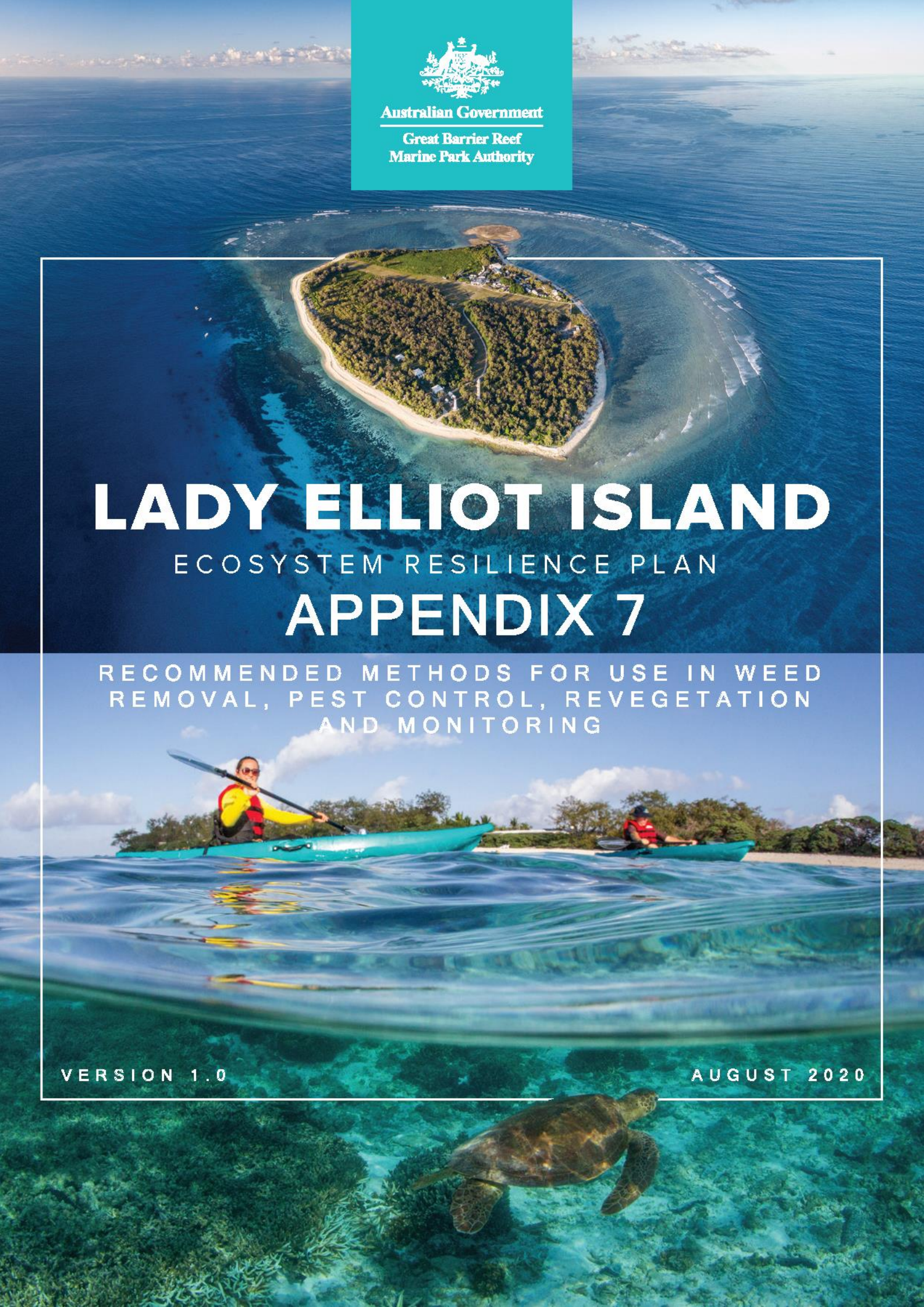

Australian Government
Great Barrier Reef Marine Park Authority

LADY ELLIOT ISLAND

ECOSYSTEM RESILIENCE PLAN

APPENDIX 7

RECOMMENDED METHODS FOR USE IN WEED REMOVAL, PEST CONTROL, REVEGETATION AND MONITORING

VERSION 1.0

AUGUST 2020

LADY ELLIOT ISLAND
ECOSYSTEM RESILIENCE PLAN

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1. INTRODUCTION

This appendix is part of the Lady Elliot Island Ecosystem Resilience Plan (the Plan). It details the recommended practical methods for pest plant removal, native cay plant species propagation and planting, invertebrate pest management, and monitoring to assess ecological restoration progress. Methods not recommended for use in specific circumstances are also included. Methods are based on the knowledge, experiences and lessons learned during the restoration and pest plant control work carried out on other Great Barrier Reef islands and cays.

In general, it is recommended that small-scale trials to assess the effectiveness and practicality of these and other methods and their suitability for use on Lady Elliot Island (LEI) (or other islands) are carried out prior to island-wide application.

This document will be available electronically only. The technical experts in the LEI Project Team will regularly update this document to ensure the information is contemporary and contains best-practice management techniques for practitioners of re-vegetation and island/cay restoration programs.

2. PEST PLANT ERADICATION/CONTROL

Keep use of herbicides to a minimum. Herbicides including surfactants and marker dyes only to be used if alternative methods prove unsuccessful. On LEI only use herbicides authorised by the LEI Project Team, who will obtain expert advice where required.

The use of herbicides that could potentially harm marine ecosystems must be managed to ensure there is no harm to the marine environment. This is particularly important in the sensitive environment of the Great Barrier Reef World Heritage Area. Some herbicides are also detrimental to human health if not used correctly. Care must be taken when storing, mixing and using all herbicides. To avoid detrimental impacts on soil chemistry and microbiota, literature research should be undertaken to identify potential adverse outcomes and recommended methods of application.

All herbicides should be used strictly in accordance with the manufacturer's directions and material safety data sheets. All Standard Operating Procedures to be adhered to which includes maintaining records of chemical application.

2.1. SYSTEMIC HERBICIDES

Glyphosate present as isopropylamine salt (e.g. Glyphosate ® 360) has been used on Capricorn Bunker cays for long periods to spray and kill pest plants. It is used by Queensland Parks and Wildlife Service (QPWS) staff with added spray marker dye to indicate which areas have been sprayed. Wick application should be used at the manufacturer's recommended concentration. This process can also be used to ensure application is only to target pest plants without spraying surface soil. Glyphosate has been used at 1:2 dilution for killing plants, including morning glory (*Ipomoea indica*), using the cut stump method. It is important when using this method to apply the glyphosate to the cut stump immediately following cutting as the cut surface of most plant species seals off very quickly. Glyphosate is most effective when applied to healthy plants in an active growth stage and may not be effective under drought conditions. Glyphosate is commercially available with or without added surfactant.

Glyphosate has been found to be ineffective in killing mature dwarf poinsettia (*Euphorbia cyathophora*).

The selective herbicide, 2,4-D present as the dimethylamine and diethanolamine salts (e.g. Amicide ®625) has been successfully used as a foliar spot spray by QPWS to kill regrowth morning glory on Lady Musgrave Island.

This chemical has the advantage of not killing native grasses.

2.2. NON-SYSTEMIC HERBICIDES

Slasher (nonanoic/pelargonic acid), an organically certified non-systemic herbicide, has been used successfully by QPWS staff to treat dwarf poinsettia (*Euphorbia cyathophora*) on Wilson Island and has been successful in killing young plants of crow's foot grass (*Eleusine indica)* on Lady Musgrave Island.

Other non-systemic herbicides available commercially include Weed Blitz (pine oil), Weed Zap (clove oil, cinnamon oil, cottonseed oil, oleic acid, lauric acid, inert ingredients: lactose and water) and Richgro Beat-a-Weed weed killer (acetic acid plus salt). Some of these are organically certified. Currently, the effectiveness and suitability of these other products for use on the cays is not known.

As native cay species have evolved in salt laden environments, they generally have better natural salt tolerance than introduced pest plant species. Various concentrations of salt (sodium chloride) including seawater or concentrated saline waste-water from the desalination plant as well as more dilute concentrations should be

tested on a range of herbaceous native as well as pest plant species to determine whether there is an optimum concentration of salt that will kill pest plants but not native species.

It is important to avoid excessive use of saltwater over large areas as this is likely to have detrimental effects on soil chemistry and microbiota. It may also result in increased salinity of the underground fresh water lens if very large amounts are used.

2.3. PHYSICAL METHODS

2.3.1. HAND PULLING

This is the preferred method for the first pass removal of most herbaceous pest plants and for the removal of herbaceous pest plants in areas where desired native cay species are growing.

2.3.2. MACHINERY

Lantana and large succulents have been successfully removed using machinery on LEI, which avoids the use of chemicals.

2.3.3. BRUSH CUTTING OR SLASHING

Brush cutting or slashing has been found to initially suppress dwarf poinsettia (*Euphorbia cyathophora*) and favour native grass and vine species immediately following slashing on LEI.

Routine brush cutting or slashing is not recommended, however, for pest plant control in the natural area zones as there is a high risk of spreading the pest plants from seeds adhering to the equipment and machinery. Repeated brush cutting or slashing is also detrimental to the longer-term survival of native vines, shrubs and some native herbaceous species and results in the eventual dominance by non-native grasses such as Mossman River grass (*Cenchrus echinatus*), crow's foot grass (*Eleusine indica*), signal grass (*Urochloa subquadripara*), couch (*Cynodon dactylon*) and love grass (*Eragrostis* spp.). Another disadvantage of brush cutting and slashing is that cut plants form a mulch on the ground that inhibits natural regeneration of native species and is likely to contain viable seeds attached to cut pest plants.

2.3.4. STEAM

Various types of steam weeders are commercially available. This method is only suitable for herbaceous pest plants. Steam is likely to be most effective in killing pest plants in vegetation-free areas such as tracks, airstrips and nursery areas. It may also, however, be a useful way of treating small accessible areas with large numbers of germinated regrowth seedlings following mass germination in areas where desired native species are absent. The manufacturers of steam weeders claim that steam also kills the seeds of many pest plant species attached to standing plants and those present on the ground surface.

Trials on LEI have found that steaming is very slow. An average of 10 seconds exposure is required for each weed seedling (varies with species). It also requires large amounts of water and fuel and is only effective on relatively flat ground. Hot water run off can also kill new plantings if steam is applied in the vicinity of their root zones. Site accessibility can also be an issue as the steamer has to be transported on the back of a truck or other suitable machinery.

The use of steam should be restricted to a brief surface application of saturated steam as soil injection or slow application can increase soil temperature, which will kill beneficial soil microbes, fungi and insects.

The planting of grass tufts or runners from turf farms into the steam-treated soil will ensure the re-inoculation of soil microbes as these will be present in the soil adhering to the grass roots. The re-inoculation of the surface soil will also occur from the subsurface soil as saturated steam application is reported to only heat the top 5 cm of soil.

A range of equipment is available and these may vary in their effectiveness depending on the model used.

2.3.5. FLAME

A range of weed burners are commercially available. These should not be used during dry periods when fire is a risk. A range of equipment is available and these may vary in their effectiveness depending on the model used.

2.3.6. HESSIAN SHEETING

Prickly seeds of pest species such as Mossman River grass (*Cenchrus echinatus*), cobbler's pegs (*Bidens pilosa*) and possibly kaki weed (*Alternanthera pungens*) can be removed by either dragging hessian (or other suitable material) across the top of weed plants or spreading and rubbing hessian sheeting (or similar material) over the

ground. The seeds adhere to the hessian, which can then be bundled up, bagged and disposed of. This method could also be useful for mopping up seeds in areas of bare soil following the first pass removal of these pest plants.

2.3.7. ORGANIC OR SAND MULCH AND PLASTIC

Mulching with paper, cardboard and seed-free mulched woody plant material and the use of black or transparent plastic are effective ways of suppressing pest plant establishment and regrowth in some situations.

Organic or sand mulch may be more effective where vegetation cover is required because the desired plants can be planted in the mulch (e.g. small landscaped areas) or in vegetation-free areas where the use of plastic is not appropriate (e.g. walking tracks). If immediate planting in mulch is to be undertaken, partially composted mulch rather than fresh mulch or chip should be used.

Organic mulch may need to be reapplied periodically as it decomposes quickly. Plastic must be in place for long enough to kill the existing plants and all seeds in the seedbank before removal. Heat from composting and sunlight will speed up this process, particularly under the plastic.

The disadvantage of these methods is that they also prevent the natural establishment of native plants and should not be used for herbaceous pest plant control in the North-East or the North-West Zones of LEI, where rapid establishment of desired native species is the objective, particularly where these native species are present in the soil seedbank.

Other disadvantages of plastic are the need to weigh down the edges to prevent it blowing away and prevent pest plants from growing out from the edges and the need to remove it after pest plants and their seedbanks are no longer present.

A small persistent isolated patch of crow's foot grass (*Eleusine indica*) was successfully eradicated on Lady Musgrave Island by covering the plants with 150 mm of sand taken from the high tide area of an adjacent sandy beach. Native cay grasses were immediately planted in this sand. The grasses were successfully established without the need to first leach out the salt. Although this was successful, it is not desirable to remove quantities of sand from the beaches and, for this reason and the others mentioned above, this method is not suited for general use in herbaceous pest plant control in the natural use zones on LEI.

2.4. NATIVE PLANT COVER TO CONTROL PEST SPECIES INVASION

Bare ground is particularly vulnerable to invasion by pest plants. Maintaining a native plant cover is a very effective way of controlling pest plants. During the Lady Musgrave Restoration Project, transplanting native grasses was found to be particularly effective in suppressing pest plant establishment. On Tryon Island, the establishment and growth of planted pisonia cuttings resulted in total weed exclusion as soon as canopy closure had been achieved with no follow-up weeding carried out during this project.

As the eradication/control of pest plant species and the establishment of native cay species are both major objectives of the Plan, establishing suitable native species as soon as possible following the initial pest plant removal will effectively assist in achieving both these objectives.

2.5. INDICATOR TRIALS FOR MANAGING PEST PLANTS

Small indicator trials are recommended to determine the most effective and environmentally friendly methods and products to control the range of pest plant species as well as test different techniques for the successful establishment of the desired native cay plant species on LEI. These trials will allow broad-scale work to proceed with confidence and provide the required knowledge to more accurately coordinate work and predict costs, labour requirement and timeframes.

The trials should be undertaken as soon as possible. Summer trials of revegetation methods are desirable as this is the period when the greatest problems and benefits will be seen.

2.5.1. HAND PULLING

Trial plots containing difficult species such as morning glory (*Ipomoea indica*), corkystem passion flower (*Passiflora pallida*), green panic (*Megathyrsus maximus* var. *pubiglumis*) and Mossman River grass (*Cenchrus echinatus*) should be marked out and hand weeded as soon as possible to determine:

- whether these can be removed without removing or cutting back native vines
- how much regrowth to expect
- the number of regrowth control cycles required
- whether eradication is achievable by hand pulling or not.

Hand pulling of other pest plants, particularly dwarf poinsettia, at the same time in these same plots will also give an indication of:

- how much regrowth to expect
- how many cycles of regrowth control are required before minimum maintenance control is achieved for each species
- whether other pest plant species, previously absent from the site, are likely to establish and spread before the desired natives are established.

2.5.2. CHEMICALS

Selected methods and products for pest plant control included in Section **Error! Reference source not found.** should be tested on a range of pest plant species during different growth stages (e.g. seed, seedling, semi-mature and mature plants) to assess their effectiveness including whether repeated applications are required and if surfactants are required and, if so, which is the most effective.

Where considered appropriate, the effect on subsequent growth or germination of desirable species should also be tested.

2.5.3. MULCH

Trials on the use of mulch will indicate: success or otherwise in suppressing pest plants; success or otherwise of planting in mulch; effect on natural regeneration of natives, particularly grasses.

2.5.4. STEAM AND FLAME

Small trials should be carried out to determine the optimum application time to achieve the killing of pest plants without overheating the subsurface soil.

These methods should be trialled on herbaceous pest plants at seed, seedling, semi-mature and mature growth stages to determine their effectiveness on each species.

2.5.5. WATER

The following should be trialled:

- hand pulling under a range of watering regimes (to simulate variation in rainfall) to provide some indication of the frequency of follow-up weeding that is necessary. This will also give some indication of whether regrowth is likely to advance to the seeding stage during wet and dry bird nesting seasons
- use of watering to speed up germination of pest plant seeds in the seedbank to decrease the time taken for the eradication of target species such as green panic (*Megathyrsus maximus* var. *pubiglumis*).

2.5.6. BRUSH CUTTING

These trials will:

- indicate whether brush cutting can be used to suppress pest plants sufficiently to allow grass growth before final removal of pest plants by hand pulling
- indicate whether re-sprouting occurs (pest plants and/or natives)
- determine optimum cutting heights
- indicate how many cycles of brush cutting can be carried out before undesirable pest plants dominate and/or desirable natives are eliminated.

It is essential that equipment is thoroughly washed down and is free of pest plant seeds.

2.6. ERADICATION OF LANTANA

Most of the lantana on LEI is present as dense impenetrable thickets approximately 1.5 to 2 m high. Some of these thickets are situated on rock piles or rocky ridges.

The eradication methods described below have the advantage of avoiding the use of chemicals, although occasionally very large stumps may prove too difficult to remove and may have to be left in the ground and killed with concentrated glyphosate using the cut stump method. Methods described in Subsections 2.6.3 and 2.6.4 leave the stump in the soil and avoid soil disturbance, thus minimising lantana regrowth and the establishment of other pest plant species. As they include the use of systemic herbicides, they should only be used on LEI if other methods are unsuccessful.

After initial treatment of the lantana by the contractors, the ecosystem management officer (EMO) should then be able to ensure its eradication from the island by regular, systematic follow-up control of any reshooting or newly establishing plants. This follow-up is extremely important to maintain manageable regrowth control.

Lantana removal cannot be undertaken during the bird nesting season. In the South-West Zone, pisonia should be planted as soon as possible following lantana removal. In the North-East and North-West Zones, lantana regrowth and other pest plants should be removed as soon as possible after the bird nesting season and the desired species planted in time for their establishment prior to the next bird nesting season.

The following methods can be used for the initial removal of lantana.

2.6.1. METHOD USED DURING INITIAL WORK ON LADY ELLIOT ISLAND

- Lantana plants were pushed out of the ground using a fork attached to the front of a loader or other suitable heavy machinery; the fork was then lifted to pull all roots out of the ground
- Pulled lantana plants were transferred to piles in the Composting and Waste Management Precincts
- Piled-up plants were run over with the loader
- The pile was periodically turned using machinery to prevent seedling establishment and assist composting
- When the pile was sufficiently composted, it was mixed with general compost piles.

2.6.2. METHOD USED BY QPWS CONTRACTORS

- Lantana plants were first flattened by driving over them with machinery
- Plants were then pulled out of the ground using machinery with a fork attachment
- Remaining plants still rooted in the ground were pulled out, either by hand or using machinery
- The plants were then reduced to manageable sized pieces using a brush cutter and piled into windrows
- The windrows were slashed with a large wide slasher to create mulch
- Mulch was spread over the area from which lantana had been removed to minimise regrowth, assist soil development and provide nutrients for planted pisonia.

In 2014, 1 ha of lantana was completely reduced to mulch in 3 days using this method (2 contractors × 10 hours and machinery operator 2 hours per day).

2.6.3. USE OF HEAVY-DUTY BRUSH CUTTERS OR SUITABLE HAND LOPPERS

The following method was successfully used by QPWS staff to clear similar impenetrable lantana thickets on Hinchinbrook Island using heavy-duty brush cutters (pers. comm. Ben Geddes, QPWS). Working in teams of two, one operator cuts through the lantana thicket until the base of the main trunk is exposed and the second operator then immediately applies concentrated glyphosate to the cut stump.

On Hinchinbrook Island, it took 50 people days to clear approximately 7.5ha of lantana and achieve an almost 100 per cent kill rate. A variation of this method is to use machinery with specialised mulching heads instead of brush cutters or hand loppers to cut through the lantana to expose the rooted stump.

2.6.4. USE OF SPLATTER GUN

Manual drench guns or gas-powered set-ups are commercially available. The lantana must be healthy and actively growing for this method to be effective and therefore this method cannot be used during dry conditions.

The procedure is as follows:

- Create paths through the lantana to provide access; splatter guns generally have a range of 6 to 10m
- A marker dye is recommended to identify splattered bushes, particularly if working in a team
- Apply approximately 15 to 20 mL of herbicide mix per splatter on large bushes to achieve the registered rate of 2 × 2 mL per 0.5 m of bush height. Arch the spray over the top of the bush and down the front face; if treating dense lantana, apply one splatter every two strides, with an occasional horizontal pass low across the front edge of the bushes to treat any seedlings
- Once the lantana plants have died, they will need to be removed or cut down to the stump before other plant removal or planting of desired species is undertaken.

2.7. REMOVAL AND DISPOSAL OF LARGE TREE SPECIES

Umbrella tree (*Schefflera actinophylla*), hoop pine (*Araucaria cunninghamii*), Norfolk Island pine (*Araucaria heterophylla*) and most other large tree species will need to be removed by cutting through the trunks with a chain saw as close as possible to ground level followed immediately by the application of concentrated glyphosate to the cut stump. All waste material should be put through the chipper and used as mulch or composted. It should be possible to remove paw paws using machinery to pull the entire plants (including roots) out of the ground with no need for follow-up chemical application. Seeds of umbrella trees should be removed prior to mulching.

It is unlikely that senescing casuarina will require cut stump treatment as they will probably not reshoot.

2.8. REMOVAL AND DISPOSAL OF LARGE SUCCULENTS

Dragon fruit (*Hylocereus undatus*), mother in law's tongue (*Agave* spp., *Sansevieria trifasciata* var. *trifasciata*), basket plant (*Callisia* sp.) and other large succulents produce large volumes of waste for removal. This waste is unsuitable for immediate mulching and requires drying prior to further processing. Initial removal trials of these species on LEI have had good results by placing the removed plants into large piles and repeatedly driving over these piles with a heavy loader. The waste is then left on the ground to dry until it has reduced in volume and can be either deeply buried (e.g. *Agave* spp.) or incorporated into the compost (e.g. dragon fruit). Piles may require turning and repeated crushing to further reduce volume. Flowering stalks of century plant (*Agave americana*) and sisal hemp (*Agave sisalana*) on the ground need to be carefully separated from the main plant prior to removal and any small buds forming on the stalk should be removed and deeply buried.

Because of the large volumes of waste generated and the need for specialised processing, large succulents need to be removed and processed ahead of other restoration work at sites where they are present.

2.9. REMOVAL AND DISPOSAL OF BRYOPHYLLUM SPP.

Plants of mother of millions (*Bryophyllum delagoense*) and resurrection plant (*Bryophyllum pinnatum*) are very invasive and difficult to eradicate. They must be carefully removed in their entirety as new plants can establish from small amounts of plant material. It is particularly important not to shake the plants as they are being removed or to leave pulled plants on the ground but to dispose of them carefully by deep burying or bagging them followed by removal from the island. Staff, contractors and volunteers must be given this information and trained before undertaking removal of these species.

Trials on LEI have found steaming to be effective in killing mother of millions.

2.10. ERADICATION OF NUT GRASS

Infestations of nut grass (*Cyperus rotundus*) on LEI are currently isolated to a few areas. It is important to eradicate these quickly before they spread throughout the island. Nut grass produces chains of six or more small tubers ('nuts') along its roots. New plants grow from these as well as from seeds. These tubers are very difficult to remove without breaking the roots. Dormant tubers can commonly persist in the soil for 3 to 4 years, but remain viable for up to 10 years in ideal conditions.

Hand weeding is not recommended as it is virtually impossible to remove all plants without breaking the fine roots above some tubers. Breaking the tuber chains and encouraging otherwise dormant tubers to sprout will make eradication even more difficult.

Trials on LEI have found steaming is not effective in the control of nut grass.

Transparent mulch films may suppress nut grass to a greater extent than the commonly used black plastic films because the emerging shoots open their leaves in response to light but become soft and unable to penetrate the mulch due to the higher temperature and humidity compared with fully opaque films.

While solarisation may be effective for short-term control to reduce competition with agricultural crops, it is highly unlikely that nut grass will be totally eradicated without the use of systemic chemicals such as glyphosate or Sempra. It is recommended that literature searches be carried out and expert opinion obtained to identify a suitable control agent that can be safely used in the cay environment.

2.11. REMOVAL OF HERBACEOUS PEST PLANTS FROM NORTH-EAST AND NORTH-WEST ZONES

This will involve a large amount of work over a long period by the EMO and will require the regular assistance of additional workers.

Indicator trials should be undertaken as early as possible to determine effective methods for eradication or control of pest plants and for the propagation and establishment of desired native cay species.

Hand-pulled herbaceous pest plants should not be left on the ground. As they may contain viable seed (unripe seed can continue to mature on the pulled plant), they may take root and continue to grow (in wet conditions) and act as a mulch that delays germination of both desired native species and pest plant seeds present in the soil seedbank. Rapid germination of the soil seedbank of pest plants is desirable to hasten the process of the replacement of pest plants with native species. Hand-pulled pest plants should instead be placed into woven fertiliser bags and taken to the Composting and Waste Management Precincts to be converted to compost. Some species should be deeply buried rather than composted (refer to following sections).

2.11.1. WEED HYGIENE

It is extremely important to introduce biosecurity measures to prevent the accidental introduction of invasive pest plants such as khaki weed (*Alternanthera pungens*), Mossman River grass (*Cenchrus echinatus*), crow's foot

grass (*Eleusine indica*) and other pest plant species via machinery and human movement through the restoration areas in these zones.

2.11.2. REMOVAL AHEAD OF GENERAL FIRST PASS WEEDING

There is a high likelihood that green panic, red natal grass (*Melinis repens*) and Mossman River grass will establish and spread quickly into newly weeded bare areas following the removal of dwarf poinsettia and lantana. The former two will spread via windblown seed and the latter by adhering to bird feathers, human clothing and equipment. Therefore, it is important to remove these (eradicate if possible) in and adjacent to the North-East and North-West Zones ahead of general first pass weeding.

2.11.3. INITIAL STAGES OF PEST PLANT MANAGEMENT

Hand pulling is the recommended method for first pass removal of herbaceous pest plant species from these zones as plants are mature and easy to pull out of the shallow substrate.

In the North-East and North-West Zones, pest plants will be best removed by initially working on small manageable areas, starting on the windward side to minimise re-infestation by windblown seeds. It is best to start from an area that already has a good diversity and cover of native species. This will allow the natives to spread naturally into newly available ground as pest plants are removed from the adjoining areas. As weeding progresses, the general approach should be to extend the weeded area from the edges of the previously weeded areas, minimising the edge to area ratio of the weeded areas and progressing at a rate compatible with the ability to manage follow-up weeding.

It is important during follow-up weeding not to let regrowth pest plants reach seeding stage. If pest plants can be prevented from seeding, this will eventually result in the elimination of pest plant seeds from the seedbank. It is also important to prevent the vegetative spread of pest plants. Therefore, regular weeding events and the timing of these is very important. Follow-up weeding must also be timed to avoid disturbance to birds during nesting season.

As the number of pest plants decreases and the cover of native species increases, increasingly larger areas will be able to be weeded and managed until eventually pest plants in the entire North-East and North-West Zones can be controlled by the EMO and regular teams of volunteers.

If hand pulling alone cannot achieve the desired outcome, or is too labour intensive in the indicator trials, the following method that proved successful on Lady Musgrave Island using a mixture of spraying and hand weeding is recommended.

Where no native cay species are present, pest plant regrowth should be sprayed with herbicide as soon as possible following germination, Herbicide application may be required for two of three germination cycles to deplete the weed seed bank prior to transplanting runners of the native grasses, spreading seeds and planting seedlings of other desired native species as recommended in the Plan. Marker dye should be used to ensure that the target pest plants are all sprayed and are not sprayed more than once. Spraying should be reduced and ultimately ceased as native species establish in these areas, to ensure the desired native species are not killed.

Where native cay species are present, herbicides that may kill non-target native species should not be used. All pest plant species should be selectively hand-pulled and the native cay species left to grow and spread. By repeated selective weeding in this way, the natives will regain dominance as they will no longer have to compete with pest plants for light, water, nutrients and space. It is essential to carry out follow-up selective weeding before the pest plant species have a chance to re-seed. In this way, the seedbank of the pest plants will slowly be depleted over time and the ratio of natives to pest plants will increasingly favour the native species. Experience on Lady Musgrave Island is that follow-up weeding is required at least every 3 months. More frequent weeding may be required during warm wet weather. In the last weeding prior to the bird nesting season and during the early regrowth phases, all emergent pest plants must be removed, including the smallest seedlings, to minimise pest plant growth during the bird season. Dominance by natives can be accelerated by seeding and supplementary planting of native species.

2.11.4. ROPE TRANSECT METHOD FOR SYSTEMATIC LONGER-TERM FOLLOW-UP WEEDING

Once the area being weeded has a significant density of native species, it is difficult to see which areas have already been weeded. To avoid missing areas during weeding and covering the same area more than once, weeding is best carried out using the following rope transect method (Brushe in prep).

Ropes are laid out across the entire width of the patch to be weeded to form transects. The width of the roped transects depends on the number of weeders, the density and height of the vegetation and the effort required to move through it. On Lady Musgrave Island, the most effective width has been approximately 2 m per weeder during the early stages of regrowth control with not more than five weeders giving a maximum transect width of approximately 10m.

Two or more ropes should be initially laid out (depending on whether there are one or more groups of weeders). Weeders move systematically along the transect, keeping in line with each other and moving across to assist other weeders as required so that everyone progresses along the transect together. When each transect is completed, the weeders then work back along the transect in the opposite direction pulling out any pest plants that were missed on the first pass. This second pass from the opposite direction does not take long and has been found to be worthwhile, particularly where taller native vegetation is present as it allows a view of the ground from a different angle, resulting in the detection of pest plant plants that were not easily visible from the opposite direction. Weeders change positions in the reverse transect, so that each weeder covers a different transect to the one they weeded on the forward pass.

2.12. ERADICATION OF MORNING GLORY AND CORKYSTEM PASSION FLOWER

Morning glory (*Ipomoea indica*) and corkystem passion flower (*Passiflora pallida*) have extensive fleshy root systems that are easily broken off during hand weeding. Care must be taken to remove as much of the roots as possible. Even when care is taken, roots are often unavoidably broken off and reshooting is very likely to occur from these. Follow-up hand pulling of these reshoots must be done as soon as possible so that further root development does not occur. After several follow-up hand pulling events, it may be necessary to treat the last of the persistent retained roots by the application of systemic herbicide via the cut stump method.

If morning glory or corkystem passion flower are tangled up with the desired native vines e.g. coastal jack bean (*Canavalia rosea*) or goat's foot convolvulus (*Ipomoea pes-caprae*), the long trailers of the native vines should be cut off close to the main stem approximately 30 cm from the roots to avoid accidentally pulling them out with the pest plants. This also allows better access to the target pest plants and minimises breaking off the roots and stems as they are pulled out.

The 'roll up' technique was used on Lady Musgrave Island for the initial removal of morning glory followed by regular follow-up removal of any reshooting plants until the species was eradicated (Figure 1). The rolling technique can only be used in areas where native species are absent and the area is densely covered by morning glory.

Areas totally dominated by morning glory are isolated by weeding a cleared boundary around each discrete area. All pest plants in the isolated patch are then completely removed from each area by forming a line of people along one edge of the isolated patch. Hand pulling is used to start a roll, which is then rolled across the area as roots and tubers are pulled out from immediately behind the rolled-up mat. Rolling continues until the roll reaches the opposite edge of the patch.

Hand pulling will be effective in removing seedlings and some reshooting tubers. Tubers that are located among rocks that cannot be hand-pulled may require treatment using the cut stump method with concentrated glyphosate or a suitable alternative herbicide to kill the tubers.

Figure 1: Roll-up technique used on Lady Musgrave Island. Morning glory (*Ipomoea indica)* ready to be rolled with edges cleared (top left). Volunteers rolling up the mat, pulling up tubers as they go (top right). Removal completed with mat rolled past the cleared edge (bottom left) (photographs M. Hallam)

2.13. ERADICATION OF GREEN PANIC AND RED NATAL GRASS

Green panic (*Megathyrsus maximus var. pubiglumis*) and red natal grass (*Melinis repens*) are wind dispersed and will quickly colonise bare areas of soil where there is no canopy cover to shade them out. It is important to eradicate small infestations (such as the recent introduction of buffel grass) before they spread. Existing infestations in or adjacent to the North-East and North-West Zones should be eradicated prior to first pass weeding in their vicinity. It may be worthwhile to cut off the seed heads before either pulling or spraying the plant to prevent seed spread. Seeds that have been removed should be transported and disposed of carefully to prevent their spread.

The following methods have been used successfully to eradicate these species:

- Completely covering the infestation area with black plastic after hand pulling. The black plastic should be kept in place by weighting down the entire edge. This also prevents regrowth from growing out from under the plastic. The plastic should be left in place for at least 12 months and the surrounding area checked regularly during this time to ensure no seeds have germinated outside the black plastic. If any are found, these must be removed before they produce seeds. This method has been used successfully in the Composting and Waste Management Precinct. However, it is not practical for large infestations and is not recommended for use in the North-East and North-West Zones as it will kill all native species that germinate and may eliminate the native seedbank in the soil under the plastic.
- QPWS staff have successfully eradicated this species by flattening the plant using protective footwear and spraying the base of the plant using 1:3 glyphosate mixed with a wetting agent and marker dye. Regrowth usually occurs very quickly and follow-up removal prior to further seeding is required a few times before the infestation is eradicated completely. Young re-growing plants were then killed by spraying with 2 to 3 per cent glyphosate (pers. comm. Ben Geddes, QPWS).

2.14. REMOVAL OF MOSSMAN RIVER GRASS AND KHAKI WEED

It is recommended that an initial pass to remove Mossman River grass (*Cenchrus echinatus*) and khaki weed (*Alternanthera pungens*) be undertaken immediately prior to first pass general removal of herbaceous pest plants to avoid spreading seeds of these species. Plants should be deeply buried and not composted. It is also important to keep tracks and mown areas free of these species to avoid further spread. Machinery and other vehicles should never be driven through revegetated areas that are free of these species.

3. BIOSECURITY AND WEED HYGIENE

3.1. PREVENTING THE INTRODUCTION OF PEST PLANTS AND DISEASES

Any machinery or equipment brought to the island should be very thoroughly cleaned on the mainland and inspected for seeds or dirt particles to make sure no new pest plants or diseases are brought to the island. Shoes, backpacks and other items used by contractors and volunteers should also be clean.

Currently, most of the North-East Zone is totally dominated by painted spurge, which is effectively excluding other pest plants or keeping their abundance low. The tracks, airstrip edges and most other regularly mown areas throughout the island are infested with khaki weed, Mossman River grass, crow's foot grass and other pest plants that are likely to invade the North-East and North-West Zones while the ground is relatively bare following first pass weeding. Therefore, the following procedures must be implemented to avoid inadvertently bringing pest plants into these areas on clothes, shoes, equipment or machinery:

- Prohibit entry of vehicles and machinery into revegetation areas unless absolutely necessary
- Thoroughly wash down any equipment or machinery entering these areas that have been used in areas infested with pest plants prior to entry into the restoration areas
- Work progressively and systematically from the edges of previously weeded areas into new areas
- Enter 'clean' work areas via 'clean' areas. Mown areas and paths contain a variety of pest plants including those with seeds that are readily transported by people and machinery. Consequently, clean access points to work areas will need to be created
- Exit 'unclean' work areas via 'unclean' areas
- Ensure this strategy is maintained by having a limited number of defined entry and exit paths into work areas
- Establish buffer strips of native grasses along mown edges adjacent to the North-East and North-West Zones
- Maintain low mowing height in existing mown areas, particularly in the vicinity of work area access points
- Establish a 'deseeding' station at the entry point to clean work areas where people can check their clothing and equipment and dispose of any seeds into designated containers. The ground at this deseeding station needs to be able to be maintained as clean, preferably by covering the ground with a membrane such as conveyor belting or something similar

- Start first pass removal from the windward South-East edge, extending the worked areas progressively downwind
- Allow no vehicle access into the North-East Zone except where absolutely necessary, e.g. lantana removal and never through previously weeded areas
- Document biosecurity procedures and make clear to all staff and contractors who need to access these zones. Other staff and guests should be prohibited from entry to areas under restoration
- Eradicate isolated patches of highly invasive pest plants that are likely to establish and spread into newly weeded areas e.g. green panic and red natal grass before first pass weeding is undertaken in areas adjacent to these patches
- Install barriers and signage, where required, to prevent unauthorised entry to restoration areas
- Maintain the plant nursery area free of pest plants by regular use of a steamer and hand weeding. Remove any pest plants that germinate in potting mix and potted plant pots before they seed
- Maintain the turf farms free of pest plants by regularly hand weeding, ensuring that pest plants are removed prior to seeding

3.2. DISPOSAL OF HAND-PULLED PEST PLANTS AND GARDEN WASTE

As a rule, pest plants should not be dropped on the ground where they are pulled as many pest plants can re-sprout and take root. Seeds (including immature seeds) on pulled pest plants can continue to mature, germinate and grow.

Where possible, the following method should be used:

- Each weeder carries a woven fertiliser bag and places pest plants into the bag as they are pulled
- Seeds on large cobbler's pegs and other species that readily drop large quantities of seeds should be carefully cut off and bagged before the plant is pulled to avoid shaking seed out on the ground
- Bagged pest plants should be deposited into nearby skips for disposal at the Composting and Waste Management Precinct or taken directly to the Composting and Waste Management Precinct.

During first pass weeding, it is likely that there will be large volumes of hand-pulled pest plants and it will be impractical to bag them. In this situation, large handfuls of weeds can be placed directly into the bins. As the walking distance to the bins increases, it will be more efficient to make an intermediate stockpile that is later transported to the bins.

All landscaping and garden waste should also be taken to the Composting or Waste Management Precincts.

Any waste plant material with fruit or seeds should be composted under secured black plastic to prevent spread to natural areas by wind dispersal, ingestion by birds or by seeds or fruit adhering to birds' feathers.

To ensure no further spreading, species such as mother of millions, resurrection plant, Mossman River grass and khaki weed should not be composted. These species should be deep buried in the Waste Management or Composting Precincts.

4. PLANT NURSERY

Establishing a plant propagation nursery is one of the first priorities for the implementation of a revegetation plan.

4.1. POTTING MIXES

All potting mix ingredients should be sourced from LEI to prevent accidental introduction of pest plants, pest insects, harmful soil biota and plant diseases. As relatively small quantities or sand are required, this could be sourced from the beach (further discussion required with staff from the Great Barrier Reef Marine Park Authority and QPWS). Sand should be washed to remove salt prior to adding to potting mixes. Mulch and compost for use in potting mixes should be prepared in the Waste Management or Composting Precincts. Mulching/chipping of pest trees will be a good source of compost and wood chip. Ensure that compost is well composted and weed-free and that woodchip has been left to partially decompose before using potting mixes. If enough quantities of ingredients for the potting mix are not available on the island, commercial suppliers can supply sterilised (steam-treated) materials free of pest plants such as composted bark chip, cocopeat and perlite. It is important to discuss with the supplier the need for these materials to be sterile to pest plants, insects and other pests, phytophthera and other plant diseases.

4.2. WATER

Water use efficiency should be incorporated into nursery design and management.

Possible sources of water include waste water (provided this is adequately treated), rain water, desalinated water and fresh ground water aquifer. Before considering the use of water from the island aquifer, information must first

be obtained regarding the volume of water contained in the aquifer, the role of the aquifer and the required water levels for maintaining the terrestrial and marine ecosystems that depend on this resource.

The use of water efficient drip irrigation systems will minimise water use. Water use can be further reduced by using commercially available water absorbing gel or crystals in the potting mix. Alternatively, a small amount of detergent may increase the water holding capacity of the potting mix. Watering from the bottom up also helps to thoroughly wet the potting mix.

4.3. NURSERY PROPAGATION

Training in nursery propagation techniques should be undertaken by staff working in the LEI nursery. The curator of the Gladstone Tondoon Botanic Gardens has offered to provide training at the Tondoon nursery for LEI nursery workers. Tondoon staff are very experienced in the propagation of native plant species and will also be able to assist with advice on equipping the nursery and recipes for suitable seed raising, cutting and potting mixes for cay plants.

Alternatively, community run nurseries such as Landcare may be willing to assist.

Professional advice should be sought in nursery design and construction as well as on the most suitable watering systems and other equipment required for the nursery and watering systems.

5. PROPAGATION AND GROWING NATIVE CAY SPECIES

5.1. TRIALS

Propagation trials will be needed to determine the:

- best mixes and techniques for each species
- time required for seed germination for each species
- expected germination success rates for each species
- relative success rates for seeds vs cuttings
- rate of growth (time in nursery prior to planting out)
- nursery survival rates.

5.2. PROPAGATING PISONIA CUTTINGS

The propagation of large numbers of pisonia plants from cuttings will require an area to be set up within the nursery with wind protection. The pisonia holding area should be situated in a protected location surrounded by a 50 per cent shade cloth windbreak supported by 2.4 m star pickets. The potted cuttings should not be covered with a shade cloth roof as this would necessitate the extra step of sun-hardening before planting out. Enclosures within the outer perimeter will also be required to hold the potted cuttings and prevent them from being blown over by the wind or toppling over as they become top heavy. The potted pisonia cuttings should be packed as close together as possible.

Potted cuttings can be partly buried to prevent blowing over. This allows roots to grow into the surrounding soil and anchor the potted cuttings. When this occurs, pots must be removed carefully when required for planting as damage to roots may result in transplant shock and decreased survival rate. Allowing roots to grow into the surrounding soil is not recommended for other tree species, particularly casuarina.

Most of the pisonia cuttings will be sourced from LEI from both old growth trees and previously planted pisonia. If possible, cutting material should also be sourced from Lady Musgrave Island, Masthead Island and Heron Island during routine safety lopping to potentially increase the genetic diversity of the pisonia population on LEI.

Data from the Tryon Island Project determined the optimum above ground cutting heights and diameters for successful direct planting were 500 to 600 mm (total cutting length approximately 700 to 800 mm) and 45 to 50 mm, respectively. Optimum cutting sizes for potting have been found to be 750 mm high × 30 mm diameter on LEI. If potted cuttings are too long and top heavy, they will blow over easily.

Cuttings should be planted in 4 litre (15 cm diameter × 22.5 cm height) potting bags using a potting mix rich in organic matter with a slightly acid pH. A mixture of approximately equal quantities of sand, compost and woodchip sourced from LEI has been used successfully in previous propagation trials. The cuttings should be scored down one side to expose the cambium layer prior to potting.

At the LEI nursery, a dripper system is currently used to water the cuttings. Water is delivered to each plant via individual drippers at a rate of 2 L per hour for 2 mins each morning in winter, 2 mins morning and afternoon in spring and autumn, and 2 mins three times per day (morning, midday and afternoon) in summer.

Under this watering regime, cuttings remain in the nursery for approximately 4 to 6 months prior to planting out.

5.3. PROPAGATING NATIVE GRASSES IN TURF FARMS

Large quantities of rooted native grass tufts or runners will be needed during revegetation, particularly in the North-East Zone.

Grasses can be propagated and potted in the nursery for planting in restoration areas.

If there is insufficient room in the plant nursery for the large quantity of grasses required, designated 'turf farms' can be established to provide an ongoing supply of desired native cay grass species. It is preferable to establish the turf farms in areas already dominated by native grasses with a low cover of pest plants. All pest plants should be removed before planting native grass species in the turf farms. Steam treatment is to be used or weed matting placed as a buffer around the edges of the turf farm areas to avoid invasion of non-native species from adjoining areas.

When establishing a turf farm, it is important to work in manageable sized blocks, gradually increasing the size of the turf farm continuing from the edges of previously established areas until the desired area has been established. Established sprigs or runners can then be transplanted to the restoration areas.

Sprigs or runners should be taken from alternate strips to allow rapid spread and reestablishment in bare areas from adjacent strips. It will be necessary to add a mixture of sand, compost and woodchip to replace the soil removed with the grass.

Seed may be able to be collected from the turf farms when grasses are seeding by mowing with a grass catcher. The mower and grass catcher should be thoroughly washed down immediately prior to doing this to avoid the introduction of pest plants and to prevent contaminating the seed being collected.

The turf farms should be hand weeded regularly to eradicate unwanted species. It is particularly important to thoroughly weed immediately before taking out sprigs and runners for planting in the restoration areas. All pest plants should also be removed immediately before mowing with a grass catcher to collect the seed.

5.4. PROPAGATING OTHER PLANT SPECIES

Naturally occurring cay plant species are quite hardy and should be relatively easy to propagate successfully either from seed and/or cuttings. It should not be necessary to add additional fertiliser to potting mixes or apply hormones to cuttings.

Tree, shrub and forb species can be propagated from seeds or stem cuttings planted initially into trays in a misting house. Following germination, seedlings should be pricked out and planted into tubes and maintained in a greenhouse until established. After potting up, the young plants will need to be grown and sun-hardened outside the greenhouse prior to planting.

Alternatively, some seeds can be planted directly into small tubes (approx. 50 mm) and then planted out directly from these tubes.

5.5. DIRECT SEEDING

Direct seeding is the preferred method of propagation for the following species:

- lantern bush (*Abutilon albescens*)
- coastal jack bean (*Canavalia rosea*)
- bull's head burr (*Tribulus cistoides*).

Direct seeding should also be carried out for other species to provide a soil seedbank to supplement the planting of nursery grown plants.

Seed harvesting by ants, particularly the non-native African big-headed ant (*Pheidole megacephala*) can reduce the success of direct seeding. Ant baiting of each restoration area in the North-East and North-West Zones should be considered prior to undertaking restoration work. Whether ant baiting is required or not should be determined by first carrying out a suitable invertebrate survey to assess the population sizes of non-native ants and to identify non-target species that may be affected. Methods for eradicating non-native ants are discussed in Section 9.

6. PLANTING OF NATIVE CAY SPECIES

6.1. TRIALS

Indicator trials should be undertaken to determine the best planting techniques to establish nursery propagated native cay species; the optimum watering regime (frequency, quantity and duration) for successful establishment of desired native species, particularly native grasses, taking into account logistics, cost and the need to minimise water usage; planting density required for optimal pest plant suppression by native grasses with consideration given to the need to maintain an adequate water supply in all currently maintained restoration areas; and whether direct seeding or planting is an effective way to establish certain native cay species.

Direct seeding trials could be carried out together with the grass establishment watering trials, including a direct seeding trial with no watering. Direct planting trials of pisonia could be undertaken in conjunction with potted pisonia being planted out and watered with a dripper system.

6.2. PLANTING PISONIA SEEDLINGS

In the first 4 years, it is proposed to plant approximately 9000 pisonia (at approx. 3 – 4 m spacings) throughout the South-West Zone.

It is recommended that the potted pisonia are planted out between July and September to avoid the use of machinery during the bird season. This will allow plants to establish before the hot weather arrives and to benefit from the summer rains.

Lantana should be removed prior to planting using the methods described in Section 2.6. During the planting out process, some hand pulling, brush cutting or spraying of dwarf poinsettia and other pest plants may be required in the immediate vicinity of some of the planting holes to prevent pest plants smothering the newly planted pisonia.

The following method has been successfully used on LEI to plant potted pisonia:

1. Approximately half the foliage is removed from the potted plant about a week prior to planting
2. A ripper attached to the front of a loader is used to dig planting holes by inserting the ripper attachment into the ground and then reversing to loosen enough ground to plant the potted pisonia
3. The potted pisonia are pulled carefully out of the ground where they have taken root in the nursery
4. The plastic potting bag is cut away and carefully removed so as not to damage the emerging roots and the plant is inserted into the planting hole
5. Woodchip is packed around the planted pisonia to stabilise them in the planting hole and help retain moisture
6. The newly planted pisonia are watered immediately using approximately 2 L to 3 L of water per plant.

6.3. DIRECT PLANTING OF PISONIA CUTTINGS

Direct planting of cuttings was used successfully to establish pisonia on LEI in the area between Noddy Lane and the old airstrip (pers. comm. Bruce Knuckey, QPWS).

To revegetate Tryon Island, 3200 pisonia cuttings were cut from material obtained during campground tree lopping on North-West Island in 2006 (Brushe 2018). All cuttings were transported to Tryon Island and successfully planted within a period of 6 days by a team of approximately 12 people. The success rate of these plantings was approximately 50 per cent with no follow-up watering and with significant disturbance by burrowing wedge-tailed shearwaters. Tryon Island plantings were probably favoured by deeper substrate (Tryon Island is a sand cay) and good rainfall during and immediately following planting.

Direct planting of cuttings, as done on Tryon Island is likely to be less successful on LEI due to the hard substrate and the need to achieve close to a 100 per cent success rate. Direct planting may be viable with a dripper irrigation system.

6.4. FOLLOW-UP AFTER PISONIA PLANTING

Initial planting on LEI found that during the first week, watering three times of approximately 2 L on each plant was required. For the next couple of weeks, plants were watered using approximately 500 mL three times per week. Watering was continued as required for approximately 4 months after planting. No further watering was done after 4 months.

On LEI, planted cuttings are now watered as required via a dripper system. The use of dripper systems reduces labour and water use.

Do not remove pest plants other than lantana, species classified as ‘Very High’ and ‘High’ priority pest plants for eradication (Appendix 3 of the Plan), and pest plants that are threatening to smother newly planted pisonia. Other pest plants will be shaded-out by the planted pisonia after several years.

In some areas, pest plant removal may be required for visual aesthetics. Remove all pest plant species at the same time. Brush cutters should not be used to manage regrowth, owing to the risk of spreading seeds.

It will be necessary to inspect the planted pisonia regularly for the presence of scale insects. If a build-up of scale insects such as cottony urbicola scale (*Pulvinaria urbicola*) occurs, particularly in association with increasing populations of non-native ants such as *Phedole megalocephala*, these should be treated using the methods described in Section 9 in consultation with QPWS. Both these species are known to be present on LEI (Burwell et al. 2010).

6.5. TRANSPLANTING NATIVE GRASSES FROM TURF FARMS

Two methods have been successfully used to transplant native cay grasses on Lady Musgrave Island:

1. Using rooted runners: Dig out long runners, being careful not to damage the roots; dig elongated trenches (root depth if possible) using a mattock; place runners in these trenches; and pack soil firmly around the roots and over the rhizomes to bury the roots and cover the rhizomes with a shallow layer of soil. After planting, the surface of the filled trench containing the planted runner should be slightly below the surrounding ground level to form a shallow trench to help prevent run-off and retain water long enough for it to be absorbed by the soil around the roots; trim off most of the leaves; water immediately and periodically until established.
2. Using rooted tufts: Dig out tufts of grass to the depth of the roots using a spade; alternatively, use machinery to remove larger strips of grass and separate them into planting sized tufts by either gently pulling or cutting them apart; plant and water as described in Method 1 above except the planting is into holes dug with a shovel or machinery rather than a trench.

7. BUFFER ZONE PLANTING

A buffer strip of native grasses should be established along mown edges adjoining the North-East and North-West Zones, and the Resort Precinct prior to clearing the adjoining edges of these zones. This could be done by first creating a vegetation-free strip, possibly using steam to kill an existing non-native grasses and forbs and establishing native cay grasses using a combination of planting and direct seeding. The strips along the edges of the airstrip would receive regular watering from the airstrip irrigation system. In other areas (e.g. adjacent to the solar panels, staff accommodation and northern edge of the resort), regular watering would be required until the native grasses are established.

8. CONTROL OF PEST BIRDS

Refer to Appendices 5 and 6 of the Plan for a list of bird species occurring on LEI at the time of the development of the Plan and their preferred habitats. Bird management or control should only be done in consultation with QPWS.

9. CONTROL OF PEST INVERTEBRATES

A list of invertebrate species recorded on LEI at the time of the development of the Plan is in Appendix 8.

To date, there has not been a major outbreak on LEI of the soft scale insect cottony urbicola scale (*Pulvinaria urbicola*), which affects pisonia. Scale insect populations are generally controlled by the scale predator lady beetle *Cryptolaemus montrouzieri,* which is present on the island (Burwell et al. 2010).

If scale insect numbers build up in the newly planted pisonia, or if seabird nesting is being adversely affected by the presence of invasive ants, QPWS should be notified for advice. Action may include ant baiting or increasing the abundance of lady beetle *Cryptolaemus montrouzieri*. Initially, baiting should be restricted to within and adjacent to problem areas only, as baiting the entire island would be extremely time consuming and expensive. If scale insect numbers build up and *Cryptolaemus montrouzieri* is locally absent then this species should be sourced and released based on advice from QPWS (Olds 2006).

Amdro® (active constituent: 7.3 g/kg hydramethylnon) has been used successfully on Tryon Island and other cays by QPWS to eradicate the invasive seed harvesting ant and the African big-headed ant and to help control outbreaks of cottony urbicola scale (*Pulvinaria urbicola*) which is 'farmed' by the ants. The product consists of corn granules impregnated with hydramethylnon. The active ingredient, present in very low concentrations, is taken back to the nest where it kills the queen and eliminates the nest. It is, however, toxic to aquatic life

(Material Safety Data Sheet, Amdro 2005) and care must be taken to ensure it does not reach the marine environment or intertidal zone. It should only be used where ants are posing a significant ecological risk.

Amdro® proved effective in the eradication of the African big-headed ant on Tryon Island and was used effectively on Wilson Island in 2006 to reduce African big-headed ant numbers prior to the release of the scale predator lady beetle *Cryptolaemus montrouzieri* (Olds 2006).

The bait was applied at the recommended rate by lines of up to 6 volunteers using fertiliser spreaders. The volunteers, approx. 3 m apart (depends on the range of the spreaders used), walked across the area to be baited in straight lines spreading the bait as they went, ensuring that the entire area was covered. The person on the end adjacent to the unbaited area marked the baited edge with flagging tape as they went along. On the return transect, the person adjacent to the previously marked edge removed the flagging tape and the person at the other end marked the new edge with flagging tape and so on until the entire area was covered with bait (i.e. roughly one granule every 200–300 mL).

Bait stations containing this product can also be used to prevent access by non-target species and to minimise the amount released into the environment. This method may be suitable for the baiting of smaller areas.

10. MONITORING

10.1. VEGETATION MONITORING METHODS

Data and photographs from all vegetation monitoring surveys will be stored in the Queensland Herbarium CORVEG database and the Queensland Herbarium photograph database.

At least two permanently marked monitoring sites will be monitored annually in each of the major vegetation communities as well as in some Human Use Management Zones such as tracks and airstrips. Sites are monitored using the recognised published Queensland Standard methodology (Neldner et al. 2019), which also enables data from these sites to be validly compared to those of reference sites in the same vegetation communities on Capricorn Bunker cays, which have been surveyed using the same methodology.

10.1.1. SITE DESCRIPTIONS

Site descriptions for each site are documented. These descriptions include all site attributes that do not change including bioregion, subregion, GPS and location description, area/width of the vegetation represented by the plot, a position in landscape diagram, landform element, landform pattern, slope, altitude, substrate, plot size and plot orientation including compass bearings from the marker post.

10.1.2. DATA RECORDED DURING EACH SURVEY

The following data should be recorded during each survey:

- site number, recorder names, date, start and finish time
- GPS location of plot centre and end points (use GDA 94 datum), location description, transect bearing
- vegetation structural layers present, median height and height range of each layer
- comprehensive species list for each layer
- ground layer per cent foliage projected cover for each vascular plant species, litter, bare ground, rock outcrop and cryptograms
- per cent crown cover by species for each layer for the emergent, tree and shrub layers
- from the species list and cover measurements, the following can be derived:
    - total vegetation cover in each layer
    - native cover in each layer
    - non-native cover in each layer
    - species richness – total and differentiated by growth form
    - native species richness – total and differentiated by growth form
    - non-native species richness – total and differentiated by growth form
- species richness in each layer – total and differentiated by growth form
- native species richness in each layer – total and differentiated by growth form
- non-native species richness in each layer – total and differentiated by growth form
- estimate of overall pest plant cover
- stem counts of woody species per species per layer in the tree and shrub layers; including standing dead plants (count per hectare can be calculated for each species, growth form and layer)
- basal area sweep measurements of woody species per species per layer
- girth measurements for woody species (basal area per hectare can be calculated for each species, growth form and layer)
- evidence of recruitment of woody species

- topsoil depth, colour and texture (full soil analyses will not be done every year)
- total length of logs (coarse woody debris)
- presence of shearwater burrows or other evidence of bird nesting
- evidence of turtle nesting
- other disturbance type (e.g. evidence of wind damage to vegetation, wind erosion, saltwater inundation, fire, mowing/slashing, other human disturbance) and severity
- patch size
- community extent
- community area
- community context (extent of connectivity to other native vegetation communities)
- evidence of disease, death, dieback, presence of scale, insect attack and leaf drop
- mean monthly climatic data (since previous monitoring)
- eight site photographs from the plot centre – a landscape and portrait photo facing the direction of the bearing and at 90, 180 and 270 degrees from the direction of the bearing

10.1.3. PLOT CONFIGURATION

Plots are located in representative areas within a vegetation community. Wherever possible, plot layout should be as illustrated in Figure 2.

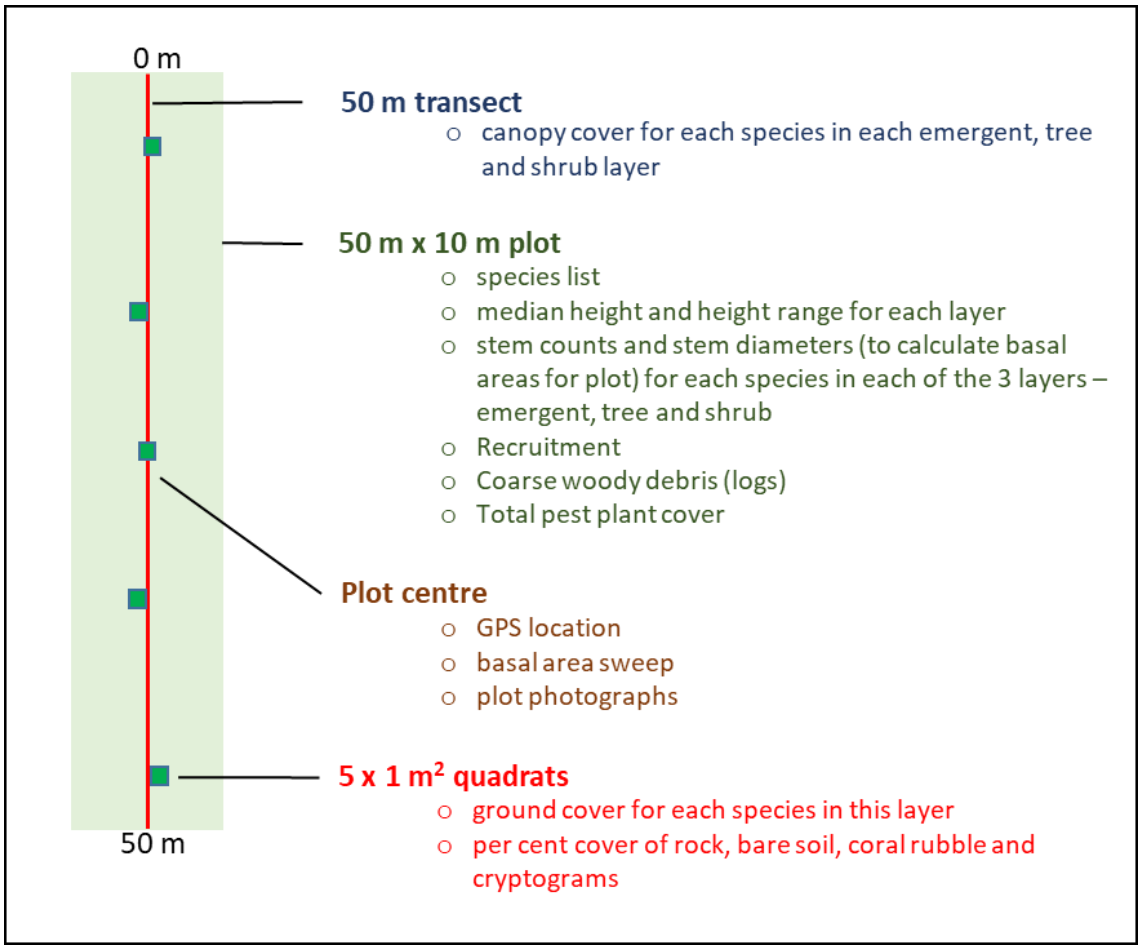

Figure 2: Schematic of the 50 m x 10 m plots and summary of data collected at each permanent monitoring site.

The width of sites located on tracks are the width of the mown track only.

The Coastal Zone may contain different vegetation communities present in narrow zones parallel to the shore. The relative locations of these zones are likely to shift either landward or seaward over time because of shoreline erosion and accretion. To provide for this shifting of zones over time, additional data is recorded in a belt transect positioned 90 degrees to the main plot. The plot layout for the coastal plots is shown in Figure 3.

The following data is recorded along the 2 m wide belt transect:

- the distance along the tape of each of the vegetation community boundaries (start and finish) including bare coral rubble banks
- ground cover in 1 m × 1 m quadrats every 5 m starting at the seaward edge of the vegetation and finishing at the boundary between the Coastal Zone and the landward non-Coastal Zone
- recruitment of woody species within 1 m either side of the tape.

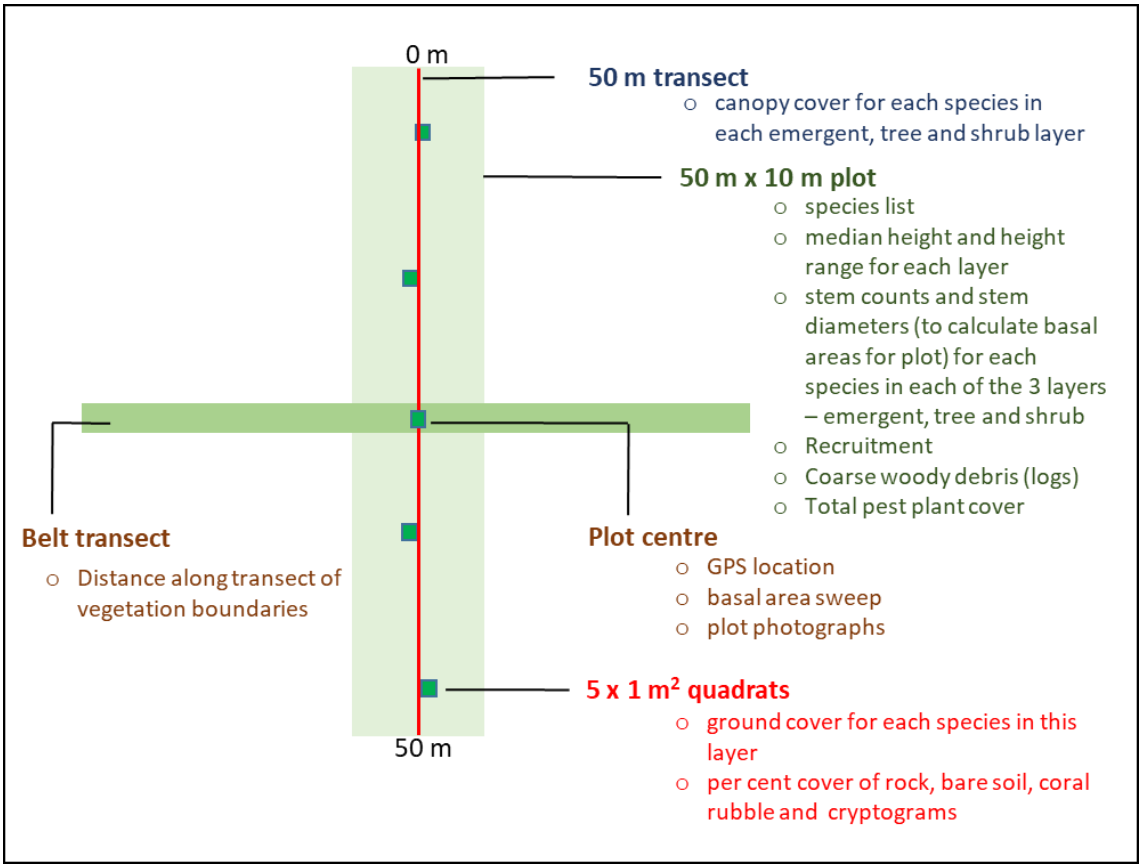

Figure 3: Schematic of the 50 m x 10 m Coastal Zone plots and summary of data collected at each permanent monitoring site.

10.2. BIO-CONDITION ASSESSMENT

The Queensland Standard methodology of Eyre et al. (2011) with some modification to suit cay ecosystems will be used to assign bio-condition scores (Neldner and Ngugi 2014). Benchmarks will be derived from selected CORVEG sites surveyed during the vegetation survey and mapping of the Capricorn Bunker cays (Batianoff et al. 2012) together with technical descriptions (Neldner et al. 2012) and supplemented with expert knowledge. Additional benchmark data will be obtained by surveying reference sites on other Capricorn Bunker cays.

10.3. BIRD MONITORING

Monitoring will be done as part of the QPWS broader Capricorn Bunker cay surveys. Any island specific monitoring will be done using methods consistent with QPWS survey techniques. A copy of collected data is to be provided to QPWS.

10.4. INVERTEBRATE MONITORING

Baseline data of the invertebrates of LEI was obtained in 2007 (Burwell et al. 2010). A list of invertebrate species recorded as present on LEI is in Appendix 8 of the Plan.

Invertebrate monitoring, in consultation with QPWS, should be carried out periodically during implementation of the Plan to determine the relative abundance of invertebrate species on the island. For meaningful interpretation of data, it is important to undertake comparative monitoring on other Capricorn Bunker cays at the same time as the LEI surveys.

10.4.1. GENERAL INVERTEBRATE MONITORING TECHNIQUES

It is recommended that annual ant surveys be undertaken to assess ant diversity as a surrogate measure of general ecosystem health using attractant bait stations placed within each of the 50 m x 10 m vegetation monitoring sites.

In addition, it is recommended that periodic invertebrate monitoring using the following techniques is carried out:

- small pitfall trapping using 120 mL cylindrical vials filled with 70 per cent ethanol and operated for approximately 24 hours
- large (1 L) pitfall trapping – short-term (24 – 48 hours)
- Elliot trapping (for hermit crabs and other large invertebrates)
- attractant baits may be a better alternative to pitfall trapping for assessing the presence of target ant species.

The following techniques may also be carried out at less frequent intervals:

- long-term large pitfall trapping (3 months)
- malaise trapping
- light trapping
- timed hand collecting.

A description of methods is available in Burwell et al. (2010).

10.4.2. SCALE INSECT MONITORING METHODOLOGY

Systematic observational monitoring of existing planted pisonia should be carried out, particularly prior to new planting. If scale insect numbers appear to be significantly increasing, systematic quantitative monitoring should be carried out using the following method adapted from Cruise et al. (2006). The following '6-leaf' method is used by QPWS to monitor scale insects on Tryon Island and other Capricornia cays:

1. Work in teams of two or three people
2. Mark out transects spaced 50 m across the pisonia forest with flagging tape following a compass bearing
3. At sample points every 20 m along the transect, locate the nearest three pisonia trees within 10 m of the transect
4. From each tree collect:
    - 1 × upper canopy leaf
    - 1 × lower canopy leaf (less than 2 m high)
5. For each leaf sampled record:
    - tree number (1, 2 or 3)
    - leaf position (high or low)
    - leaf length (accurate to 0.1 cm)
    - number of *Pulvinaria urbicola* scale along midrib
    - number of *Pulvinaria urbicola* scale along midrib that appear to be parasitised (darker brown or with exit hole)
    - number of other (e.g. hard) scale along midrib
    - number of African big-headed ants (*Pheidole megacephala)* (dark with largish head) and other ants on leaf
    - number of other insects (e.g. ladybeetles) on leaf.

If a scale outbreak occurs, seek advice from QPWS. An outbreak is defined as a mean of 0.006 scale/cm of midrib, which is equivalent to 1 or more scales per 3 leaves based on a sample size of at least 200 (preferably 300) leaves collected from across the island (Cruise et al. 2006).

The following '10 Branch Method' is a simple sampling technique for the detection of key predators/parasites and for monitoring low levels of scale infestation:

- At 20 m intervals along the transect, locate the nearest pisonia tree
- From each tree, select 10 branch ends; from each branch end visually assess 10 leaves. Record for each leaf the following data:
    - assign to one of 4 infestation levels: 0 scales; 1-50 scales; 50-500 scales; or > 500 scales per leaf
    - presence/absence of predators and parasites
    - percentage of parasites (if present)
    - any additional information.

10.5. TURTLE MONITORING

Turtle monitoring to be done consistent with the Marine Turtle Conservation Strategy (Conservation & Biodiversity Operations Branch, Department of Environment and Science 2018) and based on advice from QPWS.

10.6. SOIL AND WATER MONITORING

Soil samples will be collected every 3 years (more frequently if indicated) from the vegetation monitoring sites and sent to analytical laboratories for analyses.

Water samples will be collected from the permanent wells and bores located on the island and sent to suitable analytical laboratories for analyses. Depth to the top of the water lens should also be measured when the samples are collected.

Further research is required to provide more information on the spatial distribution, depth and function of the water lens(s) on LEI and other Capricorn Bunker cays.

10.7. MONITORING RODENTS AND CANE TOADS

Monitoring should be carried out annually during the Plan's implementation, in conjunction with the invertebrate survey. The following should be undertaken to monitor for rodents and cane toads:

- Use Elliott traps of an appropriate size with a mixture of peanut paste, rolled oats and oil for bait
- Place traps approximately 50 m apart along transects running across the entire island at 50 m intervals
- Check traps twice daily for 3 days
- This will have to be done a few transects at a time, depending on the number of Elliott traps available.

10.8. PHOTO-MONITORING

In addition to photo-monitoring in the vegetation monitoring plots, several permanent photo-points should be established in suitable locations to take landscape panoramas. These should be taken annually as part of the vegetation survey to demonstrate broader changes in the vegetation on the island.

Before and after photographs as well as photographs of work in progress should be taken and stored in a suitably catalogued photo database maintained by the EMO as historical records and for use in reporting, interpretation and presentations.

Aerial or drone photographs (or similar) should be taken periodically to demonstrate and interpret changes in the vegetation patterns and for use in updating the Vegetation and Regional Ecosystem Mapping.

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