A Revegetation Guide for Tropical Riparian Forests

Australian Government
Department of Sustainability, Environment, Water, Population and Communities

Greening Australia

Landcare Australia

A REVEGETATION GUIDE FOR TROPICAL RIPARIAN FOREST

Who this guide is for?

Tropical Riparian Forests are found throughout northern Australia, including some of the islands in the Gulf of Carpentaria and the Van Dieman Gulf. They are or were located along water courses throughout northern Australia and often weave their way across fertile floodplains (Photo 1ab). They have been highly cleared for agriculture, urban and industrial development. Most remnants of tropical riparian forests are found in isolated patches or in protected areas. The remaining tropical riparian forests are fragmented and often have just a few remaining stands of trees (Photo 2).

Tropical riparian forests play a vital role:

- Provide habitat, refuges and dispersal corridors for many species of wildlife.
- Trees that fall into rivers and creeks provide important habitat for aquatic species.
- Stabilise banks, slow floodwaters and reduce erosion.
- Biomass provides organic input to stream.
- Provide shading and regulate fresh water temperatures.
- Trap sediment and filter nutrient pollutants from overland flow of water, and;
- Take up nutrients from groundwater before it enters streams and rivers

This introductory guide is for people wishing to learn, or be reminded about the basic principles and practices of planting trees, shrubs, grasses and other herbaceous plants for revegetation of tropical riparian forests for dry wet tropical regions of northern Australia. This guide describes eight key steps that need to be followed to help ensure a successful revegetation project

Photo 1a.

Photo 1b.

Photo 1 (a-b) Riparian forests are found along (a) ephemeral creeks and (b) rivers throughout northern Australia. These fringing forests are often surrounded by much drier savanna woodlands and grasslands.

Photo 2. Tropical riparian forests have often been greatly reduced in their width when they occur on highly fertile floodplains suitable for intensive agriculture, in this case the lower Burdekin River, Qld. Increasing the width and continuity of riparian forests provides many ecosystem services including wildlife habitat, improved water quality and erosion protection of high value agricultural.

STEP 1.

Assess site conditions

Revegetation is needed when there are local constraints that limit the natural return of tropical riparian plant species. Constraints include:

1. Recruitment
- Lack of seeds
- Lack of suitable sites for seed germination (establishment niche)
- Lack of wildlife to spread seed (e.g. fruit eating birds)
- Too much competition from weeds

2. Altered physical environment
- Frequent and intense fires
- High solar radiation (lack of shade)

3. Hostile soil conditions for native plants
- Soil compaction from cultivation, vehicles and livestock
- River bank instability and soil erosion by water (Photo 3)
- Nutrient enrichment (high levels of Phosphorus and Nitrogen – good for weeds but not most native plants)
- Lack of soil microbes that greatly assist native plant survival and growth

Photo 3. Loss of riparian vegetation can accelerate riverbank erosion, often the largest source of catchment sediment. Such bank instability may require earth-works, if so contact a specialist, start with your Regional NRM organisation.

4. Threats to tropical riparian plant survival
- Weed competition from woody shrubs, grasses, vines and broad leaved weeds
- Grazing by cattle and horses
- Furrowing by feral pigs
- Browsing by native mammals
- Vandalism

Examine your site carefully to determine if you have any of these constraints. If you do, then active revegetation is needed, and you will need to reduce these threats to successful establishment of a diversity of tropical riparian species.

STEP 2.

Set clear site objectives

There are many different reasons to plant locally native tropical riparian species. This includes:
- Wildlife habitat and dispersal corridors
- Stream and riverbank stabilisation
- Carbon sequestration
- Aesthetics

Historically the objective of restoration has been to fully recreate the native vegetation believed to have occupied the site before it was degraded. However, comprehensive restoration of hundreds of plants species is costly ($50-$90,000/ha). In contrast, revegetation usually only goes part way to re-establishing a diverse tropical riparian indistinguishable from healthy native remnants. The greatest diversity of plants is found within the groundcover of a high quality tropical riparian forest (grasses, lilies and sedges). A diverse riparian understory can be the most difficult to restore so tropical riparian revegetation tends to focus on rapidly growing pioneer and climax species of trees. With these in place, understory can often naturally re-establish at no cost.

A decision on whether to attempt full restoration, or scale back to simple revegetation should be based on costs compared to benefits, your objectives, and the importance of the restoration in the bigger picture.

Landscape context

Ideally revegetation or restoration should be conducted to increase diversity in a degraded tropical riparian forest and connect existing high quality native vegetation remnants, particularly remnants that are protected by covenants or are in reserves.

In many landscapes wildlife, particularly birds can be used as groups for prioritising connectivity between patches of remnant tropical riparian forest. Revegetation is then focused on increasing diversity in degraded areas and connecting key tropical riparian remnants to create 'stepping stones' or a 'corridor' along these identified broad routes for connectivity to allow movement of wildlife in response to climate change. Filling in gaps in riparian vegetation is important for both habitat and water quality in creeks and rivers (Photo 2).

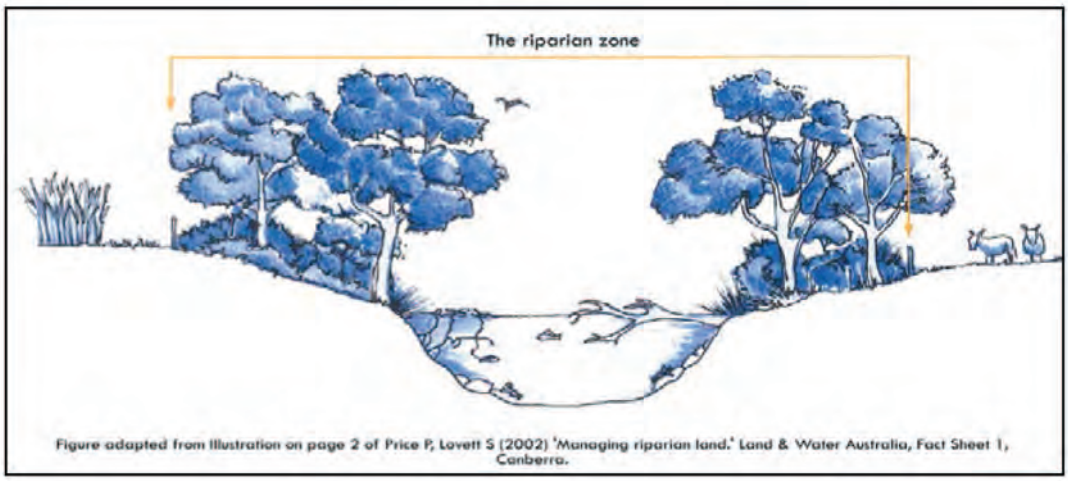

Figure 1. The riparian zone includes a diversity of plant species adapted to particular position (niches) from the river bank to the edge of drier savanna vegetation. It is important to get the right plants situated in the right places including understory species that can tolerate episodic flooding.

Riparian forests along rivers are natural corridors from the top of a catchment to the coast. A continuous ribbon of riparian forest is the ideal. So it can be useful to consult with your surrounding neighbours and local community to identify opportunities for linkages with adjacent revegetation work and existing remnants.

STEP 3.

Choose species to suit local conditions

Choose tropical riparian species that occur in remnant tropical riparian forests nearby. It is not realistic to restore all species that occur on a site because of limitations of seed collection, propagation, establishment and cost. Select a mix of species that provide layers of vegetation from tall trees (often eucalypts or melaleucas), medium sized trees/ tall shrubs (often ficus), and large tussock herbs (often lomandra) (Figure 1). Different layers of vegetation such as short lived trees and shrubs provide food for pollinators, nesting sites for insect and fruit eating birds. Dense forest layers also resist the invasion of weeds. But most importantly choose native plant species that will survive. Dead seedlings don't provide habitat nor fix carbon.

Seed for the chosen plants should come from healthy populations growing on similar sites within the same bioregion so they are adapted to the environment of the planting site. Rainfall, soil, altitude, aspect and slope position are important environmental factors in plant adaptation.

Securing a supply of seed has to be considered early in the planning for revegetation. Seed of the required species may only be available for harvest for a short period in its natural habitat. Planning has to be in place for seed collection (e.g. acquire state, local permits and permission from landholders) or seed purchase. Seed suppliers need plenty of advance notice to collect quality seed and process it appropriately. Like any crop, native seed quantity varies from year to year based on rainfall. A drought one year can greatly reduce seed supply in some eucalypt species three years later. Ordering native seed is not the same as buying a packet of veggie seeds from the shops.
Where the species is rare and seed is generally unavailable from seed suppliers, seed nurseries (orchards) have to be established. A nursery area has to be set aside to grow rare plant species for seed collection. Once plants reach maturity seed is collected and stored for use in restoration. The seed of these species is often so valuable that it is better plant seedlings rather than use seed of these species in the seed mix.

STEP 4.

Select quality plant material

Only use healthy seedlings.
The size and root structure of seedlings is critical to their survival after transplanting and to their long term survival. Poor root development in the nursery can result in early death, slow growth, instability in flood events and long-term self-strangulation by spiralling roots.

Nursery containers should be chosen to produce healthy roots with lots of strong growing tips. Lots of roots are more important than lots of leaves. Root development should be sufficient so that potting media does not collapse on removal of

the seedling from the container. Nursery systems should allow for maximum air pruning of roots. Modern nursery tubes are fluted (rather than smooth and round) so that roots are directed downwards (Photo 4). In addition, slots and holes in the sides of the tubes air-prune roots so root-binding does not occur. Seedlings should also be ordered or germinated with enough growing time to be able to meet specifications.

Photo 4. Seedlings should have well developed roots (right) that bind the potting mix together. The seedling on the left has insufficient root development to with stand the rigours of transplantation. These seedlings have been grown in rectangular pots with grooves that help reduce the risk of root spiralling and strangulation that can occur in round pots (tubes).

A good quality seedling should be hardened in the nursery before delivery. Seedlings that are not hardened properly will be set back or killed when transplanted into hot or dry conditions. Hardening involves nutrient starvation for at least one month (so leaves are tough and unpalatable), and exposure to the natural climatic condition out side the shade house for at least one month. Seedlings that have too much lush and fresh growth are actually less preferable than seedlings that look a bit stunted. Seedlings should arrive on-site well watered, disease and pest free, with just a bit of fresh growth (Photo 5). Most nurseries take back the pots to be cleaned and reused, so don't leave them at your planting site.

Photo 5. The seedling on the left is poorly developed whereas the seedling on the right has many active growing tips.

Genetics

It is vital to use the appropriate seed source for revegetation plantings. A local native seed source has traditionally been the rule of thumb (Text Box 1).

Exceptions to 'local is best' include:

- Avoid local native seed sourced from an isolated tree or scattered (fragmented) population. Isolated plants are at risk of self-pollination that can produce seed that is weak and seedlings that grow slowly or have high death rates. Collect seed from the nearest healthy intact population of the species containing at least 100 individuals in close proximity.
- Where there is expected to be a shift in the climate (through climate change) during the life of long lived species such as eucalypt trees. It may be necessary to include in the seed lot seed from lower altitude and drier sites than the local native provenance to take account of climate change.
- Poor quality seed will result in poor revegetation, so make sure it's healthy (Text Box 2). Once collected, conduct viability tests on your seeds so you know the sowing rates needed to germinate sufficient quantities of seed for your restoration plantings. Click here to see the Florabank

Text Box 1

Provenance – where seed should come from

Provenance should be considered in the following manner when collecting seed for revegetation:

Get the taxonomy right first

- Make sure you are dealing with the same species, sub-species, variety or cultivar
- Get the physical and genetic quality right
- Collect from over 100 plants when possible apart

Only collect from large populations or pool multiple collections from smaller populations

Store seed under best conditions from collection right through to use

Match the site condition

- Soil (texture and origin)
- Altitude
- Aspect
- Slope position
- Latitude (use bioregions as the boundary)

web site for some simple techniques.

It is also important to collect seed from the right part of the tree. Seed from the upper outer branches of a tree is more likely to be out-crossed (not inbred) than lower branches. When collecting seed don't destroy or over-collect from a single individual. Collect seed over only a proportion of the tree or shrub.

Record the position of plants, ideally with a GPS reference and keep a copy with the seed. If the seed is sown in a nursery, label the seedlings with the source location too. This information is important for knowing where quality seed (e.g. good survivorship) came from for future collecting.

Getting the most from your seed

When ordering seed from a commercial seed supplier, ask these important questions:

- What is the viability (%) of the seed?
- Where has the seed come from (its provenance)?
- What is the age of the seed and how has it been stored?
- When comparing seed prices, remember that 1 kg of 90% viable seed is worth much more than 1 kg of seed with just 10% viability.
- Old seed may be OK, if it has been stored well. The moisture content of seed is key. Each percentage point decrease in seed moisture content between 15% and 5% **doubles** the life of the seed.

Text Box 2.

STEP 5.

Site preparation

Tropical riparian plantings will only thrive if you've prepared the site well (Photo 6ab). The primary purpose of site preparation is to control competition (weeds and browsing animals).

Photo 6a.

Photo 6b.

Photo 6ab. Weed control may be the most expensive part of a revegetation project particularly when infested with woody weeds such as this site before (a) and after (b) control.

Weed control

Weeds compete with newly established plants for moisture. Many weeds are much more efficient at drawing moisture from the soil than new seedlings, so reduced growth or plant death usually results. Plants which struggle in the first few years of life never reach their full potential or growth rate. Weeds should be controlled in the revegetation area for at least 2 years to ensure the plants are vigorous enough to out-compete weeds (Photo 7).

Treat a tropical riparian planting like a high value crop. Up to five applications of herbicide may be necessary per year to ensure a weed-free site until revegetation plantings can compete:

1. Ideally one month before planting a broad spectrum herbicide to kill existing competitive plants.
2. Follow-up application one month after planting.

Photo 7. These seedlings have been planted in a site with good initial weed control, but control must be maintained until seedlings are well established and above the height of any subsequent weed incursion. Note the rapid incursion of weeds in the background

3. Third spray applied after the first on set of rain to control emerging weeds from seed bank in soil.
4. Forth spray mid wet season when conditions are right for spraying.
5. Fifth spray at the start of the dry season.

Tropical riparian plantings can easily be re-invaded by weeds. The soil seed bank may contain millions of seeds built up over decades of weed growth. Wet season flooding can deposit more weeds seeds from the upper catchment. Hence, monitoring is needed to control weed re-invasions. The risk of weed re-invasion will depend on the weed history of the site, the weediness of the upper catchment and climatic conditions (e.g. regularity of flooding).

It is important for people doing weed control to be skilled and able to identify native versus weed species to avoid damage to native species, especially rare ones. Also, make sure your weed control equipment is appropriate to the size of the job. Backpack sprayers are suitable for spraying small areas or individual weeds, while a spray unit with a tank mounted on a ute or quad bike will be necessary for larger areas. For very large

areas, a boom spray will be more efficient. Consider a weed control contractor for large jobs.

Browse control

Regardless of the quality of weed control for your tropical riparian planting, it will fail if heavily browsed (eaten). Seedlings are particularly attractive to browsing animals and easily killed by them. Your assessment of site conditions (Step 1) should have identified what browsing animals pose a threat (e.g. cattle or feral pigs).

In most situations fencing off the area to be restored is essential. An ordinary stock fence should be sufficient if cattle are the primary concern for browsing on riparian plantings. Fencing out riparian areas will also reduce soil compaction and erosion.

Other then cattle, feral pigs can be a big threat of tropical riparian plantings. Pigs can cause considerable damage to remnant riparian areas and in just one night, an entire planted site can be destroyed by pig furrowing (Photo 8). Feral pigs in some states and territories are a declared pest. This Declaration requires landholders to control pigs on their land (check your relevant state and territory acts).

Photo 8. This planting has been greatly damaged by pigs rooting in the foreground. A pig control program coordinated with neighbours may be needed well in advance of a riparian planting. Pigs preferentially use riparians areas for foraging, drinking water and shade.

To control feral pigs there are three options:

1. Trapping
2. Baiting (1080) and
3. Shooting

A feral pig control strategy should involve four key components:

1. Defining the problem
2. Management plan
3. Implementation
4. Monitoring and elevation

Due to the technical challenges of ethically killing, handling and disposing of feral pigs, it is best to contract out the implementation of your plan to a qualified specialist who specialises in the control of feral animals.

STEP 6

Planting

For broad-scale planting it is most practical to use contractors to do the planting. A single professional planter can plant up to 3000 seedlings a day using a 'Pottiputki' (a steel tube with a trigger release at the bottom; Click here).

The Pottiputki is pushed into the ground, the bottom of the tube is opened and a plant passes down the tube into the ground so the root ball is below the mound surface. The ground is compacted using the feet and the planter moves onto the next placement. Normally seedlings are spaced at 2/3 m within rows giving 1000-1300 stems per hectare.

On soils not suitable for a Pottiputki, shovels, mattock or an auger can be used to dig the holes. Using this method on clay soil can cause the holes to be glazed which will not allow the plant roots to penetrate the surrounding soil. If glazing occurs, the four sides of the holes will need to be scraped using the edge of the shovel creating a XXXX pattern to allow plant roots to penetrate the surrounding soil.

Plantings are usually undertaken late during the dry season (September-November). This will allow plants and the river bank time to stabilise before the wet season begins.

The planting technique for shovels or mattocks is as follows (Figure 2):

- Plant in a hole only slightly deeper than the depth and width of the pot;
- Holes are to be dug sufficiently to allow for wells around each plant for water collection;
- Fertilise with a water crystal based fertilizer on sandy soils;
- Water with a minimum of 10 litres of water immediately after planting and
- Place a weed mat that is biodegradable around each plant

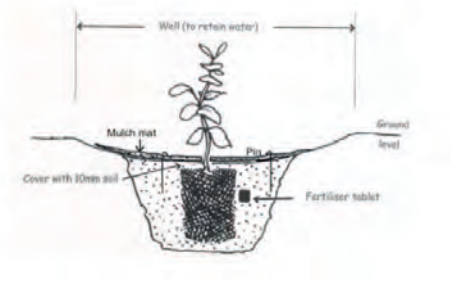

Figure 2. Seedlings should be planted just below the general soil surface in order for a 'well' to be formed to capture additional rainfall. It is also important to cover each seedling with at least 2 cm of local topsoil to prevent the seedling from drying out.

STEP 7.

Maintenance post-planting

Maintenance is crucial for the long term success of any riparian planting. Maintenance should include site monitoring, weed control, and firebreak maintenance. Site maintenance should continue for as long as the revegetation is at risk of weed encroachment and killing fires.

It is important to ensure that whoever is carrying out weed control can distinguish between weeds and native trees, shrubs, and grasses at all growth stages. If the scale of the project allows it, weeding by hand is the best method. Seedlings should be at least 8 cm tall before a non-residual herbicide such as glyphosate mixed at half strength is used within the site. You should take great care to avoid drift or overspray.

If you notice seedlings drooping, wilting or browning watering may be need during prolonged dry spells. However, some plants may show similar signs of stress if the soil is too wet or waterlogged for too long. If this is the case, then soil or surface drainage may be needed – hence the importance of the initial site assessment and preparation steps.

STEP 8.

Monitor to learn and improve

Follow a four-year planting cycle for maximum success, with 2 years of preparation before planting and at least two years of monitoring and maintenance afterwards. Most nurseries require six months' notice to supply trees and shrubs. For difficult-to-propagate species or species not usually grown (such as most ground-layer plants), nurseries are likely to require two years notice.

After planting, the new seedlings are vulnerable to weeds and browsing. They will need to be closely monitored to ensure high survival and good growth. In dry periods supplementary watering may be needed.
Monitoring should record what is done at each step of any planting project (Figure 3).

Monitoring just Outcomes like diversity of tropical riaprian birds makes no sense if few plantings lived (Results). Monitoring of Actions (inputs) is needed to know what plant species were sown and at what density, and with what sorts of site prepartation. If this Action data is not collected and archived, then it's hard to determine what lived versus what died (Results). Monitoring Objectives and Strategies is needed so ten years later Outcomes can be assessed against Objectives. It makes no sense to unfairly judge the habitat quality of a site if the original objective was simply to establish a visual screen with some hardy native trees and shrubs.

Horses for Courses

There are no universally applicable methods for monitoring Outcomes, because that depends on site objectives. There are standard methods for monitoring birds if the site objective is to provide bird habitat, similarly there are methods to assess the reduction in salinity and erosion risks if these are site objectives. Objectives define monitoring. However, the Table below provides a guide to the 'generic' kinds of monitoring data that need to be collected for any type of planting. Such record keeping and measurements should be complemented by photo monitoring (Photo 9ab).

Photo 9a.

Photo 9b.

Photo 9ab. Photos taken from the same place are a simple complement to good record keeping and measurements. Photo-points can capture the rapid improvement in vegetation cover, particularly ground cover, as seen in these photos taken just six months apart.

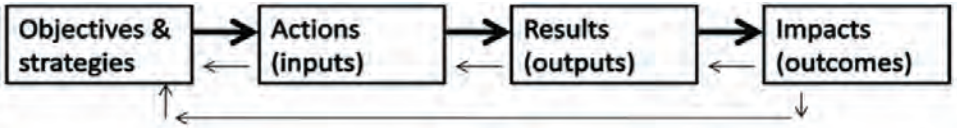

Figure 3. A framework that identifies the multiple points at which monitoring is needed to improve revegetation practices and identify outcomes. The thick arrows indicate the consequences of implementation and the thin arrows indicate key interpretation and learning feedback loops (from Freudenberger 2012).

Table 1. Key monitoring data for revegetation sites (adapted from CSIRO/ABARES research). To download and manage free database (VegTrack) click here.

Data type	Details	Definitions
Site Data		
1. Data record	Unique identifier for the site	The site is the area of the revegetation work for that season
2. Date	Day/Month/Year	Date of primary observation
3. Data source	• Name of observer • Contact details	Data collector's name and contact details including agency or business name
4. Site location	• Nearest Town & State • GPS coordinates for a site access point • Tenure of Site • Owner of land	Google Earth can be used to determine the coordinates (Lat/Long) of an access point like a gate if a GPS is not available.
5. Site area	• Hectares	Google Earth can be used to measure the area of a site
6. Existing land cover	• Describe the pre-planting vegetation cover or type of land use	Include dominant plant species covering the site pre-revegetation
Establishment Data		
7. Revegetation objective(s)	Improvements in: • shade & shelter • wildlife habitat • seed production • riparian health or water quality • soil stability • carbon sequestration • etc.	If more than one objective, specify primary and secondary objectives
8. Funding source and resources invested	• Agency or person supply funding • Dollars spent per site (grant and in-kind) • Hours of labour • Materials (fencing, herbicide, total kg of seed or total number of seedlings)	Include multiple funding sources. Dollars spent includes site preparation, planting and maintenance to date.
9. Site preparation	• Dates • Weed control technique (e.g. glyphospate at X ml/ha) • Soil preparation (e.g. rip and mound, or scalp with direct seeder)	Describe the dates and methods used to prepare the site for planting and/or direct sowing of seeds
10. Species planted or sown	• Species name (Latin binomial) • Seed provenance (source location)	Specify species of seed or seedlings used and where the seed was collected from (when known)
11. Planting or sowing rate	• Kg of seed/ha/species directly sown • Nursery seedlings planted/ha/species	List the planting or seeding rate for each species
12. Revegetation methods	• Direct seeding • Nursery seedlings • Tree guards • Mulches • Watering • Stimulate natural regeneration (e.g. fire or ripping) • etc	Describe what was done to establish more native plants on the site
Monitoring and Maintenance		
13. Monitoring frequency	• None • Occasional-opportunistic • Regular (planned)	If regular, list how often per year
14. Monitoring method(s) for revegetation	• Casual look around • Plots and formal surveys • What measured	Describe the method(s) used to monitor the status or health of the planting
15. Revegetation monitoring results	• Date • Names (Latin binomial) of surviving species • % of species planted that have survived • Density of surviving species (number/ha) • % of seedlings planted still surviving • General health or vigour of the reveg • Species of weed • Cover of weeds (e.g. low, medium, high)	Describes and quantify the success rate (results) of the revegetation at this site
16. Site Management	• Date • Observed threats to the revegetation • Management activity • Effectiveness	Lists management activities on the site post revegetation (e.g. weed and pest control) and describe how well they worked
17. Methods to measure outcomes	• None • Bird surveys • Habitat Hectares • Carbon sequestration • Salinity • etc	Describe methods used to measure or estimate the outcomes of the planting. Outcomes are the consequences or environmental ***impacts*** of the revegetation.
18. Results of outcomes monitoring	• Date • Survey or observational data	What found and what it means
19. Other observations/notes	• Date • Text or data	Other observations conducted at the site

Further Reading

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Robbins, L. (2002). Managing Riparian Land and Trees for Multiple Uses. RIRDC

Further Assistance

For further assistance or advice we suggest you try contacting:

Greening Australia
ph 1300 886 589
or find us on our web page

Your Regional NRM (catchment) Organisation

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