paint	Glyphosate	1:1.5 Gly:water			
		Basal Bark (saplings)	Fluroxypyr	210ml:10L diesel			
		Spot spray	Glyphosate + Metsulfuron Methyl	200ml Gly + 1.5g MM in 10L water + S + D			
			Glyphosate	200ml:10l water + A + D			
Cadaghi	*Corymbia torelliana*	Cut, Scrape and Paint	Glyphosate	1:1.5 Gly:water			
		Stem Inject	Glyphosate	1:1.5 Gly:water			
		Basal Bark (saplings)	Fluroxypyr	210ml:10L diesel			
		Spot spray	Glyphosate	100ml Gly: 10L water + A + D			
Loquat	*Eriobotrya japonica*	Basal Bark(sapling)	Fluroxypyr	210ml:10L diesel			
		Spot spray	Glyphosate	200ml Gly:10L water +			
		Cut Scrape and Paint	Glyphosate	1:1.5 Gly:water			
		Stem Inject	Glyphosate	1:1.5 Gly:water			
Cockscomb Coral Tree and Coral Tree	*Erythrina crista-galli and E. x sykesii*	Spot spray	Glyphosate	200ml Gly:10L water + S+ A			
		Basal Bark (sapling)	Fluroxypyr	210ml/10L diesel			
		Cut Scrape and Paint	Glyphosate	1:1.5 Gly:water			
		Stem Inject	Glyphosate	1:1.5 Gly:water			
Brazilian cherry	*Eugenia uniflora*	Cut Scrape and Paint	Glyphosate	neat (undiluted)			
		Stem Inject	Glyphosate + Metsulfuron Methyl	1g MM added to 1 Gly:1.5 water			
		Spot Spray	Glyphosate + Metsulfuron Methyl	200ml Gly + 1.5g MM in 10L water + S + D			
Golden Rain Tree	*Koelreuteria elegans; paniculata*	Cut Scrape and Paint	Glyphosate	1:1.5 Gly:water			
		Stem Inject	Glyphosate	1:1.5 Gly:water			
		Basal Bark (sapling)	Fluroxypyr	210ml:10L diesel			
		Spot spray	Glyphosate	100ml Gly:10L water + A + D			
Privet (Large and Small leaved)	*Ligustrum lucidum and L.sinense*	Spot Spray	Glyphosate	200ml Gly:10L water + S+ D			
			Metsulfuron methyl	1.5g MM:10L water + A + D			
			Fluroxypyr	30ml:10L water +			
		Cut Scrape and Paint	Glyphosate	1:1.5 Gly:water			
		Stem Inject	Glyphosate	1:1.5 Gly:water			
		Basal Bark (sapling)	Fluroxypyr	210ml:10L diesel			

Mulberry	*Morus spp.*	Spot Spray	Glyphosate	200ml Gly:10L water + S + D			
		Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			
		Stem Inject	Glyphosate	1 Gly:1.5 water			
		Basal Bark (Juvenile)	Fluroxypyr	210ml:10L diesel			
Canary Island Date Palm	*Phoenix canariensis*	Spot Spray	Glyphosate	200ml Gly:10L water + S + D			
		Stem Inject	Glyphosate + Metsulfuron Methyl	1g MM added to 1 Gly:1.5 water			
Guava	*Psidium guajava*	Spot Spray	Glyphosate + Metsulfuron Methyl	200ml Gly + 1.5g MM in 10L water + S + D			
		Cut Scrape and Paint	Glyphosate + Metsulfuron Methyl	1g MM added to 1 Gly:1.5 water			
		Stem Inject	Glyphosate + Metsulfuron Methyl	1g MM added to 1 Gly:1.5 water			
Umbrella Tree	*Schefflera actinophylla*	Spot Spray	Glyphosate + Metsulfuron Methyl	200ml Gly + 1.5g MM in 10L water + A + D			
		Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			
		Stem Inject	Glyphosate	1 Gly:1.5 water (do not stem inject when in flower)			
Broad-leaf Pepper Tree	*Schinus terebinthifolius*	Spot Spray	Glyphosate	200ml:10L water + S + A			
			Glyphosate + Metsulfuron Methyl	200ml Gly + 1.5g MM in 10L water + S + A			
			Fluroxypyr	30ml:10L water			
		Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			
		Basal Bark (sapling)	Fluroxypyr	210ml:10L diesel			
		Stem Inject	Glyphosate	1 Gly:1.5 water			
Giant Devils Fig and Wild Tobacco	*Solanum chrysotrichum and S. mauritianum*	Spot Spray	Glyphosate	150ml Gly:10L water + A + D			
			Fluroxypyr	30ml/10L water			
		Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			
		Basal Bark (Juvenile/ Mature)	Fluroxypyr	210ml/10L diesel			
		Stem Inject	Glyphosate	1 Gly:1.5 water			
African tulip tree	*Spathodea campanulata*	Spot Spray	Glyphosate	200ml Gly + 1.5g MM in 10L water + A + D			
		Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			
		Stem Inject	Glyphosate	1 Gly:1.5 water			
Cocos palm	*Syagrus romanzoffiana*	Stem Inject	Glyphosate + Metsulfuron Methyl	1g MM added to 1 Gly:1.5 water			
		Spot Spray	Glyphosate + Metsulfuron Methyl	200ml Gly + 1.5g MM in 10L water + A + D			
Yellow Bells	*Tecoma stans*	Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			
		Basal Bark	Fluroxypyr	210ml/10L diesel			
		Spot Spray	Glyphosate	150ml Gly: 10L water + A + D			
		Stem Inject	Glyphosate	1 Gly:1.5 water			
Tipuana	*Tipuana tipu*	Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			
		Stem Inject	Glyphosate	1 Gly:1.5 water			

GRASSES							
Creeping Bamboo/ Clumping Bamboo	*Arundinaria spp./ Bambusa spp.*	Cut and spray (re-growth/seedling)	Glyphosate	100ml Gly: 10L water + D			
			2,2-DPA	150g:10L water			
		Cut stump and fill segment	Glyphosate	1 Gly:1.5 water			
Broad-leaved carpet grass, Narrow-leaved carpet grass, Para grass, Mosman River grass , Pangola grass, Guinea grass, Rhodes grass, Molasses grass, Sour grass, Paspalum, Bahia grass, Vasey grass, Broad-leaf paspalum, Kikuyu grass, Bana grass, Elephant grass	*Axonopus compressus, A. fissifolius, Brachiaria mutica, Cenchrus echinatus, Chloris gayana, Digitaria eriantha, Megathyrsus maximus, Melinis minutiflora, Paspalum conjugatum , P. dilatatum , P. notatum , P. urvillei , P. wettsteinii , Pennisetum clandesti*	Spot Spray	Glyphosate	100ml Gly:10L water + D			
Herbs							
Agave/Century plant	*Agave americana*	Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			
		Stem Inject	Glyphosate	1g MM added to 1 Gly:1.5 water			
Crofton weed	*Ageratina adenophora*	Spot Spray	Glyphosate	100ml Gly:10L water + D			
			Metsulfuron methyl	1/2 - 1g MM: 10L water + D			
Mistflower	*Ageratina riparia*	Spot Spray	Glyphosate	100ml Gly:10L water + D			
			Metsulfuron methyl	1/2 - 1g MM: 10L water + D			
Blue billy-goat weed	*Ageratum houstonianum*	Spot Spray	Glyphosate	100ml Gly:10L water + D			
			Metsulfuron methyl	1g MM: 10L water + D			
			Fluroxypyr	30ml/10L water			
			2-4,D	30ml/10L water			
Ragweed	*Ambrosia artemisifolia*	Spot Spray	Glyphosate	100ml gly:10L water + A + D			
			Metsulfuron methyl	1.5g MM: 10L water + A + D			
Cobblers pegs	*Bidens pilosa var. pilosa*	Spot Spray	Fluroxypyr	30ml/10L water			
			2, 4-D	30ml/10L water			
			Glyphosate	100ml Gly: 10L water + A + D			
			Metsulfuron methyl	1g MM: 10L water + A + D			
Mother of Millions; Live Leaf Plant; Resurrection Plant	*Bryophyllum delagoense; Pinnatum*	Spot Spray	2, 4-D	50ml/10L water			
	Bryophyllum delagoense		Metsulfuron methyl	1.5g MM:10L water + S + D			
Purple/Green Succulent, Inch Plant	*Callisia fragran; repens*	Spot Spray	Fluroxypyr	90ml/10L water			
			Metsulfuron methyl	1.5g MM:10L water + S + D			
			Glyphosate	200ml Gly:10L water + A + D			
			Glyphosate + Metsulfuron Methyl	200ml Gly + 1.5g MM in 10L water + A + D			

Hairy Commelina; Trad (wandering Jew); Purple Succulent; Striped Trad	*Commelina benghalensis; Tradescantia fluminensis/ albiflora;Tradescantia pillida; Zebrina pendula syn Tradescantia zebrina*	Spot Spray	Glyphosate + Metsulfuron Methyl	200ml Gly + 1.5g MM in 10L water + A + D			
			Glyphosate	200ml Gly:10L water + A + D			
			Metsulfuron methyl	1.5g MM: 10L water + S + D			
			Fluroxypyr	90ml/10L water			
Glory lilly	*Gloriosa superba*	Foliar Spray	Glyphosate + Metsulfuron Methyl	200ml Gly + 1.5g MM in 10L water + A + D			
Polka dot plant	*Hypoestes phyllostachya*	Spot Spray	Metsulfuron methyl	1.5g MM:10L water + S + D			
			Glyphosate + Metsulfuron Methyl	200ml Gly + 1.5g MM in 10L water + A + D			
Fish bone fern	*Nephrolepis cordifolia*	Spot Spray	Metsulfuron methyl	1g MM: 10L + A/S + D			
			Glyphosate + Metsulfuron Methyl	200ml Gly + 1.5g MM in 10L water + A + D			
Coral berry	*Rivinia humilis*	Spot Spray	Glyphosate	100ml Gly: 10L water + A + D			
			Glyphosate + Metsulfuron Methyl	100ml Gly + 1.5g MM in 10L water + A + D			
Mother-in-law's tongue	*Sansevieria trifasciata*	Spot Spray	Glyphosate + Metsulfuron Methyl	200ml Gly + 1.5g MM in 10L water + A + D			
Flannel Weed	*Sida cordifolia*	Spot Spray	Fluroxypyr	60ml/10L water			
Ground Asparagus	*Asparagus aethiopicus*	Spot Spray	Metsulfuron Methyl	1.5g MM : 10L water + A + D			
			Glyphosate + Metsulfuron Methyl	200ml Gly + 1.5g MM in 10L water + A/S + D			
Singapore Daisy	*Sphagneticola trilobata*	Spot Spray	Metsulfuron methyl	1.5g MM in 10L water + A + D			
			Glyphosate + Metsulfuron Methyl	100ml Gly + 1g MM in 10L water + A + D			
SHRUBS							
Groundsel bush	*Baccharis halimifolia*	Spot Spray	2,4-D	40ml/10L water			
		Spot Spray	Glyphosate	200ml Gly:10L water + A + D			
		Stem Inject	Glyphosate	1 Gly:1.5 water			
		Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			
Green cestrum	*Cestrum parqui*	Spot Spray	Glyphosate	200ml Gly:10L water + A + D			
			Glyphosate + Metsulfuron Methyl	200ml Gly + 1.5g MM in 10L water + A + D			
Duranta	*Duranta erecta*	Overall Spray (re-growth/seedling)	Glyphosate	200ml Gly:10L water + A + D			
		Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			
		Stem Inject	Glyphosate	1 Gly:1.5 water			
Lantana	*Lantana camara*	Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			
		Spot Spray	Fluroxypyr	40ml/10L (spring, summer)-60ml/10L water (Autumn, Winter)			
		Spray (spot spray and overspray)	Glyphosate	100ml Gly:10L water + D			
		Spray Red Flowering species	Glyphosate	200ml Gly:10L water + A + D			
		Splatter Gun	Glyphosate	1 Gly:9 water			

Leucaena	*Leucaena leucocephela*	Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			
		Spot Spray	Fluroxypyr	30ml/10L water			
HERBS							
Murraya	*Murraya paniculata*	Spot Spray	Glyphosate	200ml Gly:10L water + A + D			
		Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			
		Stem Inject	Glyphosate	1 Gly:1.5 water			
Mickey mouse bush	*Ochna serrulata*	Basal Bark	Fluroxypyr	210ml/10L diesel			
		Spot Spray	Fluroxypyr	30ml/10L water			
		Spot Spray	Glyphosate + Metsulfuron Methyl	200ml Gly + 1.5g MM in 10L water + A/S + D			
		Scrape (lightly) and Paint - juvenile	Glyphosate	neat (undiluted)			
		Cut Drill and Fill - mature	Glyphosate + Metsulfuron Methyl	1g MM added to 1 Gly:1.5 water			
Prickly pear	*Opuntia Spp.*	Spot Spray	Glyphosate + Metsulfuron Methyl	100ml Gly + 1.5g MM in 10L water + A + D			
		Cut Scrape and Paint in horizontal cuts across flat stems	Glyphosate + Metsulfuron Methyl	1g MM added to 1 Gly:1.5 water			
Castor Oil Plant	*Ricinus communis*	Spot Spray	2, 4-D	45ml/10L water			
			Glyphosate	100ml/ 10L water			
		Cut Scrape and Paint	Glyphosate	1g MM added to 1 Gly:1.5 water			
		Stem Inject	Glyphosate	1g MM added to 1 Gly:1.5 water			
Easter Cassia/ Winter Senna	*Senna pendula var. glabrata*	Spot Spray	Glyphosate	200ml Gly:10L water + A + D			
		Cut and Paint		1 Gly:1.5 water			
		Stem Inject (Mature)	Glyphosate	1 Gly:1.5 water			
Smooth senna	*Senna septemtrionalis*	Spot Spray	Glyphosate	200ml Gly:10L water + A + D			
		Cut and Paint	Glyphosate	1 Gly:1.5 water			
		Stem Inject	Glyphosate	1 Gly:1.5 water			
Yellow Oleander	*Thevetia peruviana*	Basal Bark	Fluroxypyr	210ml/10L Diesel			
		Spot Spray	Glyphosate	200ml Gly:10L water + A + D			
		Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			
		Stem Inject	Glyphosate	1 Gly:1.5 water			
VINES							
Madeira Vine	*Anredera cordifolia*	Spot Spray	Fluroxypyr	30ml/10L water			
		Spot Spray	Glyphosate + Metsulfuron Methyl	200ml Gly + 1.5g MM in 10L water + A/S + D			
		Scrape and Paint (mature vines)	Glyphosate	Scrape as much stem as possible in 1m lengths on alternate sides. Gouge and paint ground tubers. Scrape and paint roots			
Moth vine	*Araujia sericiflora*	Spot Spray	Glyphosate + Metsulfuron Methyl	200ml Gly + 1.5g MM in 10L water + A + D			
		Cut Scrape and Paint	Glyphosate (aerial)	1 Gly:1.5 water			

Dutchman's pipe	*Aristolochia elegans*	Spot Spray	Glyphosate + Metsulfuron Methyl	200ml Gly + 1.5g MM in 10L water + A + D			
		Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			
Climbing Asparagus	*Asparagus africanus; plumosus*	Basal Bark	Fluroxypyr	210ml/ 10L diesel			
		Spot Spray	Glyphosate	200ml Gly:10L water + A+ + D			
Balloon Vine	*Cardiospermum grandiflorum*	Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			
		Spot Spray	Glyphosate	100ml Gly:10L water + D			
Green/ Silver-leaf desmodium; Siratro; Horesgram; Glycine	*Desmodium intortum; Macroptilium atropurpureum; Macrotyloma uniflorum; Neonotonia wightii*	Spot Spray	Glyphosate	200ml Gly:10L water + A+ + D			
			2,4-D	40ml/10L water			
			Glyphosate + Metsulfuron Methyl	100ml Gly + 1.5g MM in 10L water + A + D			
		Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			
Moon flower; Mile-a-minute; Morning Glory; Blue Morning Glory	*Ipomoea alba; I. cairica; I. indica and I.purpurea*	Spot Spray	Glyphosate + Metsulfuron Methyl	100ml Gly + 1.5g MM in 10L water + A + D			
			2, 4-D	30ml/10L water			
		Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			
Creeping Lantana	*Lantana montevidensis*	Spot Spray	2,4-D	40ml/10L water			
			Glyphosate + Metsulfuron Methyl	100ml Gly + 1.5g MM in 10L water + A + D			
			Metsulfuron methyl	1.5g MM : 10L water + A + D			
Cat's Claw Creeper	*Macfadyena unguis-cati*	Spot Spray	Glyphosate	100ml Gly : 10L water + S + D			
			Glyphosate + Metsulfuron Methyl	100ml Gly + 1g MM:10L water + A + D			
		Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			
Edible passionfruit; Stinking Passionflower; Corky Passionfruit; White Passionfruit	*Passiflora edulis; foetida; suberosa; subpeltata*	Spot Spray	Glyphosate + Metsulfuron Methyl	100ml Gly + 1g MM in 10L water + A + D			
			Glyphosate	200ml Gly:10L water + A + D			
			2,4-D	30ml/10L water			
		Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			
Kudzu	*Pueraria lobata*	Spot Spray	Glyphosate + Metsulfuron Methyl	100ml Gly + 1.5g MM in 10L water + A + D			
			Fluroxypyr	30ml/10L water			
		Gouge and Paint tubers	Glyphosate	1 Gly:1.5 water			
		Stem Inject	Glyphosate + Metsulfuron Methyl	1/1 (g) + 1g (MM) Per Litre of water			
Climbing nightshade	*Solanum seaforthianum*	Spot Spray	Fluroxypyr	30ml/10L water			
			Glyphosate	100ml Gly : 10L water + A + D			
		Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			
Black eyed susan	*Thunbergia alata*	Spot Spray	2-4,D	30ml/10L water			
			Glyphosate	200mL in 10L water			
			Metsulfuron methyl	1.5g in 10L water			
		Basal Bark	Fluroxypyr	210ml/ 10L diesel			
		Cut Scrape and Paint	Glyphosate	1 Gly:1.5 water			