REVEGETATION MANAGEMENT GUIDELINES

CITY OF MELVILLE








May 2020

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City of Melville

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1 Executive Summary

This guideline was prepared to accompany the Natural Areas Asset Management Plan (NAAMP) and provide a reference document detailing guidelines for the management of ecological restoration, namely through revegetation activities, at all natural areas within the City of Melville. Revegetation often involves initiating or accelerating recovery of bushland areas to create a diverse, self-sustaining ecosystem with the resilience to recover from natural disturbance events.

The City's approach to revegetation revolves around:

- focusing on improving those areas that are in good or better condition and which will require minimal restoration effort where possible such that they are maintained in the longer
- term; and
- Improving areas of poorer condition in accordance with priorities described in the NAAMP and Strategic Reserve Plans.

There are three broad revegetation techniques that are commonly used, either singly or in combination. These methods are:

- direct seeding;
- planting of tubestock; and
- natural regeneration.

Ecological Restoration results in a number of benefits, including:

- improved species diversity,
- increased number of habitats and niches that can be occupied by different fauna species,
- the potential to increase underrepresented vegetation types,
- improved connectivity with other ecological systems,
- resilience and the ability of the ecosystem to respond to events such as storms and fire,
- increased potential for carbon sequestration in plant materials,
- cooler temperatures around the bushland areas, and
- contribution to human uses such as passive recreation.

In recognising the values associated with restoration outcomes, there are also a number of processes that have the potential to reduce or impact negatively on those outcomes. These include:

- weed invasion,
- uncontrolled access,
- the presence of feral and pest animals,
- frequent, destructive fires, and
- dieback and disease.

An assessment template has been prepared that allows consideration of the need for revegetation along with the presence of and impacts associated with threatening processes on planned activities (Appendix 2).

2 Acronyms and Abbreviations

CALM	Conservation and Land Management
CBD	Central business district
CoM	City of Melville
DBCA	Department of Biodiversity, Conservation and Attractions (Formally DEC or DPAW)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)
ha	hectare
km	kilometre
m	metre
NAAMP	Natural Areas Asset Management Strategy
NAC	Natural Area Consulting
SERA	Society of Ecological Restoration Australasia

3 Introduction

The City of Melville is a local government area of 52km² located 8km south of the Perth CBD. It contains a number of significant biodiversity assets that are under threat. Revegetation of bushland areas has been identified as one means of restoring flora and fauna biodiversity in the Natural Areas Asset Management Plan (NAAMP) (City of Melville 2011). The objective of this guideline is to provide key information regarding ecological restoration processes to direct on ground revegetation activities within the City of Melville at its:

- Bush Forever reserves,
- ecological community sites,
- wetland sites,
- heritage sites, and
- community interest sites.

Ecological Restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed (SERA 2017). A fully restored state can only be considered achieved when the ecosystem's attributes are on a secure trajectory to resemble those of a reference or pre-disturbance state, without the need for further interventions from the land manager (SERA 2017).

It is recognised that restoration of bushland, foreshore and wetland areas will contribute to species diversity, genetic diversity and create or enhance habitats and food sources for native animals.

Restoration principles and/or steps include:

- having clearly defined aims and objectives – e.g. restoration of natural area, biodiversity enhancement, aesthetic values, and similar
- selection of a suitable reference site
- stakeholder engagement
- determine a suitable species list for the nominated site, considering soil type, planting zone within the landscape, vegetative structure (over, middle and understorey) and site aims
- determine most appropriate method for restoration
- consider threats to revegetation success, such as the presence of weeds, rabbits, and similar and how they may need to be controlled,
- consider costs and timeframes required to achieve restoration outcomes,
- develop and/or implement an appropriate management plan for the site, and
- develop appropriate completion criteria and monitor outcomes to determine whether or not they have been achieved.

4 Approaches to Ecological Restoration

As with many environmental issues today, prevention is easier and more cost effective than having to implement recovery programs, and the same principle can be applied to ecological restoration. Preventing deterioration in bushland areas of good condition will be easier and more cost effective in the longer term than allowing degradation to continue. It should be noted that restoration is a process that aims to increase natural succession towards a mature, stable community with a high level of diversity. Accordingly, this process may take 20 or more years to achieve, and nesting hollows and other features of a mature ecosystem will not occur in the short term. The aim of maintaining bushland areas in good or better condition is reflected in the NAAMP with the rating of reserves according to overall condition. While the overall aim is to maintain bushland reserves in good condition, disturbances still occur that may require some form of management intervention.

4.1 Aims and Objectives

Table 1 below illustrates different approaches to restoration and example objectives of each approach with an increasing requirement for resource investment.

Table 1 Revegetation Objectives and Investment

Revegetation Objectives Category	Objectives	Examples of Potential Functional Benefits	Investment Requirement
Establishment of individual plants or artificial hollows	• Plants > 5 years old • Hollows used by target species • A number of plants or artificial hollows (the number varying between sites)	• Increased number of populations • and/or Increased population sizes for species rare in the City • Increased ecological connectivity in ecological linkages (e.g. for birds using small reserves in moving between larger reserves)	Lowest Cost Shortest Time ↓
Rehabilitation The process of reinstating self-sustaining and functional ecosystems based on local species, but not aspiring to fully replace all of the original components of an ecosystem.	• Plants > 5 years old • Gaps between native plants < 1 m x 1 m • Weed cover < 25% in any $100m^2$ area (in which a rectangle with a minimum side of 2 m can fit) • A number of shrubs/trees (the number varying between sites) • Diversity criteria generally not set	All the above plus: • Increased buffering of higher value sites from threats • such as weeds • Reduced fuel loads by displacing weeds • Increased effective fauna habitat area available to fauna • Reduced fuel loads by displacing weeds	↓
Restoration of vegetation The process of fully repairing the composition, structure, function and dynamics of pre-existing indigenous ecosystems	• Diversity and density measurements benchmarked against reference site	All the above plus: • entirety of possible ecological functions	Highest Cost Longest Time

4.2 Site Assessment

Before commencing revegetation activities, it is necessary to undertake a suitably comprehensive site assessment that will assist with determining the level and type of revegetation activities that will need to take place, and the various threatening process that will need to be managed. Typical assessment activities may include:

- Heritage or community interest values of the site (can be done by stakeholder engagement, desktop assessment or consultation of the NAAMP assets)
- vegetation type and condition surveys,
- identification of floristic species present,
- the presence of any rare or endangered flora and fauna species, along with threatened or priority ecological communities listed at a State and Commonwealth level,
- weed presence and mapping,
- if required, consideration of Phytophthora dieback,
- identification of other threatening processes, such as the presence of feral animals, erosion, or uncontrolled access,
- Presence of irrigation that may lead to overspray into revegetation sites
- determining areas (m2, ha) where revegetation works are recommended, and
- recommended planting density, along with target species composition and diversity based on current site conditions.

In order to assist with determining whether or not a particular area needs to be revegetated, a site assessment template has been developed, and is provided in Appendix 2.

The City of Melville NAAMP has documented key information such as soils, climate and broad vegetation information across the City boundaries. The City also has other records available that will assist with the site assessment, such as information from the Department of Biodiversity, Conservation and Attractions (DBCA) regarding the presence of rare or endangered flora, fauna and ecological communities. Ground-truthing of Information should be undertaken during on-site assessment activities.

Outcomes of the assessment will enable recommendations to be made in the relevant reserve management plans that detail:

- revegetation aims and objectives,
- area (m2, ha, other) where revegetation needs to occur,
- revegetation techniques to be used,
- management of any threatening processes that will need to occur prior to and/or post planting,

4.3 **Reference Sites**

A reference site is an area of native vegetation that represents the attributes of the ecological community that you are trying to restore. It should represent the substrate, functional attributes (including nutrient cycling, disturbance regimes and species interactions), characteristic species composition of that community type, habitat availability of important plants and animals, and any spatial patterns within the community existing across the landscape (SERA 2017).

Reference sites can be a physical area of vegetation, or if no pre-disturbance state exists, a combination of physical reference site and historical records.

4.4 **Species List Selection**

Species should be selected based on the aims and objectives of the site; however priority can be given to species under certain circumstances. Table 2 gives some examples of considerations for species selection.

Table 2 Examples of Considerations in Species Selection for Revegetation

Consideration	Comment
Vegetation Integrity	Revegetation objectives determine whether appropriate species are those naturally occurring (past or present) onsite or those occurring in a regional vegetation complex.
Conservation Significance	Consideration should be given to giving priority to plants listed in Table 18Table 18Table 17, if there are not numerous and extensive populations in the City (and noting that there are requirements for Ministerial permits to collect seeds etc from Declared Rare Flora in the wild)
Feral Animals	A continuous canopy and a thick understorey of shrubs can reduce the exposure of native fauna to predation by feral animals (DEWHA, 2008c)(DEWHA, 2008c).
Fauna Habitat	The specific important plants are identifiable for some significant fauna species such as Carnaby's Cockatoos (see https://www.dpaw.wa.gov.au/plants-and-animals/animals/40-plants-for-carnaby-s-search-tool). Artificial roost and nest boxes need to be specific to the requirements of the animals they are intended for. The main factors that may influence the suitability of hollows are entrance size, hollow volume, hollow depth below entrance and wall thickness (Goldingay and Stevens, 2009). Other factors may include construction materials, height above the ground, proximity to other hollows, orientation (due to differences in temperatures arising from differences in sun exposure) and surrounding vegetation (Goldingay and Stevens, 2009), and tree health and number of entrances (Gibbons and Lindenmayer, 2002). It should also be noted that several different box designs may need to be provided for one species in a reserve given the different requirements during the year (breeding versus non-breeding periods) (Goldingay and Stevens, 2009). Multiple boxes may also be required for individuals in a reserve as some species may regularly move between a number of roosts. Lesser Long-eared, and Greater Long-eared Bats have been recorded moving between non-maternity roosts on an almost daily basis, likely in response to temperatures, rain and impermanence of roosts under loose bark (Hosken, 1996). It should also be noted that artificial alternatives such as small bat boxes may provide temporary shelter for small roosting groups of White-striped Freetail Bats but may not be suitable substitutes for habitat loss for this species (Rhodes, 2006)
Rarity in the City	The rarity of plants cannot be readily determined on the basis of the flora inventory in the NAAMP. Priority should be assigned to species only recorded in one reserve where that species would not be managed indirectly because it occurs in a high value site or reserve.
Altered groundwater	Groom et al. (2000)(2000) found that of the 42 myrtaceous shrub species, those with shallow roots (rooting depth <1 m) and occurring in winter wet depressions had the greatest reduction in population size in response to long-term falls in groundwater levels.
Flammability and Fuel Loads	The City's *Bushfire Management Guidelines* sets out how weed species in bushland are controlled as a means of fuel reduction. The control of Veldt Grass contributed to a reduction in the intensity and rate of spread of fires in Kings Park bushland (Dixon et al., 1995)(Dixon et al., 1995). Native species might be selected to compete directly with flammable weeds in order to reduce this risk.

5 Method of Restoration

There are three main ways to undertake ecological restoration, namely:

- natural regeneration;
- direct seeding; and
- tubestock planting.

Each of these methods has a range of advantages and disadvantages and different resource requirements, making them better suited to some situations, and which will need to be considered when deciding on the most appropriate method(s) for a nominated area. Sometimes a combined approach may be the best option for the site.

Irrespective of the method adopted, there are a number of general principles that will assist with maximising the success of revegetation activities, including:

- understanding site characteristics (both abiotic and biotic factors),
- working outward from areas of good vegetation to those areas in poor condition,
- treating any weeds present at an appropriate stage of their development and prior to replanting activities, recognising that follow-up weed treatments may be required,
- if required, undertaking other ground preparation activities, such as the treating compacted areas,
- using appropriate species to restore a natural vegetation structure that will provide or restore a range of habitats and ecological niches that can be occupied by native fauna species, with details being included within the NAAMP
- considering the need to control the presence of invasive species (e.g.: rabbits) or other threatening processes (e.g.: erosion) that might otherwise impact on seedlings becoming established in the longer term,
- determining success criteria and monitor over time to evaluate whether success criteria have been achieved,
- where possible, sourcing seed of local provenance to ensure species are adapted to local environmental conditions and to preserve the local genetic diversity,
- recognition of the needs for post revegetation maintenance, and
- best practice would include attempts to replant ‘difficult’ to grow/propagate species

5.1 Natural Regeneration

Natural regeneration as a revegetation technique relies on the germination of native plant seeds that have been dispersed from the parent plants into the topsoil or the tree canopy, waiting until conditions are appropriate for establishment and growth. This form of revegetation often requires a long lead time for results to become apparent, but can be assisted through the management of threatening processes such as weed invasion, feral animal management and trampling.

This method is the overall goal of restoration, with seeding and planting used to facilitate and accelerate the process of returning an area to a self sustaining ecosystem. Considerations associated with natural regeneration as a revegetation technique include:

- likely to result in a greater species diversity and more natural vegetation structure (under, middle and upper storey),
- likely to result in ‘hard-to-propagate’ species being able to be returned to the site,
- plants are particularly suited to the on-site growing conditions, and thus likely to be healthier and more resistant to disturbances in the longer term,
- protects the genetic diversity of the local plant populations,

- works best in proximity to a vegetation stand in good condition, as this will supplement seed supplies in the area to be revegetated,
- ongoing weed treatment or management of other threatening processes may be required to protect plants from damage during the establishment period.

5.2 Direct Seeding

Direct seeding uses seed of appropriate species that are sown mechanically or by hand within the area to be revegetated at a rate of between 2 - 4 kg/ha, depending on site conditions and target species. It is a useful method of restoring a diverse range of species in a nominated area with healthy plants, as well as being a good means of supplementing the planting of tubestock and/or natural regeneration. Considerations and recommendations for direct seeding include the following:

- where possible, use of local provenance seed that is adapted to local conditions, including local climatic conditions,
- requires a longer establishment period,
- monitoring of results should be undertaken over many years as seed will have differing dormancy periods,
- uses more seed than will actually germinate, as seed viability is difficult to ensure,
- can include species that cannot be grown in a nursery,
- many local native plant seeds require one or more treatment methods to break seed dormancy and to maximise the likelihood of germination and healthy growth,
- predation by insects, particularly ants, and birds is common,
- weeds treatment prior to revegetation activities is recommended, and may need to be undertaken during establishment,
- likely to result in a bushland structure typical of the area,
- while some seed can be expensive to purchase, establishment costs are lower than planting of tubestock, and
- weed control needs to be undertaken with extreme care on direct seeding sites by very experienced operators so that new germinates are not treated with herbicide due to misidentification.

5.2.1 Local Provenance Seed

Collection of local provenance seeds is preferred for revegetation projects within the City. ‘Local provenance’ relates to seeds that are sourced from species currently growing in a particular area, and thus are best suited to the soil type, climate, and other growing conditions present. Seed collected from the same target species from other locations may have developed adaptations suited to its source area, and may not germinate or flourish in differing conditions.

Local provenance seed for the City of Melville is considered seed collected from reserves or bushland within the City’s boundaries or within 30km of our boundaries.

5.2.2 Seed Collection

The collection of seed needs to be carried out by appropriately experienced and licensed personnel at a suitable time of year for the target species. Seed collection considerations include:

- areas where collection can occur – e.g.: within nominated reserves, foreshore, or similar,
- accessibility of sites,
- collection from identified target species,
- seed collection tools need to be cleaned before use,
- seeds should be collected from:
    - mature plants, with no more than 20% being taken from a particular plant,

- o taken from the 30% of the crown and all sides of the plant,
- o at least ten (10) plants of the same species,
- o in equal quantities from each plant,
- o with plants with a good fall distance between each plant,
- o from plants which are true to form rather than hybridised varieties, and
- o from plants that are not isolated or only occur in remnant lines along fence lines or
- o verges.

- licenses/permits applied for and received,
- seed returns completed when due

5.2.3 **Mechanical Seeding**

Mechanical seeding involves the use of machinery to disperse seed from the back of a vehicle; the seed is typically mixed with clean sand to aid in dispersal. This method of seeding has the advantage of broadcasting considerable volumes of seed over a large area with minimal physical effort. The main disadvantage of this method is that it often requires vehicle access, is not suited to large areas and requires large volumes of seed. In addition, there is less control of the depth of seed burial. Mechanical seeding is best suited to large scale restoration projects where a large surface area requires seeding. Accordingly, this method is unlikely to be used within the City of Melville.

This method of seeding is not suitable for all species due to the potential for damage. Examples include large seeds, such as those of the Zamia Palm (*Macrozamia riedlei* and *M. Fraseri*), and the Woody Pear (*Xylomelum occidentalis*), or large, papery seeds from some Banksia and Hakea species (DBCA, undated).

5.2.4 **Hand Seeding**

Hand seeding involves physically walking the area to be seeded with a container or kidney bucket, which has ergonomic advantages, and dispersing the seed mixed with sand. This method is ideal for large and/or ‘papery’ seeds that can be damaged in mechanical seeders, application in smaller areas and where vehicle access is not available. The advantage of this method is the greater control over where the seed is broadcast and the lower investment in equipment.

A disadvantage of this method is the weight involved with the seed mix to be spread by hand in terms of manual handling and ergonomics from an occupational health and safety perspective. The use of some form of strap on the shoulder(s) attached to the container is recommended, as is the use of a kidney-shaped bucket and limiting the weight of the seed mix to be spread at any one time is the best way to manage the risk of strain or injury (Figure 1).

Figure 1 Seeding Bucket with Waist and Shoulder Straps

5.2.5 **Seed Processing and Storage**

After collection, seeds need to be processed to avoid rotting, the proliferation of mould and fungi, or the inclusion of insects in seed batches. Processing will include:

- drying away from wind and animals,
- extraction of the seed from the casing (e.g.: capsule, pod, cone), using a range of methods according to the seed type, such as:
  - air separation,
  - threshing,
  - soaking and de-pulping,
  - hand sorting,
- storage in a suitable facility that is temperature (room temperature as a minimum) and humidity controlled (less than 50%), secure and protected from light, dust, insects and
- animals,
- seed is stored in air tight plastic containers, labelled, and details recorded in an appropriate database (date and place of collection, collector).

5.3 **Tubestock Planting**

Tubestock planting involves the growing of selected species in forestry tubes from seed, cuttings, or the division of parent stock. Tubestock are raised in a nursery until they reach an optimum size for planting, and then transported to the location where they are to be planted. Considerations for tubestock planting as a revegetation technique include:

- provides an outcome visible to the general public,
- can be costly due to labour involved with seedling production and planting,
- range of species available is often less than would occur naturally within a given location, but are unavailable for a variety of reasons, including difficulties in sourcing viable seed and propagating tubestock in a nursery environment.
- if not planned effectively, installation of plants can result in unnatural looking vegetation stands because they are planted in clumps of the same species, in uniform rows, or similar,

and
- outcomes are more reliable, with survival rates of 75% or more achievable when planting is done in conjunction with weed control and other revegetation principles

Tubestock planting is preferable over direct seeding method where environmental conditions may constrain natural germination of seed, such as in degraded areas, where there is a higher potential for weed invasion, and where an outcome is required in the short term rather than a longer timeframe.

Tubestock should be sourced from reputable suppliers, such as Nursery Industry Accreditation Scheme, Australia (NIASA) and/or Nursery and Garden Industry Association (NGIA) accredited suppliers, and using species grown from local provenance seed where possible. Planting should occur during cooler months after the first winter rains to encourage establishment in a short time frame. The use of tree guards and fertilising at the time of planting will increase survival and promote growth.

5.3.1 **Planting Density**

When tubestock planting is the preferred method of revegetation, it is necessary to determine a suitable planting density and ratio of over storey, middle storey and understorey species whilst also avoiding over representation by coloniser species. While the accepted planting density is one plant per square metre (1 plant per m^2) for dryland species, there are a number of factors that need to be taken into consideration, including:

- the current density of vegetation at the site, as the overall aim is to achieve 1 plant per m2, including any plants already present at the site,
- the ratio of trees (over storey) to shrubs (middle storey) and herbs and grasses (understorey) which should be based off the reference site and aims of restoration. As a generalisation, over storey species can be planted at densities of 1 plant per 10 to 20 m2, according to canopy cover and vegetation type, while middle storey species (shrubs) can be planted at densities of 1 plant per 5 to 10 m2; understorey plants can be planted at densities of 2 plants per 1 m2.
- The accepted planting density for wetland plants such as sedges and rushes is usually six plants per m2 (6 plants per m2). Larger water tolerant trees such as *Melaleuca rhaphiophylla* and *Eucalyptus rudis* would be planted at a similar density as dryland species.

5.3.2 **Planting Additives**

Perth soils are naturally low in nutrients, in particular phosphorus, due to their age and lack of geological processes over thousands of years. Many native plants have specialised strategies and adaptations to cope with low nutrients, therefore soil nutrient additives are usually not necessary unless the soil is particularly degraded. The City utilises a native fertilizer tablet (must be low in phosphorus) for dryland planting only, to assist with the provision of nutrients for the first year. Native fertiliser is not added to sedges and other wetland species.

Water crystals and wetting agents are no longer applied in the City's restoration sites. Water repellence results from waxy organic compounds coating soil particles, which is particularly prevalent in the sandy soils present in the Perth area (Sheppard, Hoyle and Murphy, 2020). However wetting agents have been shown to have a negative affect on wetland animals such as frogs and tadpoles (DBCA, 2012).

5.3.3 **Planting Method**

Please see Appendix 1 showing the planting method for tubestock.

6 Threatening Process Management

Revegetation usually occurs after some event or process results in degradation, such as weed invasion, the presence of pest or feral animal species, frequent fires, storm events, or similar. The presence of such threats needs to be considered and managed to maximise the likelihood of a successful revegetation outcome. Some discussion of key threatening processes is provided, recognising that the information is expanded on in the relevant guideline documents associated with the NAAMP.

6.1 Weeds

A weed is a plant species that is found outside of its usual range, and often in the absence of diseases and/or predators that would normally keep populations in check. Weeds often have one or more characteristics that enable them to out-compete native plant species for resources such as light, water space, and nutrients. The presence of weeds in bushland and other areas has been identified in the NAAMP as being one of the ten most threatening processes to biodiversity within the City. The presence of weeds should be assessed and any controls implemented in accordance with the NAAMP Weed Guideline prior to undertaking revegetation works.

6.2 Feral Animals

Feral animals pose a threat to the presence of native animal species that would occur naturally in bushland areas, and have also been identified in the NAAMP as being one of the ten most threatening processes to biodiversity in the City. Feral animals are also known to pose a risk to revegetation activities through predation on tubestock and damage to flora and vegetation. The presence of feral animals should be assessed prior to revegetation works, and the NAAMP Feral Animal guideline consulted to determine the most appropriate control method if required.

6.3 Access

Access by people, vehicles, and/or pets or other larger animals to bushland areas can result in or decrease the success of planned revegetation works. Access may need to be limited by:

- limiting vehicle movement to authorised areas and tracks only,
- precluding pets from nominated reserves or key locations within a reserve, and
- using some form of fencing to prevent access to areas being rehabilitated, at least until such time as plants become well established (duration will be dependent on the revegetation methodology chosen).
- The Sign, Path and Barrier Guideline should be referred to for further information.

6.4 Fire

Many Australian plants have developed afire ecology over time, meaning that fire can be an important consideration in revegetation activities as some plants require heat to release seed from their canopy or the presence of smoke to trigger seed germination. However, fire also has the potential to encourage weeds if they occur too frequently or burn at an intensity that kills plants rather than assists with seed release and germination. Fire management in the form of:

- consideration of controlled burn frequency and locations, and
- management response in the event of a fire needs to be considered when planning and implementing revegetation activities, as seedlings and both immature and mature plants will not be able to withstand the effects of fire.

Fire events can be a good opportunity to undertake revegetation activities in conjunction with weed control. If fires do occur, the opportunity to commence revegetation works should be taken. Please see the COM Bushfire Guidelines for more information on the approach to revegetation after fire.

6.5 Soil/Ground Preparation

Depending on the nature and extent of the degradation, some form of ground preparation may be required. This may include:

- ripping of areas where compaction has occurred, noting that compaction can be at or below the surface,
- restoring areas where erosion has occurred,
- preventing further erosion, and
- undertaking mulching.

6.5.1 Ripping

Ripping involves mechanically breaking up soil that has become compacted, thus restricting plant growth and affecting the movement of water and nutrients. There are two types of compaction; cultivation and traffic. A cultivation hardpan is formed by moist clay soils breaking down over time and is typically located bellow the soil surface. A traffic hardpan is associated with sands and sandy loams and forms in response to vehicle traffic. Individual grains of sand interlock and form a hard surface layer preventing root penetration. There are a number of different t types of ripping machinery although the most effective is a multi bladed hydraulic ripper. The maximum ripping depth is 30 cm in soils with a cultivation hardpan and 45 − 50 cm for a traffic hard pan (Mullan and White, 2002).

6.5.2 Erosion Control

Erosion control is required where there is a potential for sediment and productive topsoil to be moved by the action of wind, water and biological agents, such as within foreshore areas. A loss of productive soil has the potential to damage restoration by removing nutrients and beneficial soil biota. Types of erosion likely to affect revegetation activities are identified in Table 3.

Table 3 Erosion Types, Effects and Treatment

Erosion Type	Characteristics	Treatment
Bank Erosion	associated with waterways may result from tidal action, boat wash or wave action	brush mattressing rock toe protection biodegradable geo-textile matting
Gully Erosion	forms when high velocity water removes sediment along drainage lines forming deep a deep rut	install contoured drainage lines install rocks to disperse flow of water
Sheet Erosion	occurs on slopes loss of sediment and topsoil	break up the movement of water with physical barriers such as geo- textiles or logs
Wind Erosion	moves small soil particles	biodegradable geo-textile matting sand trap fencing wind protection fencing

6.5.3 Mulching

In order to maintain revegetation sites and keep them separate from grassed areas it may be necessary to install a layer of mulch. Mulching is beneficial in reducing water loss from the soil, suppressing weed growth and providing nutrients once the media begins to breakdown. Installation before or after planting will need to be assessed on a case by case basis. Material should be sourced from reputable suppliers or clean green waste as not to introduce weeds or plant pathogens.

6.6 **Climate Change**

It has been identified under current climate change models that the south-west region of Western Australia will experience a more arid climate with increasingly erratic rainfall and more intense storm events. While this may impact on species present at a particular location over time, plants should be selected that are of local provenance ensuring they are adapted to local site conditions and selective pressures.

It may be necessary to plant species that will fare better under increasing water stress where it has been identified that the current vegetation type is in decline, such as a drying wetland. It may be necessary to alter planting techniques to include the provision of more water in particularly long periods of drought.

6.6.1 **Watering**

In previous years, tubestock were planted during winter months, usually after the first winter rains that typically occurred in May, with no further attention. As the Western Australian climate dries, less rainfall in winter and drier, hotter summers can impact negatively on a seedling’s ability to become established and thrive. Accordingly, watering may be required during the first summer at a rate of 2L per plant on a monthly or more frequent basis if conditions are particularly warm/hot and dry. This requirement will need to be assessed according to conditions that occur during and after the initial planting.

7 Success Criteria and Monitoring

As the establishment of native plants takes time, and not all seeds will germinate and not all tubestock will survive the initial planting season, it is essential that success criteria is established and monitoring of those criteria over time are developed. These goals are typically measured against a 2-3 year timeframe, although longer term monitoring allows for a comprehensive insight into revegetation success. Monitoring goals should be established that take into account current site attributes such as weed coverage, native species diversity and plant survivability.

Success Criteria for Revegetation Sites:

- Survival and establishment of plants to > 5 years old
- Artificial and natural hollows used by target species
- Gaps between native plants < 1 m x 1 m
- Weed cover < 25% in any 100m2 area (in which a rectangle with a minimum side of 2 m can fit)
- Diversity and density measurements benchmarked against reference site

The Ecological Restoration Standards developed by SERA (SERA, 2017) have some suggested ways of measuring the success of ecological restoration, based on a star ranking system (see Table 4 below). The ecosystem attributes looking to be restored through ecological restoration cover six principle areas:

- Absence of Threats (e.g. invasive species, contamination)
- External exchanges (habitat links, gene flow)
- Ecosystem Function (resilience, natural recruitment, nutrient cycling, habitat availability)
- Structural Diversity (vegetation strata, trophic levels and spatial mosaics)
- Species Composition (desirable plants and animals and absence of undesirable species)
- Physical conditions (chemical and physical characteristics of substrate and water)

Table 4 Restoration Recovery Ranking System (SERA 2017)

Number of stars	Recovery outcome (Note: modeled on an appropriate local indigenous ecological reference)
1	Ongoing deterioration prevented. Substrates remediated (physically and chemically). Some level of indigenous biota present; future recruitment niches not negated by biotic or abiotic characteristics. Future improvements for all attributes planned and future site management secured.
2	Threats from adjacent areas starting to be managed or mitigated. Site has a small subset of characteristic indigenous species and there is low threat from undesirable species on site. Improved connectivity arranged with adjacent property holders.
3	Adjacent threats being managed or mitigated and very low threat from undesirable species on site. A moderate subset of characteristic indigenous species are established and evidence of ecosystem functionality commencing. Improved connectivity in evidence.
4	A substantial subset of characteristic biota present (representing all species groupings), providing evidence of a developing community structure and commencement of ecosystem processes. Improved connectivity established and surrounding threats being managed or mitigated.
5	Establishment of a characteristic assemblage of biota to a point where structural and trophic complexity is likely to develop without further intervention other than maintenance. Appropriate ecosystem exchanges are enabled and commencing and high levels of resilience is likely with return of appropriate disturbance regimes. Long term management arrangements in place.

7.1 **Monitoring Methods**

Monitoring of a revegetation site should be undertaken on an ongoing basis to determine when success criteria have been met. In this way, it can be determined if infill planting or some other means of enhancing outcomes needs to be implemented or when the location requires less active management.

Monitoring activities typically occur for a minimum of two or three years after planting during autumn and spring. Typical monitoring activities can include any or all of the following:

- recording the numbers and species of tubestock planted, along with location,
- undertaking survival counts, indicating the percentage of seedlings that are in good health, poor health, or have not survived,
- setting up quadrats or transects within the revegetation zones to undertake detailed assessments for species diversity, structural composition, and weed presence, and
- photo monitoring points at nominated locations that can be used to record vegetation change over time. Photo monitoring should occur 6 monthly to cover season differences in the site.

8 **Conclusion**

Restoration is a key management activity that can improve and enhance natural areas after disturbances such as fire, weed invasion or clearing. In order to maximise success rates, restoration needs to be planned after undertaking an assessment of the target area to ensure threatening process are effectively managed.

Prevention of degradation is more cost and resource effective than undertaking restoration activities. As highlighted in the NAAMP, management and maintenance of bushland areas with a rating of 1 will be given priority for revegetation activities. Given that the City cannot control degrading processes that occur outside reserve boundaries, such as the spread of weed seeds, land clearing, fire and adjacent land management practices, there is likely to be an ongoing need for revegetation in the longer term.

It is also recognised that revegetation activities may include assessment of key threatening processes, thus it will be necessary to refer to relevant Guideline documents associated with the NAAMP, such as:

- Weed Control guidelines,
- Feral Animal guidelines,
- Signage Guidelines
- Stormwater Guidelines
- Path and Barrier guidelines, and
- Bushfire Management Guidelines.

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10 Appendix 1- Tubestock Planting Method

Planting Procedure

1.

Equipment - Gloves - Trowel - Mallet - Stakes - Sleeve - Soil Additives - Tubestock (plant)	

2.

Dig the hole deeper and wider than the pot being planted, ensuring the soil of the pot is covered by the existing soil level	

3.

Put fertiliser tablet into hole (if using). Backfill some soil over top so the plant roots don't touch the tablet directly.	

4.

Put A PINCH of water saving crystals into the hole (if using)	

5.

Get plant ready: squeeze container and then tap firmly with the trowel on top of the container to dislodge plant	 

6.

Spread out the roots at the bottom of the plant, gently, by rubbing your fingers along the bottom.	

7.

Hold sand back whilst you put the plant into the hole.

Make sure the hole is deep enough to cover up to the stem of the plant.

8.

Push dirt down firmly around the plant – make sure none of the potting mix protrudes from the hole.

If it does, start again and did a deeper hole!

9.

Create a well around the plant (a well is a dip below ground level that aids water to drain towards plant)

DO NOT build a well up above the level of the ground.

10.

Don't forget to collect your seedling pots so they can be recycled or reused.

Tree-Guarding Procedure

1.

Using your mallet, secure one stake into the ground, about a hands distance away from the plant.

2.

2.

Using your mallet, secure a second stake into the ground, about a hands distance away from the plant and on the opposite side. Pull the green sleeve carefully over the plant and over the two stakes.	

3.

Using your mallet, secure a third stake into the ground, inside the green sleeve. PULL TIGHT	

4.

Check to make sure the stakes are in the ground firmly and won't pull over.	

11 **Appendix 2- Revegetation Site Assessment Form**

Revegetation Site Assessment

Site Name: ____________________________ Location: _________________ Date: ______________

Assessor: ____ Site NAAMP Priority Rating: _________

Key Site Characteristics

Characteristic	Description	Outcomes
Area	1 ha = 10 000 m^2	
Threatened or priority flora	Specie(s)	
Threatened or priority fauna	Specie(s)	
Threatened or priority ecological communities	Type, area, location	
Vegetation community	E.g.: Banksia/Jarrah Woodland	

Presence of Threatening Processes:
(Note: refer to relevant NAAMP strategy and guideline documents)

Threatening Process	resent (Y/N)	Description	To be Considered Revegetation Planning (Y/N)
Cubby houses/smoking dens			
Erosion			
Feral animals			
Fire			
Plant disease or pathogens			
Rubbish dumping (garden, litter, soil)			
Track formation			
Vandalism			
Vegetation removal or death			
Vehicles (4WD, car, motorbikes)			
Weeds			

Treatment(s) Required

Restoration Treatment	Description	Required (Y/N)	Length/Area/
Direct seeding	Species, area locations		
Fertiliser treatment	Tablet, granular		
Fire restoration	Area, species, other		
Installation of fences, barriers, signs	Length, type, locations		
Jute matting/coir logs for erosion control	Number, area to be treated		
Mulch	Area to be treated		
Natural regeneration potential	Yes/no		
Removal of feral fauna population(s)	E.g.: bees, rabbits, foxes		
Removal of rubbish, litter, soil	Amount, location		
Replanting with tubestock	Area, species		
Restoration of clear, bare areas	Area, species		
Seed collection	Yes/no		
Soil breaker or ripping (compaction)	Area, depth, locations		
Soil wetter (hydrophobic soils)	Amount required		
Treatment of graffiti, vandalism, etc	E.g.: signs, fences, trees		
Vegetation health assessment (e.g.: *Phytophthora* dieback assessment)	Obvious signs of decline, fungi or other symptoms present		
Watering	During warmer months during establishment period		
Weed control	Grasses, herbs, bulb, trees/shrubs, vines, area, location		